SPATIAL FEATURES OF ENTREPRENEURIAL ECOSYSTEMS

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ABSTRACT

Growing importance has been attached to the concept of Entrepreneurial Ecosystems (EE) as productive structures that encompass complex sets of interaction driving economic agents' competitive capabilities. Drawing from biomimetism, the EE approach dedicates attention to unraveling the mechanisms through which socioeconomic environments organize to introduce new knowledge and innovations in markets. Yet, while challenges associated with identifying the spatial scale of natural ecosystems have long been part of discussions in the field of ecology and evolutionary biology, and in economic geography, the geographic reach of EE remains largely uncharted in literature. Importantly, from a biomimetic standpoint, we know that ecosystems' boundaries must be defined according to their formative processes, rather than reflect predefined political or administrative boundaries. In this study, we try to shed some light on these topics, underscoring the analytical and methodological challenges associated with the spatiality of entrepreneurial ecosystems. Thinking about entrepreneurial ecosystems as fixed analytical units attached to administrative boundaries will likely cause an inadequate analytical understanding of how entrepreneurship-oriented relationships are distributed in space.

1. INTRODUCTION

Knowledge-intensive entrepreneurship (KIE) represents a socioeconomic phenomenon that drives economic competitiveness and innovative capabilities (Malerba & McKelvey, 2020; Ács et al., 2017). However, the entrepreneurial individuals and companies that lie at the core of this discussion do not exist in a vacuum. Instead, they are embedded in complex socioeconomic environments that can either enable or constrain their emergence (Guerrero & Urbano, 2017, 2019; Mason & Brown, 2014; Audretsch & Belitski, 2017). As a result, entrepreneurial activity is unevenly distributed in geographical space, a function of heterogeneous endowments in knowledge, institutions, resources, and demand. This generates spiky geography of economic activities – accentuated by technological evolution (Adler et al., 2019; Florida & Mellander, 2014; Crescenzi & Rodríguez-Pose, 2017).

Along these lines, growing importance has been attached to the concept of Entrepreneurial Ecosystems (EE) as productive structures that encompass complex sets of interactions that shape aggregate competitive capabilities in economic agents (Clarysse et al., 2014; Alvedalen & Boschma, 2017; Schaeffer et al., 2018; Malecki, 2018). Drawing from biomimetics, the EE approach dedicates attention to unraveling the mechanisms through which socioeconomic environments organize to introduce new knowledge and innovations in markets (Oh et al., 2016). Following its evolution, the literature has departed from inductive examples based solely on highly successful cases (Nicotra et al., 2018; Stam & Spigel, 2016) to include more fine-grained analyses of a broader array of functional ecosystems (Auerswald & Dani, 2017; Alves

et al., 2021; Stam & van de Ven, 2019; Sternberg et al., 2019; Vedula & Fitza, 2019; Spigel & Harrison, 2018; Autio et al., 2018).

Yet, if we take the entrepreneurial ecosystem metaphor seriously (as called for by Kuckertz, 2019 and Oh et al., 2016), an issue of critical importance concerns the spatial morphology of these complex arrangements. While challenges associated with identifying the spatial scale of natural ecosystems have long been part of discussions in the field of ecology and evolutionary biology (Levin, 1992; Bailey, 2004; 1985; Strayer et al., 2003), and even in systems involving human-environment interactions (Ostrom, 2007), the geographic reach of EE remains largely uncharted in literature. This is odd since entrepreneurial ecosystems are 'an inherently geographic concept' (Godley et al., 2021, p. 725). Loose definitions mentioning regions, localities, or even countries have been used by conceptual, inductive, and deductive approaches in literature (see Cao & Shi, 2021 for a systematic review). Traditional economic appraisal methods concerning the dynamics, determinants, and outcomes of ecosystems require relatively uniform analytical units (cities, regions, countries) that can be compared. Additionally, data availability often hinders a proper examination of data at the truly ecosystem level (instead of the political unit level) (Schäfer, 2021). But this means that the heterogeneous nature of such ecosystems (Brown & Mason, 2017) is mostly omitted from empirical assessments – at least from a territorial standpoint.

From a biomimetic standpoint, we know that ecosystems' boundaries must be defined according to their formative processes (Bailey, 1983), rather than reflect predefined political or administrative boundaries (Carayannis et al., 2018). Economic geographers have long grasped these issues in the definition of conurbations (e.g., Gordon & McCann, 2000; Taylor, 1975), industrial clusters (Dicken & Malmberg, 2001) or districts (Markusen, 1996), and 'borrowed size' dynamics (Meijers & Burger, 2015). Geographers have also long paid attention to the spatial structure and boundaries of urban settlements such as metropolitan areas (e.g., Berry & Okulicz-Kozaryn, 2012; Lang et al., 2020; da Cruz et al., 2020), although no consensus on how to identify boundaries has been reached (Nelles, 2021). This literature recognizes spatial features of economic systems as key for urban planning and governance. Nonetheless, these discussions have yet to find their place in the field of EE studies. As Hesse (2014) highlights, the spatial connection between economic agents, forming networks, is the key to understand the geographic reach of economic activity.

Such issues have significant implications for how entrepreneurial ecosystems are addressed by researchers and policymakers (Bruns et al., 2017; Kuckertz, 2019; Autio & Levie, 2017; Roundy et al., 2018). An in-depth exploration of the territorial coverage of a given EE – an issue that is likely connected to its stage of maturity - can set the parameters for informed initiatives that can efficiently promote stronger linkages (the quintessence of the EE phenomenon). In line with the propositions made by Auerswald (2015), Phillips and Srai (2018) are among the first to explore the challenge of identifying ecosystems' boundaries. Still, their approach is agent-centered, looking into ecosystems participants and leaving aside the geographical nature of linkages. Schäfer (2021) has recently offered new insights on the relevance of spatial features in assessing entrepreneurial ecosystems. Brown and Mason (2017) also provided some initial insights on the association between spatial dynamics of EE and their degree of maturity. But a more systematic perspective is needed to offer guidance on this topic.

