The dynamics of entrepreneurial ecosystems: an empirical investigation

Martina Buratti, Uwe Cantner, James A. A. Cunningham, Erik E. E. Lehmann, Matthias Menter

Angaben zur Veröffentlichung / Publication details:

Buratti, Martina, Uwe Cantner, James A. A. Cunningham, Erik E. E. Lehmann, and Matthias Menter. 2023. "The dynamics of entrepreneurial ecosystems: an empirical investigation." *R&D Management* 53 (4): 656–74. https://doi.org/10.1111/radm.12565.

R&D MANAGEMENT

The dynamics of entrepreneurial ecosystems: an empirical investigation

Martina Buratti[1], Uwe Cantner[1], James A. Cunningham[2,*], Erik E. Lehmann[3] and Matthias Menter[1]

[1]Faculty of Economics and Business Administration, Friedrich Schiller University Jena, Jena, Germany. martina.buratti@uni-jena.de, uwe.cantner@uni-jena.de matthias.menter@uni-jena.de
[2]Newcastle University Business School, Newcastle Upon Tyne, UK. james.cunningham@newcastle.ac.uk
[3]Faculty of Business and Economics, University of Augsburg, Augsburg, Germany. erik.lehmann@wiwi.uni-augsburg.de

The purpose of this paper is to examine the longitudinal dynamics within entrepreneurial ecosystems. We empirically test how entrepreneurial activities affect intrapreneurial activities within entrepreneurial ecosystems, and *vice versa*, analyzing twenty-two entrepreneurial ecosystems in Germany from 1993 to 2016. Our analyses reveal that transitions occur among entrepreneurs and intrapreneurs through the different phases of an ecosystem's lifecycle. Our findings provide empirical evidence over time on the evolutionary dynamics of entrepreneurial ecosystems, demonstrating that an increase in entrepreneurial activities leads to a decrease in intrapreneurial activities, and *vice versa*. Our study offers guidance for policymakers on how to consider fluctuating entrepreneurial and intrapreneurial activities over time and builds the basis for future empirical studies to further advance our understanding of the dynamics of entrepreneurial ecosystems.

1. Introduction

Studies of entrepreneurial ecosystems have emphasized the importance of the entrepreneurial context and how entrepreneurship and innovation influence economic growth in an organizational community (Stam, 2015). Mason and Brown (2014, p. 5) define an entrepreneurial ecosystem as a 'set of interconnected entrepreneurial actors, entrepreneurial organizations, institutions and entrepreneurial processes which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment'. Hence, the literature underlines that the primary function activity in an entrepreneurial ecosystem is entrepreneurship, representing the diffusion of previously non-commercialized knowledge and ideas (Cantner et al., 2021), that the creation of new businesses ultimately fosters a region's economy and a national economy as a whole (Liguori et al., 2019). Empirical studies have highlighted how an entrepreneurial ecosystem enables entrepreneurship and consequently innovation creation at the regional level (see Fritsch, 2013; Autio et al., 2014; Tsvetkova, 2015).

Against this burgeoning empirical focus and studies on entrepreneurial ecosystems, there is also well-established literature on agglomeration economies with constructs such as industrial districts, clusters, and regional innovation systems (Marshall, 1890; Porter, 1998; Acs et al., 2017; Brown and Mason, 2017, 2019). These theoretical concepts focus on the interactions between co-located economic actors, that is, incumbent firms disseminating and commercializing new ideas through intrapreneurship (Cantner et al., 2021). Existing studies and scholars converge on a core premise that entrepreneurial activities can lead to a diffusion of innovation through which incumbent firms are also able to benefit, thus creating a favorable economic environment (Wesseling et al., 2014; Diekhof, 2015). Considering this perspective, it is necessary to take the evolutionary dynamics of entrepreneurial ecosystems into account and examine the interdependencies that occur between entrepreneurial and intrapreneurial activities.