Our goal in this article is to articulate the literature on entrepreneurial ecosystems with contributions dealing with how innovative activity is organized within and across territories. We also combine these contributions with relevant insights on the boundaries of natural ecosystems. Key elements in this debate concern the underlying structure of entrepreneurship-oriented relationships established among agents – and to what extent they involve different 'formal' territories. This is a fundamental methodological requisite since ecosystems are relational structures, not linear events leading to innovative output (Alvedalen & Boschma,

2017). Also, the spatial features of entrepreneurial ecosystems cannot be detached from their evolutionary stages. Hence, the geographic coverage of EE is bound to change over time.

Following this introduction, the paper is structured as follows. Section 2 discusses the theoretical foundations of entrepreneurial ecosystems from the perspectives of economic geography and biology. Section 3 expands to innovation ecosystems. Section 4 synthesizes towards the spatial view of entrepreneurial innovation ecosystems and addresses the theoretical and methodological challenges involved with future research on this topic. Section 5 concludes with final remarks and the contributions from articles included in this Special Issue.

2. ENTREPRENEURIAL ECOSYSTEMS

In the literature on entrepreneurial ecosystems, new venture formation is typically circumscribed to the case of knowledge-intensive firms (Stam, 2015). Hence, innovative content of business activities is a requisite for these companies. Because of asset constraints, KIE firms become dependent on access to complementary external resources to achieve sustained competitiveness (Godley et al., 2021). The access to these resources often becomes dependent on the local dynamics in terms of myriad elements of the knowledge and business context (Hervás-Oliver et al., 2021). This is where the entrepreneurial ecosystem rationale comes in. Drawing from biomimetic arguments, these structures are characterized as collaborative arrangements between firms and governments, institutions, universities, research institutes, technology transfer offices, sources of funding, incumbents and networks of entrepreneurs themselves (Tsouri & Pegoretti, 2021; Stam & van de Ven, 2019; Donegan & Lowe, 2020; Walsh, 2019; Clarysse et al., 2014). Shaw and Allen (2018, p.88) refer to this as "interlinked business models". The main argument behind this approach is related to the idea that the generation and diffusion of innovations, as well as entrepreneurial activity, are shaped by the local infrastructure, its externalities, specialized services and levels of trust involved in relationships between agents (Alvedalen & Boschma, 2017; Delgado et al., 2010).

Accordingly, elements associated with interactions, connections and knowledge flows lie at the heart of ecosystems of innovation and entrepreneurship, where local and regional elements shape aggregate capabilities of agents (Rodríguez-Pose & Ganau, 2021; Fischer et al., 2018; Autio et al., 2018; Alvedalen & Boschma, 2017; Carayannis et al., 2016; Stangler & Bell-Masterson, 2015). This environment of innovative activity works as a critical source of entrepreneurial opportunity and performance (Radosevic & Yoruk, 2013). In this context, *voluntary and involuntary* knowledge spillovers take place, favoring open innovation strategies. This situation generates fruitful opportunities for entrepreneurs to engage in value co-creation and to participate in established industries despite the dominance of large firms (Nambisan et al., 2018). The prevailing perspective to treat these issues is that of the Knowledge Spillover Theory of Entrepreneurship, an analytical approach that deals with how localized knowledge flows benefit innovative and entrepreneurial endeavors (Ács et al., 2009). Such spillovers are spatially concentrated, benefitting entrepreneurial individuals and firms which are at a close distance of other actors (Adler et al., 2019)[1]. This perspective enhances the importance of enabling and supporting ecosystems' actors to expand connectivity among key players embedded in any given entrepreneurial ecosystem (Ketonen-Oksi & Valkokari, 2019).

In these terms, entrepreneurial ecosystems can be characterized as "agglomerations of human, social, intellectual and financial capital stocks and flows as well as cultural and technological artifacts and modalities, continually co-evolving, co-specializing, and co-opeting" (Carayannis & Campbell, 2009, p. 206). For obvious reasons, Silicon Valley rapidly became the example *par excellence* of what an entrepreneurial ecosystem should look like

[1] Although one might argue that spatial proximity *per se* is not sufficient – aspects related to cognitive, social, organizational and institutional distances are probably also involved in these dynamics (Boschma, 2005).

(Jackson, 2011, p. 3). Again, interactions are key in these dynamics, as well as processes of resource allocation and governance systems involving communities of stakeholders directly or indirectly involved with entrepreneurial activity (Cao & Shi, 2021; Stam, 2015). This generates a sense of interdependence among actors, i.e., the entrepreneurial event becomes a systemic output rather than solely a decision of isolated individuals (Stam & van de Ven, 2019). Notwithstanding, actor-centrism is often found in EE assessments, incurring in a neglection of the pivotal role of interactions (Roundy, 2016). As a result, ecosystems are often taken for granted wherever entrepreneurs are located – regardless if they are involved or not with interactions with other local agents.

Another interesting feature in the EE debate concerns how historical trajectories and generation of an entrepreneurial culture within the ecosystem shape both its composition and strength of interactions among players (Mack & Mayer, 2016). These patterns reinforce themselves through time because geographic proximity functions as a fundamental vector for knowledge exchange among ecosystem participants (Gilbert et al., 2004; Agrawal & Cockburn, 2003; Asheim et al., 2011). Although these processes are essentially originated from bottom-up actions, they can also benefit from top-down coordination to reach maturity (Ratten, 2020; Brown & Mason, 2017).

Recent evidence has, however, defied some of the analogies of the entrepreneurial ecosystem concept. For instance, Brown and Mason (2017) have underscored distinct levels of maturity in EE, offering an insightful taxonomy. Also, issues related to the existence of heterogeneous configurations in successful ecosystems have highlighted the various ways in which components can be combined to foster new venture formation (Alves et al., 2021; Vedula & Fitza, 2019; Spigel, 2017; Wurth et al., 2021). Interestingly enough, this seems to approximate the ecosystem concept from its biomimetic roots – much more than monolithic prescriptive models were able to. We then turn to contributions from the fields of economic geography and biology to look for some guidance on how to achieve a better strategy to identify EE spatial patterns and boundaries.

2.1 An Economic Geography view

Ecosystems of entrepreneurship represent an issue of interest for the regional development literature due to their connection to socioeconomic development and an intrinsic association with industrial districts, clusters, and regional innovation systems (Ács et al., 2017). Accordingly, the dynamics of EE interactions are a fundamentally spatial concept. Resources, institutions, and networks including small firms, larger incumbents, universities, venture capitalists, culture and governments are embedded in geographical settings (Belitski & Godley, 2020; Jolley & Pittaway, 2019; Malecki, 2018). There are advantages for startups to locate in leading economic hotspots that provide access to knowledge sources that can be translated into entrepreneurial opportunities (Clarysse et al., 2014). This is aligned with the perspective of the Knowledge Spillover Theory of Entrepreneurship propounding that opportunity recognition and exploitation take place as an outcome of knowledge generation within the ecosystem (Acs et al., 2009). But what prior research has to say about the spatial scope of these ecosystems?

Qian et al. (2013) state that these ecosystems should have identifiable boundaries, but they fall short in guiding *how* these boundaries should be defined. Instead, as their argument goes, the regional aspect of EE could basically mean anything: “a region can be a county, a city, a state, a group of any type (e.g., a metropolitan area or a megaregion) or any definable geographic area that has a function of facilitating entrepreneurial activity” (Qian et al., 2013, p. 562). Stam (2015) follows a similar path, arguing that ‘geographically, it [entrepreneurial ecosystem] could be a city, a region or a country’ (Stam, 2015; p. 1764). Some very small countries might indeed be equivalent to regions (or even large cities), but this talks more about political boundaries than it does about how interactions that affect entrepreneurial dynamics

occur in geographical space. Plus, it adds the temptation of assuming that standardized areas are good enough to compare ecosystems – thus presuming that political boundaries can delimit the scope of connections among entrepreneurial agents and other elements of EE.

Most researchers treat the EE concept as a localized phenomenon (discarding the country-level as a proper analytical unit), although it is unclear how cutoff points are determined (Dias Sant'Ana et al., 2020; Tsouri & Pegoretti, 2021; Malecki, 2018). Some authors use distances to estimate the geographic coverage of EE. Gauthier et al. (2017) delimit ecosystems around a 100 km radius of some given 'central' location. Cukier et al. (2016) establish ecosystems within a 50 km radius or a 1-hour drive. Radziwon and Bogers (2019) build the notion of the ecosystem around a 25km radius of the city center[2]. While these approaches have the merit of ignoring political boundaries, it is hard to think about ecosystems worldwide as sharing the same (or similar) spatial patterns.

Other scholars follow a more conventional approach taking administrative units – such as cities or the adequate scope to address entrepreneurial ecosystems. Zhang et al. (2020) use province-level data in China. Lee et al. (2013) base their approach on cities and counties. Interestingly, their assessment reveals that knowledge production affects entrepreneurial activity within *and between* regions, suggesting some level of integration among these administrative units – but one is left to wonder whether adjacent cities/regions can compose functional ecosystems beyond political boundaries.

An insightful example in this regard concerns the assessment of the Greater Reading area (Godley et al., 2021; Belitski & Godley, 2020). This region is taken as an EE in its own right, even though the authors acknowledge its strong connections to London and Oxford (Godley et al., 2021; Belitski & Godley, 2020). This becomes clearer in the characterization of the Greater Reading ecosystem provided by Godley et al. (2021; p. 729): "Reading is closely connected with London and has several financial channels for entrepreneurs to explore". This makes us question whether this region is not an evolutionary emancipation of a larger entrepreneurial ecosystem centered in London. Would the Greater Reading emerge as a thriving ecosystem without its relational proximity with the UK's capital? To be fair, the authors then reflect whether Reading should be included as part of a larger ecosystem (Thames Valley Berkshire or even the whole Southeast of England.

On the other hand, some authors argue that the knowledge spillovers that compose the essence of entrepreneurial ecosystems are highly local phenomena with sharp attenuation when distance increases (Kerr & Kominers, 2015; Rosenthal & Strange, 2008). This affects even where *entrepreneurs locate within individual cities* (Arauzo-Carod, 2021; Adler et al., 2019; Jolley & Pittaway, 2019). In this view, entrepreneurial ecosystems would have a hyperlocal character, and initiatives targeting to promote EE should take a microgeographic approach (Arauzo-Carod, 2021; Donegan & Lowe, 2020). But often, these authors define ecosystems solely based on where entrepreneurs are located. This is not just limited because of its actor-centric nature (Roundy, 2016), but it also defines the ecosystem as per its output (Stam, 2015). Even though these intra-urban pockets of entrepreneurial activity are usually close to universities (Adler et al., 2019), eventual connections are taken as given – and linkages with other actors (such as venture capitalists) are not considered in this discussion. The entrepreneurial ecosystem then runs the risk of becoming not more than an incubator or tech park. Ultimately, this leads to a false sense of simplicity in the complex configuration of these structures.