However, a fundamental question that still remains is how entrepreneurial ecosystems evolve over time. Despite the richness of studies on entrepreneurial ecosystems, there have been some criticisms concerning the static nature of definitions, which do not consider the dynamics of the ecosystem actors that are part of it (Spigel, 2017; Acs et al., 2018). Some studies have taken a system perspective to better understand the internal dynamics and the quality of an ecosystem (see Stam and van de Ven, 2021). Other recent studies have taken an evolutionary perspective to understand the wider evolution of entrepreneurial ecosystems and to overcome the static interpretations of entrepreneurial ecosystems (Auerswald, 2015; Mack and Mayer, 2016). The evolution of entrepreneurial ecosystems is complex and considered as a 'nonlinear chaotic process that changes over time' (Haarhaus et al., 2020, p. 1). Building on these perspectives, Cantner et al. (2021) posit a theoretical foundation of a dynamic lifecycle model that describes the phases of birth, growth, maturity, decline, and re-emergence of entrepreneurial ecosystems. However, we still lack an understanding of the evolution and underlying processes through which the ecosystems follow a dynamic lifecycle, with a clear empirical foundation that analyzes the emergence, development, and change of entrepreneurial ecosystems over time. Moreover, Wurth et al. (2022) confirm the lack of empirical analyses aimed at demonstrating how entrepreneurial ecosystems work and evolve over time and Cho et al. (2022) call for further research on entrepreneurial ecosystem evolutionary processes over time. Furthermore, Spigel and Harrison (2018) note that how entrepreneurial ecosystems are reproduced and transformed over time is still an open question. Hence, a significant deficit remains in the literature with a lack of detailed empirical analyses of the evolutionary dynamics within entrepreneurial ecosystems.

Given the lack of empirical evidence on the dynamics of an entrepreneurial ecosystem, where different actors play a fundamental role in its lifecycle and influence each other, our study analyzes these dynamics. We empirically test how entrepreneurial activities affect intrapreneurial activities within entrepreneurial ecosystems, and *vice versa*. Specifically, we empirically examine the underlying oscillation that occurs among entrepreneurs and intrapreneurs. Based on an analysis of twenty-two entrepreneurial ecosystems across Germany and considering a timeframe from 1993 to 2016, we empirically assess the lifecycle of entrepreneurial ecosystems by employing panel regression techniques.

The contributions of our study are threefold. First, we provide robust longitudinal empirical evidence on the dynamics of entrepreneurial ecosystems over time, addressing some of the core criticisms of entrepreneurial ecosystems to date. Our findings support and build on the propositions posited by Cantner et al. (2021): after an initial increase in entrepreneurial activities, a decline follows, which corresponds with an increase in the number of intrapreneurial activities. Second, our empirical models enhance our understanding of the dynamics of entrepreneurial ecosystems and provide guidance for policymakers on how to consider fluctuating entrepreneurial and intrapreneurial activities over time. Based on our analyses, policymakers might better understand the interdependencies among various actors and institutions of entrepreneurial ecosystems and may better promote a favorable entrepreneurial environment that leads to a renaissance of R&D innovations, inducing a positive economic impact both at a regional and at a country level to overcome technological, social, and societal challenges. Third, our study builds the basis for future empirical investigations aimed at explaining the flow of knowledge that is exchanged inside and outside an entrepreneurial ecosystem, and how these flows affect entrepreneurial and intrapreneurial activities.

The remainder of this paper is structured as follows. Section 2 reviews the existing literature on pioneering theories prior to entrepreneurial ecosystems, outlines evolutionary perspectives of entrepreneurial ecosystems, and derives hypotheses. Section 3 describes our data and the utilized empirical approach.Section 4 presents our main results. Section 5 discusses our findings. The final section concludes and provides future avenues of research.

2. Literature review

2.1. Pioneering theories prior to entrepreneurial ecosystems

The idea of (spatial) agglomerations has been of great interest to scholars in the economic literature for decades (Feldman, 1999; Rosenthal and Strange, 2020). To fully understand the concept of entrepreneurial ecosystems, it is necessary to distinguish ecosystems from other theoretical constructs such as industrial districts, clusters, and regional innovation systems, but also entrepreneurial milieus and entrepreneurship systems, which for years have dominated the theories of economic agglomerations with characteristics similar to each other, but with clear theoretical distinctions from the more recent concept of entrepreneurial ecosystems (Spigel and Harrison, 2018).

The concept of 'agglomeration economies' was first promoted by Marshall (1890) with an analysis of industrial concentrations in England, emphasizing the importance of the advantages obtained by firms with spatial proximity to each other and belonging to the same industrial sector. Accordingly, spatial co-location results in economic returns, namely 'the development of specialized pools of human capital, the creation of specialized suppliers and the creation of specialized infrastructures for the benefit of companies in the same sector' (Brown and Mason, 2017, p. 12). Hence, the concept of an industrial district dates back to Marshall (1890), stimulating the investigation of interactions of co-located firms. The literature following the economies of agglomeration supported the theories of Marshall (1890), in particular the importance of the competitiveness that is created within these industrial districts. The concept of agglomeration has also been studied at the regional level (see Kelley and Helper, 1999), so-called 'regional agglomerations', highlighting that localization and urbanization foster knowledge transfer between firms in the same region.