Recognizing these aspects and inconsistencies, recent research has formally acknowledged the multi-scalar constitution of entrepreneurial ecosystems. Authors who perceive entrepreneurial ecosystems as regional phenomena highlight that localized features are also

[2] One can only hope that the city center coincides with the EE geographic core, not to mention that the ecosystem should describe a perfect circle in a map.

embedded in national and sectoral systems that affect each individual EE (Brown & Mason, 2017; Pombo-Juárez et al., 2017; Meuer et al., 2015). Although this view represents a significant advance in how entrepreneurial ecosystems are understood from a geographical standpoint, it is still based on highly arbitrary choices about where to draw the ecosystem boundaries. For instance, assume a deeply integrated sectoral system that involves players from multiple countries (a typical Global Value Chain structure), where knowledge, demand, investments, and even regulatory conditions involve cross-border *relationships*[3]. As pointed out by Schäfer and Henn (2018), transregional or transnational interactions involving knowledge, migration, or capital flows are becoming more and more common in the dynamics of EE. So where should ecosystem boundaries be drawn?

The key, we believe, is to forget about political limits altogether and focus on interactions. Why? First, because they are the foundation of entrepreneurial ecosystems. Second, because networks and flows of knowledge and resources play an essential role in addressing the structure of innovative activity across territories (Ter Wal & Boschma, 2011). This means that the geography of the entrepreneurial ecosystem is likely to have a much more complex morphology than it has been recognized by prior literature on the topic.

2.2 A Biological view

Although reliant on a biological metaphor, ecosystems of entrepreneurship are not the same as natural ecosystems (Kuckertz, 2019). Perhaps the main epistemological difference is related to the teleological constitution of the concept (Oh et al., 2016). Nonetheless, the use of the term was proposed due to the analogies that can be established. The key to drawing this parallel is related to the interactions between biotic and abiotic elements, usually taking place within a regional scope (Kuckertz, 2019) – although our prior discussion has highlighted that 'regional' can mean many things for different authors. And this is fine. The problem arises when there is a lack of clear definitions on where to draw these regional boundaries. This can confuse how to achieve efficient governance of entrepreneurial ecosystems since targets for policy become blurry. For instance, highly integrated cities can compete to foster their 'own' ecosystems when in fact, they might just as well be *one unified* entrepreneurial ecosystem. Without claiming to present a comprehensive perspective on the biological approach on the boundaries of the natural ecosystem, we bring here some arguments and elements that deserve consideration when applying the ecosystem rationale to address the spatial features of entrepreneurial activity and context.

First, natural ecosystems usually comprise contiguous areas involving interactions amongst biotic and abiotic elements (Bailey, 2004). But this notion can have very different meanings in dedicated literature, generating heterogeneous structures in scale and relative size (Strayer et al., 2003; Bailey, 1985). Illustratively, ecosystems can range from large territories (like the Arctic tundra) to small entities (such as a single tree in the Amazon rainforest) (Sayre & Hansen, 2017). Also, land cover is often used as a proxy to identify the extension of natural ecosystems (Sayre & Hansen, 2017). Most research dealing with natural ecosystems looks into boundaries as a combination of identifiable tangible structures and analytical units imposed by human order (Cadenasso et al., 2003; Strayer et al., 2003).

Post et al. (2007) define boundaries as functional (based on interactions and exchanges among units of study) and structural (which can be process independent, similar to administrative boundaries in political geography). Because the ecosystem concept involves 'a region of strong interactions among organisms and between organisms and the flux and flow of

[3] One can think of the current technological trends associated with the automotive sector worldwide as a good illustration of this example. Relationships with entrepreneurial firms have rapidly accelerated to promote learning and value co-creation in information technologies, artificial intelligence, machine learning and so forth.

energy or material' (Post et al., 2007, p. 113), functional assessments dealing with the dynamics of linkages among components of ecosystems seem to offer more adequate interpretations of the phenomenon. In this regard, Kolasa (2014) states that ecosystem boundaries should contain discernible internal processes that characterize interactions among entities.

This literature recognizes that the choice of boundaries is a pivotal element in the conceptualization of ecosystems and the scope of scientific inquiries addressing its features. Accordingly, a clear alignment between processes under analysis and definition of territorial reach becomes necessary (Post et al., 2007). Unfortunately, this is seldom the case in conceptual and empirical approaches dealing with the entrepreneurial ecosystem – and this is yet another missing piece for entrepreneurial ecosystems to escape the atheoretical status.

3. INNOVATION ECOSYSTEMS

Economic geography has long paid attention to the dynamics of innovative activity within and across territories, a topic also known as the geography of innovation. In general terms, definitions coincide with pillars of the entrepreneurial ecosystem approach in that innovation consists of regionally bounded interactions amongst firms, research institutions, and government (Doloreux, 2002). Again, this is largely attributed to the localized character of knowledge spillovers driving agglomeration of economic activity (Krugman, 1991; Jaffe et al., 1993), as well as the spatial concentration of knowledge networks (Audretsch, 1998; Ellison & Glaeser, 1997; Innocenti et al., 2020; Giuliani, 2013; Huggins & Thompson, 2013). Increasing geographical distance has negative effects on knowledge transfer and capture. This is particularly relevant *vis-à-vis* the spatial stickiness of tacit knowledge. Such conditions reinforce the need to establish network assets involving regionally available competences (Strumsky & Thill, 2013; Parry, 2018). A striking outcome of such conditions is given by the spatial fragmentation and concentration of innovative activity in a relatively small number of hotspots (Crescenzi et al., 2020; Tóth et al., 2021).

Yet, this evidence is far from deterministic. Observed trends are heterogeneous across industries and technologies, where marked variations in the geographical spread of knowledge networks occur (Ascani et al., 2020; Faggio et al., 2020; Neuländtner & Scherngell, 2020; He & Fallah, 2009). Additionally, distinct configurations of the local-level intensity of interactions among agents have been reported (Tödtling & Trippl, 2005; Markusen, 1996). As a result, clusters of productive activity often 'differ in terms of their dynamism, degree of maturity, spatial extension, and local embeddedness' (Dicken & Malmberg, 2001, p. 357).

These issues highlight that while geographical proximity plays the role of an enabler of innovation-driven linkages, it is neither a sufficient nor a necessary condition for these networks to emerge (Balland et al., 2020). A cornerstone of this argument is given by the analytical framework developed by Boschma (2005). Although geographical proximity can affect these other dimensions, cognitive, social, institutional, and organizational distances complement spatial issues in driving interactions. More recent arguments discuss the role of compatibility (or relatedness) of the local/regional productive structure in driving knowledge spillovers (Bond-Smit & McCann, 2020). This feature simultaneously connects different categories of proximity.

However, assessments dealing with agglomeration trends fall short in explaining cross-region knowledge exchanges (Carayannis et al., 2016). This aspect has taken center stage in discussions concerning the geography of innovation (although this remains relatively uncharted by the entrepreneurial ecosystems literature). Researchers have identified that achieving a balance between intra- and inter-regional collaboration is key to driving superior knowledge productivity (De Noni et al., 2017). More importantly, wider interregional networks appear to lead to better technological performance than locally embedded networks (De Noni et al.,

2018). Thus, the innovation performance of cities depends on their capabilities of establishing connections with other cities, thus forming geographical networks of inventive activity (Yao et al., 2020). From an evolutionary perspective, this also appears to be the case for economic diversification, a central feature for technology upgrading and economic resilience (Balland & Boschma, 2021).

For instance, positive impacts of commuters from neighboring regions in patenting activity have been identified for the case of Switzerland (Cristelli & Lissoni, 2020). In a similar vein, Moreno et al. (2005) found knowledge interdependencies across European regions, where spatial spillovers appeared to be constrained by national borders and within a 250km radius. This represents a much larger area than what has been proposed for entrepreneurial ecosystems, although our criticisms on such standardized territorial shape also apply.

In contrast, these territorial dynamics can also present a different direction regarding benefits arising from geographic proximity. The concept of "borrowed size" (the notion that satellite cities can tap into agglomeration benefits accruing from adjacency to economic hubs) suggests that agglomerations not only exert attraction to knowledge and resources from neighboring areas but they also disseminate these assets (Meijers and Burger, 2015). Such interplay suggests a clear evolutionary nature of the territorial spread of innovation in geographical space (Esposito, 2021). Connections become denser over time (Boschma & Frenken, 2010; Giuliani, 2013), and the constraining role of distance decreases (Ter Wal, 2013). In addition, the stage of technologies in their respective life cycles affect the territorial reach of linkages. Thus, as technologies mature, networks become widespread, altering their patterns of geographical concentration (Bloom et al., 2021).

This has led to the emergence of local innovation ecosystems with strong global connections (Crescenzi et al., 2020; WIPO, 2019), where innovative activity can be perceived as a 'glocal' phenomenon (Ghazinoory et al., 2021). This represents the complementarities between regional capabilities and external knowledge inputs (Ascani et al., 2020; Bianchi et al., 2020), where firms seek and combine valuable competences that are dispersed across territories (Frigon & Rigby, 2021). Such discussions highlight that the idea of innovation as a feature simply embedded in an undefined 'regional' scope falls short in offering a consistent picture of the complex geography of innovation. Political and administrative boundaries are inefficient in this regard. Instead, there is a clear need to incorporate network dynamics in analyzing knowledge spillover processes (Huggins & Thompson, 2015). Perhaps the most insightful contributions for this debate applied to the concept of entrepreneurial ecosystems come from the literature on Relational Economic Geography.

3.1 A Relational Economic Geography view

From a relational perspective, geographical proximity reduces network transaction costs, affecting the possibilities for organizational and technological learning (Storper, 1997). These conditions lead to economic agglomerations as an outcome of relationships and exchanges among agents. Such learning processes are associated with the spatial stickiness of knowledge (especially tacit knowledge). Still, these should not be related to local practices or assets but rather to unique interactions (Amin & Cohendet, 2004). Consequently, regions ought to be understood as socially constructed entities where agents establish connections (Maskell, 2001).

Importantly, knowledge itself is not a substantive artifact. Instead, it results from interactive processes involving co-creation, interpretation, integration, and transformation (Bathelt & Glückler, 2003). Economic resources are used or produced through relational processes involving social interactions. It is not the access *per se* to substantive resources that generate competitiveness and differentiation, but how they are *combined* in a superior manner (Bathelt & Glückler, 2005). The geography of innovation then becomes the geography of linkages that are formed to generate new products, processes, and services. Even if such elements are

spatially constrained within a district, a city, or a larger region, the territorial scope is defined by the structure of networks, not by predetermined geographical boundaries. The spatial reach of localized industrial systems rarely coincides with political boundaries (Dicken & Malmberg, 2001).