Other concepts have evolved since then, especially in the field of economic geography, with regional clusters being one of the most prominent ones. One of the first definitions of clusters can be traced back to Porter (1998, p. 78) who defines clusters as 'geographic concentrations of interconnected companies and institutions in a particular field', underlining the advantages of institutions that help companies inside these clusters, such as 'universities, standards-setting agencies, think tanks, vocational training providers, and trade associations, that provide specialized training, education, information, research, and technical support'. In empirical analyses, clusters are often analyzed from an evolutionary perspective, considering regional path dependencies that influence the entry and exit of firms, ultimately affecting how clusters can survive over time (Menzel and Fornahl, 2010; Boschma and Frenken, 2011). An important role is played by knowledge spillovers from firms to entrepreneurial actors entering the market, but also from universities and other institutional players present in clusters that enable new ventures to access the market (Henry and Pinch, 2001; Rocha and Sternberg, 2005). Clusters thus generate advantages at the local level, because the presence of many firms with similar technological patterns stimulate knowledge transfers, resulting in the formation of a specialized and skilled labor sector (Glaeser et al., 2010).

The theory of regional innovation systems received attention from policymakers and researchers from the beginning of the 1990s, to understand the dynamics of innovation processes among regional economic actors (Cooke, 2002; Doloreux and Parto, 2004). These studies are based on the notions of innovation systems and built on evolutionary theories of economic and technological changes where innovation is processed and influenced by various factors and players, both internal and external to a single firm (Dosi, 1988; Edquist, 2004). The strength of regional innovation systems is thereby not only based on the interaction between technologically similar firms but also on the knowledge exchange between technologically related firms (Doloreux and Parto, 2004). Additionally, links with external institutions, such as universities, promoting research and innovation are of importance (Cooke, 2002). Hence, the networks that are created between entrepreneurial and industrial activities, innovators, and research institutes guarantee access to resources for innovation and knowledge generation (Cooke, 2002; Spigel and Harrison, 2018).

Whereas theories of industrial districts, clusters, and regional innovation systems have mainly focused on incumbent firms, assigning entrepreneurship a minor role in agglomeration economies, almost neglecting entrepreneurial activities (Wurth et al., 2022), other precursor concepts of entrepreneurial ecosystems have emerged with a core focus on entrepreneurship taking place in localities and regions, broadening the importance of entrepreneurial activities for local economies such as entrepreneurial milieus, entrepreneurial environments, or infrastructure for entrepreneurship (Malecki, 2018). Julien (2008, p. 116) defines an entrepreneurial milieu as 'both a place and the collective mechanism that explains and facilitates various social ties, allowing a collective entrepreneurial spirit to blossom and providing the basic resources, including information and tools needed to transform it into knowledge, to meet the challenges of the new economy'. For example, Stathopoulou et al. (2004) use the concept of entrepreneurial milieus to understand the role of rural entrepreneurship, highlighting the importance of local entrepreneurship in the regional context. Entrepreneurial milieus allow access to formal and informal knowledge that ultimately affects the firm performance of new technology-based firms (Löfsten and Lindelöf, 2003). Van de Ven (1993) investigates the role of infrastructure for entrepreneurship and shows that industrial infrastructures support the development of entrepreneurship, but also that entrepreneurs can facilitate the growth of specific infrastructures together with institutions and available resources.

Besides the focus on the individual entrepreneur and the role of (formal and informal) institutions, several studies have also taken a system perspective on entrepreneurship (Qian et al., 2013; Acs et al., 2014, 2016). Concepts such as entrepreneurship systems or regional entrepreneurial systems emphasize the unique relationships and interactions of various economic entities in a region, forming a system conducive to entrepreneurial activities. Qian et al. (2013, p. 561) underline the lack of analysis on the role of entrepreneurs and start-ups in the literature relative to innovation systems, and define systems of entrepreneurship as 'those economic, social, institutional, and all other important factors that interactively influence the creation, discovery and exploitation of entrepreneurial opportunities'. Neck et al. (2004) reveal that formal and informal networks, regional culture, physical infrastructures, and the existence of incubator organizations and spin-offs are essential determinants for the creation of a dense and productive high-tech entrepreneurial system. Qian (2017) follows this line of argument and emphasizes the importance of localized specific knowledge that with institutions and regional factors can support innovation and entrepreneurship.