For this reason, the definition of analytical units needs to be based on different types of flows, territorial connectivity, and multiple geographical expressions, becoming impossible to choose the boundaries of interest for socioeconomic processes *a priori* (Amin, 2004). Such arguments are analogous to the functional approach used to delineate the spatial scope of natural ecosystems. Of course, in this case, we are dealing with economic actors who build and shape their own regional contexts (Bathelt & Glückler, 2003). This generates a variegated topology of actor-networks across territories (Amin, 2004). Plus, the extension of firms' geographic boundaries changes as they evolve and engage in increasingly complex networks with other firms and institutions (Dicken & Malmberg, 2001). It follows that the geography of innovation cannot be static from a temporal viewpoint (Glückler, 2007). This carries important implications for the effectiveness of using relatively fixed units (neighborhoods, cities, regions) to address the nature of the entrepreneurial and innovative activity.

4. SPATIAL FEATURES OF ENTREPRENEURIAL INNOVATION ECOSYSTEMS: CHALLENGES AND A RESEARCH AGENDA

Even if knowledge-intensive entrepreneurial activity presents highly concentrated spatial patterns, our discussion based on different strands of literature underscores that *ecosystems* do not necessarily coincide with this territorial distribution. The problem is that thinking about entrepreneurial ecosystems as fixed analytical units attached to administrative boundaries is likely to cause an inadequate analytical understanding of how entrepreneurship-oriented relationships are organized in geographical space. In turn, this has affected the quality of directions for policy, which remain largely connected to local provision of incentives, support, and infrastructure. Worse, a sense of territorial competition often emerges, leading to inefficiencies in public and private expenditures. Examples include redundant efforts to set up tech parks and incubators in adjacent locations to compose a single integrated ecosystem.

Although we must recognize that ecosystems are multiscalar in nature (national-level embeddedness, international embeddedness), clearer insights on where to draw the primary focal scale of EE are needed. This is particularly challenging considering that diversified spatial morphologies exist (just like they do for natural ecosystems). Importantly, these conditions are not static. If evolutionary trends affect the level of maturity in ecosystem linkages and outcomes (Brown & Mason, 2017; Malecki, 2018; Ratten, 2020; Godley et al., 2021), then taking spatial boundaries as fixed (as the limits of a city) will offer an inaccurate comprehension of EE territorial coverage. If we go back to biomimetics, then literature states clearly that evolutionary aspects affect boundaries in natural ecosystems (Post et al., 2007), possibly leading to mergers between adjacent structures (Bailey, 2004; Strayer et al., 2003).

For instance, as an entrepreneurial ecosystem thrives, it is common to generate agglomeration diseconomies related to prices of housing and office rentals. Yet, if contextual conditions (a leading research university, for instance) remain fixed in the area, new entrepreneurs might want to relocate to neighboring regions or cities. The reach of knowledge spillovers will then spread across the territory – as will other forms of networks, a typical 'borrowed size' mechanism associated with functional interconnectedness in socio-economic activity (Meijers & Burger, 2015). These dynamics also seem to resemble biological trends, where a shift in one subsystem can cause changes in surrounding areas (Bailey, 1985). In turn, as this stylized ecosystem evolves to become a hotbed of knowledge-intensive entrepreneurship, it is likely to attract increasing attention from key agents located in other

regions or even countries, venture capitalists, for example. These investors transfer financial resources and managerial capabilities to investees. Does it make sense to address this evolving ecosystem as solely happening in the city or neighborhood from its inception? At the same time, shall we not consider that these investors are expanding the boundaries of their ecosystem of origin? Or could we take this as the integration between ecosystems?

In addition, divergences in the configurations of entrepreneurial ecosystems in developed and developing economies have been observed in recent literature (Cao & Shi, 2021). We can expect that such differences also affect the territorial spread of ecosystems located in countries in distinct stages of development. The particularities of economic geography patterns in developing countries have been the topic of extant research. Maladies associated with rapid urbanization combined with severe institutional voids and infrastructural deficiencies have been associated with different spatial dynamics in economic activity (Fischer et al., 2018; Glaeser & Henderson, 2017; Chauvin et al., 2016; Espinoza-Benavides et al., 2021). Hence, the mere replication of initiatives to foster entrepreneurial ecosystems in these countries presumably neglects more fundamental elements that affect how linkages are distributed across territories. For example, increasing the quality of physical infrastructure dedicated to connectivity can be a more vital enabler of interactions in cities and regions than setting up an innovation habitat from scratch (Balland & Boschma, 2021; Audretsch & Belitski, 2017; Stam, 2015).

We acknowledge that these are not trivial matters to deal with. When we address economic activity, territorial aspects should be considered as a continuum of socially constructed scales so that no clear boundaries can be identified (Dicken & Malmberg, 2001). Like biological ecosystems, ecosystems of innovation and entrepreneurship are never closed systems (Ghazinoory et al., 2021). But this leads to the need to establish measures assessing the extent to which a given location is linked to other regions (domestic or foreign). The dominant feature of entrepreneurial ecosystems' maps should be relational, and geographical patterns should emerge as an outcome of that (and not act as predefined limits to linkages).

4.1 Theoretical Aspects

Defining strategies to assess the spatial patterns of entrepreneurial ecosystems is a complex task. From our perspective, two challenges stand out. First is the association between the spatial reach of linkages and the evolutionary stage of entrepreneurial and innovation ecosystems. Second is the proper degree of linkages for entrepreneurial and innovative activity. We now address each of these issues in turn.

In the literature one observes approaches dealing with connections at distinct levels: hyperlocal (incubators, innovation districts, neighborhoods, etc.), local (city-level and metropolitan areas), regional, national, and global. Again, we stress that these features cannot be disentangled from temporal evolution. EE are dynamic structures that never reach an equilibrium stage (Carayannis et al., 2016). This means that spatial features of the ecosystem change over time (Schäfer, 2021). In this regard, Brown and Mason (2017) argue that more mature ecosystems are less inward-oriented, and, as ecosystems evolve, one should expect its connections to expand territorial boundaries. A similar view can be found in Huggins et al. (2019). We believe that this issue deserves further scrutiny in order to avoid oversimplifying highly complex processes. If we make an analogy to evolutionary patterns observed in the context of Global Value Chains, successful catching-up countries often present high levels of openness in the initial stages, followed by periods of inward orientation, ultimately reaching out again to global markets with stronger sets of capabilities (in-out-in-again hypothesis proposed and tested by Lee at al., 2018). Recent evidence even suggests that embryonic entrepreneurial ecosystems can reap substantial benefits from the presence of anchor multinationals (Godley et al., 2021; Ryan et al., 2020). Although MNEs are based locally, their knowledge base is likely to be generated abroad, so incoming knowledge from overseas might

be related to the inception of ecosystems. On the other hand, mature ecosystems shall receive multinational branches for knowledge-seeking purposes. Notice that the economic events in place are fundamentally the same. Differences lie in the content and direction of knowledge flows. In turn, increasing the internationalization of firms may lead to competitive concentration around dominant firms. In this case, thriving entrepreneurial ecosystems may become mature industrial clusters. If these conditions harm the dynamics of new firm emergence, the original ecosystem may lose vibrancy and wither (a compelling case is that of Detroit, Michigan – see Glaeser, 2011). We believe further explorations on the associations between EE evolutionary stages and the types and spatiality of linkages represent a promising avenue for future research. Analytical endeavors dealing with these aspects can offer significant insights into policy. For instance, initiatives targeting the territorial scope of interactions should look like at each development stage of entrepreneurial ecosystems.

Another conceptual feature of interest concerns the connection distance (non-geographical scope) between agents within networks. Our recommendation is to take into account a conservative approach and use first-degree interactions as a cutoff point, i.e., those linkages that are directly connected to promoting entrepreneurial activity. The risk of using interactions of higher degrees is that one might rapidly run into "small world" networks (Albert & Barabási, 2002; Milgram, 1967) and conclude that entrepreneurial activity is connected worldwide. This can be a valid point in a world where economic activity is globally connected (Amin, 2004). But it offers little guidance on how entrepreneurial ecosystems can be nurtured. Think, for instance, about the pivotal role played by Stanford in shaping regional capabilities that spill over to entrepreneurial individuals and firms in the Sillicon Valley (first-degree connection). If we move upstream to investigate the networks in which Stanford researchers are embedded (second-degree connections), then we are dealing with inherently global linkages that connect the university with a vast number of institutions all over the world. If we keep on searching for further linkages, things become complex and detached from entrepreneurial events of interest.

4.2 Methodological Aspects

We recognize that our discussion leads to substantial challenges concerning data and information used for analyses dealing with the concept of entrepreneurial ecosystems. Actor-centric approaches and assessments using the information on administrative units (mostly cities and regions) have undeniably improved our understanding of the dynamics of knowledge-intensive entrepreneurship. However, for the reasons exposed earlier in this paper, they fall short in providing a proper comprehension of how EE spread across territories, thus seldom reflecting how economic events occur in geographical space (Bosker et al., 2018). As our argument goes, if the core of the entrepreneurial ecosystem is based on linkages and interactions, then relational data is key (Schäfer, 2021). According to Roundy et al. (2018, p. 8), "the functioning of an EE requires metrics that assess the characteristics of the ecosystem directly related to its complexity […] the behaviors of EEs are largely a result of the complexity of the interactions among system components." The need for methods that allow addressing interactions and knowledge flows within spatially-bounded economic systems have long been recognized as crucial in identifying proper geographical scales of innovative activity (Dicken & Malmberg, 2001).

In this case, low-hanging fruits include economic and social integration data among neighboring urban areas. This approach has been part of the mainstream of economic and human geography for some time through the assessment of commuting flows, logistics, labor market, and commercial ties (Lang et al., 2020; da Cruz et al., 2020; Moreno-Monroy et al., 2020; Nelles, 2021; Duranton, 2015). More recently, satellite images of night lights have been added as a valid methodology to identify metropolitan areas (Dingel et al., 2021). Yet, although these mechanisms have been extensively used in prior research, they fall short in offering an

in-depth view of relationships between agents and their institutional environment (biotic and abiotic elements). Knowing that a metropolitan area is functionally integrated tells us very little about the actual entrepreneurial interactions taking place. Still, these methods provide interesting insights on creative strategies to assess economic integration – rather than legal jurisdictions or administrative boundaries.

The main challenge is the scarcity of relational data attached to geographical space (Glückler, 2007). A traditional indicator of interest is patenting activity. Patents not only allow the proper identification of networks across territories (Balland & Boschma, 2021; He & Fallah, 2009), but they also represent ecosystems services, i.e., outcomes that can benefit entrepreneurial agents (Kuckertz, 2019; De Noni et al., 2018; Ács et al., 2002). This goes beyond a regionalized perspective of the ecosystem, providing elements that address locations' linkages with Global Value Chains (Lee et al., 2021). Nonetheless, we recognize some critical shortcomings in using patent data for these purposes. First, beyond sectoral heterogeneity in terms of patent propensity, startups demonstrate only marginal tendencies to file for patents (Wolf, 2013). Plus, patents represent formal connections. While deliberate flows of knowledge and resources show a significant association with regional innovation capabilities (Rondé & Hussler, 2005), the role of informal interactions cannot be neglected within the scope of entrepreneurial ecosystems (Stam, 2015; Breschi & Lissoni, 2001).

Promising avenues to overcoming these weaknesses point towards the inclusion of big data analysis drawing from different sources (Bloom et al., 2021) that allow obtaining relational information. Such data, for instance, already contain detailed information on a substantial amount of investment rounds in entrepreneurial firms. This might provide useful insights into the territorial pattern of this specific flow of assets. Since such investments are often associated with the transfer of managerial expertise (smart money), they can also be a good proxy for knowledge exchanges. The compilation of unstructured data from professional and social networks can represent another source of interest to estimate individual-level mobility and professional trajectories. Mapping of university alumni and academic spinoff activity can also be derived. Complementarily, surveys that collect primary data on entrepreneurial networks and their territorial dispersion are long overdue. Initiatives to collect entrepreneurial data (such as the Global Entrepreneurship Monitor) dedicating more attention to these matters would rapidly refine our understanding of contextual features underlying entrepreneurial events.

Inductive methods based on case studies can also supply relevant information on these matters. These include the collection of entrepreneurial narratives concerning the geographic scope of the ecosystems in which they see themselves embedded (Muñoz et al., 2020). Case studies using different data collection techniques are also necessary. From an analytical perspective, the use of Social Network Analysis – an inherently relational approach – deserves more attention from EE scholars (Walsh, 2019; Alvedalen and Boschma, 2017; Malecki, 2018). This can be especially useful if networks are plotted in maps. Even though such perspectives cannot provide generalizable knowledge on the territorial morphology of any EE, they represent the possibility of deepening our understanding of such spatial patterns. Comparative assessments can be particularly fruitful.

Ideally, all of these elements should also include a temporal perspective. Not only are ecosystem boundaries often unclear, but they suffer constant shifts as these ecosystems evolve (Galán-Muros et al., 2021; Sternberg et al., 2019). This happens due to changes in linkages among agents involved in economic activity (Rodrigues da Silva et al., 2014; Ottensmann, 1996). Hence, building a thorough understanding of the geographical spread of EE over time can help us understand how its maturity stage relates to its territorial coverage.

5. CONCLUDING REMARKS

In this guest editorial paper to the Special Issue on Knowledge-Intensive Entrepreneurship and the Dynamics of Innovation Ecosystems, we have addressed a pressing issue in analytical endeavors dealing with entrepreneurial ecosystems. Entrepreneurial dynamics is a matter of utmost interest within business studies and economic geography. Individuals and firms involved with knowledge-intensive entrepreneurship are pivotal actors in generating innovation. These economic events shape aggregate competitiveness and renewal, reducing risks for cities and regions to become locked-in declining technologies and business models (Glaeser, 2011). Nonetheless, the widespread use of entrepreneurial ecosystems without deeper theoretical underpinnings causes the risk of turning this dynamic approach into solely a buzzword without analytical meaning (Suominen et al., 2019; Oh et al., 2016).

For this reason, key authors in the field have called for more consistent definitions and measurements to advance our comprehension of this phenomenon (Kuckertz, 2019; Stam & van de Ven, 2019). Accordingly, if the literature on natural ecosystems considers the proper identification of boundaries as a key analytical element, we wonder why administrative units could provide reliable scales to assess entrepreneurial ecosystems. This becomes particularly critical considering that EE will likely change its reach over time.

This discussion carries implications for how ecosystem policy is defined and which actors should be involved in governance structures (Schäfer, 2021). Yet, we recognize that identifying the boundaries of EE cannot be deemed as an objective task. Instead, it will be contingent upon the quality and content of data used for classification - in a similar fashion to the classification of natural ecosystems (as demonstrated in Bailey, 2004). The challenge is that entrepreneurial ecosystems are moving targets and technological shifts can severely alter their spatial configurations. For instance, rapid advances in digital technologies may cause significant transformations on where and how agents interact (Cao & Shi, 2021; Esposito, 2021; Ghazinoory et al., 2021). We expect that our efforts to provide conceptual guidance on spatial patterns of EE can help researchers and policymakers better understand the geographic scope of these productive structures.

5.1. Contribution of the papers published in this special issue

In this Special Issue, we gather a variety of contributions dealing with the dynamics of interactions and knowledge flows taking place within ecosystems of innovation and entrepreneurship. Vlasova (this issue) investigates whether firms cooperating with universities and R&D organizations are more likely to be supported by the state and demonstrate higher innovation performance in Russia. Results indicate that such connections are not fully functional since these linkages do not seem to translate into higher levels of competitiveness when comparing companies to a control group – although it increases the likelihood of firms receiving access to public funds. For the Brazilian case, Schaeffer, Guerrero, and Fischer (this issue) dig deeper into qualitative aspects of such university-industry interactions to identify the existence of mutualistic dynamics in these relationships, i.e., universities not only transfer knowledge to other agents of the ecosystems in which they are embedded, but they also increase their scientific capabilities and access to crucial resources for research purposes.

Pereira et al. (this issue) address the entrepreneurial behavior of a Chinese multinational company to acquire and integrate knowledge through global expansions, thus addressing how these players can have significant effects in shaping the functional boundaries of innovation ecosystems. Siaw and Sarpong (this issue) analyze the processes through which KIE firms and incumbents co-create and co-capture value within entrepreneurial ecosystems. Their results highlight how benefits from these linkages shape the competitive capabilities of these actors, ultimately affecting the level of maturity of economic outcomes arising in these ecosystems.

Amankwah-Amoah and Adomako (this issue) use data from entrepreneurial firms in Ghana to identify that knowledge integration strategies affect firm-level ambidexterity. Yang and Han (this issue) analyze the relationship between entrepreneurial team composition and fundraising performance in knowledge-intensive firms. Together with this opening article, this collection of papers offers valuable insights to move forward in our knowledge concerning the dynamics of innovation and entrepreneurship taking place from an ecosystem perspective.

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