All the theoretical concepts described above underline the importance of agency and context, attempting to address a fundamental question about why entrepreneurial and innovation activities differ across regions and nations. The more recent conceptualization of entrepreneurial ecosystems follows a similar path, yet focuses on the complexity and non-linearity of entrepreneurship. For example, Cavallo et al. (2019, p. 1,299) state that the concept of entrepreneurial ecosystems 'is driving towards an approach to entrepreneurship that is evolutionary, socially interactive and non-linear'. Whereas existing concepts have mainly considered the elements of a system, entrepreneurial ecosystem frameworks allow an investigation of the connection between these elements and their evolution over time (Alvedalen and Boschma, 2017). Hence, the concept of entrepreneurial ecosystems considers entrepreneurship as the primary function activity (Cantner et al., 2021) with entrepreneurs being at the center of entrepreneurial ecosystems (see Auerswald and Dani, 2017) and offers a dynamic perspective on entrepreneurship.

2.2. *The evolutionary perspectives on entrepreneurial ecosystems*

The conceptualization of entrepreneurial ecosystems among scholars and their evolution over time offers a wider interpretation of actors, processes, and activities (Brown and Mason, 2017). The definitions of 'ecosystem' in the economic sphere mostly agree on the analogy with the natural perspective as a 'community of living organisms in conjunction with the non-living components of their environment, where the 'eco' part of the word is assumed to be related to the environment and 'system' implies the function as a collection of related parts that function as a unit' (Smith and Smith, 2015, p. 19). Audretsch et al. (2019, p. 316) analyze the scholarly debate regarding the definition of an ecosystem and its boundaries and affirm that these definitions are essentially metaphors that 'have been mapped on to the environmental context' and are capable of giving us an explanation of what is created in certain territories, cities, or regions, essentially representing the exchange and connection between different entrepreneurial actors and factors. The general definition of ecosystems is applied to different domains such as the digital ecosystem (Sussan and Acs, 2017; Song, 2019), the financial ecosystem (Cumming et al., 2019), the business ecosystem (Moore, 1993; Clarysse et al., 2014), the university ecosystem (Hayter, 2017; Wright et al., 2017), and the entrepreneurial ecosystem (Mason and Brown, 2014).

Mack and Mayer (2016) define the entrepreneurial activities born in a definite region together with their connection with the industrial sectors as an entrepreneurial ecosystem. Alternative definitions exist, according to which an entrepreneurial ecosystem is the agglomeration of social, political, and cultural factors that in a definite region encourage the growth of innovative and entrepreneurial activities (see Spigel, 2017; Carayannis et al., 2018). The importance of the relationships among actors inside an entrepreneurial ecosystem has also been broadly investigated by Acs et al. (2014, p. 479), who introduce and define the national system of entrepreneurship as 'the dynamic, institutionally embedded interaction between entrepreneurial attitudes, ability, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures'. Those components of an entrepreneurial ecosystem are moved by the actors concentrated in a defined territory. Mason and Brown (2014, p. 5) thus note that entrepreneurial ecosystems can be 'industry-specific or may have evolved from a single industry to include several industries. They are geographically bounded but not confined to a specific geographical scale. And they are not related to define sizes of city'. Mason and Brown (2014) also underline that entrepreneurial activities are the primary functions of entrepreneurial ecosystems that are influenced by other factors, like culture, finance, and service suppliers. But also, policy, markets, supporters, and human capital are elements that distinguish an entrepreneurial ecosystem (Isenberg, 2011; Liguori et al., 2019).

Recently, some criticisms were raised concerning the static definition of entrepreneurial ecosystems present in the literature and the lack of theoretical models concentrated around the measures of the impact of the actors on the components inside an entrepreneurial ecosystem (Alvedalen and Boschma, 2017; Spigel, 2017; Acs et al., 2018). Brown and Mason (2017, p. 26) therefore state that the necessity to capture the 'complexity of the dynamics' exists. Moreover, based on a survey among ecosystem scholars, Ritala and Gustafsson (2018) highlight the need to empirically assess the dynamics and interdependencies among the actors that are part of an entrepreneurial ecosystem. As a response to these criticisms, scholars have adopted an evolutionary perspective.

Some scholars identified the dynamics and the different steps that characterized these ecosystems over time from different points of view: the economic geography perspectives by Mack and Mayer (2016) describe phases of birth, growth, maintenance, and decline. Moreover, evolutionary biology and ecological perspectives from Auerswald and Dani (2017) as well as Autio and Levie (2017) inspired the creation of a theoretical framework for entrepreneurial ecosystems. Auerswald and Dani (2017) consider the evolution of the regional entrepreneurial ecosystem by describing a theoretical framework that investigates the biotech business dynamics in US regions with the different phases of the lifecycle. Also, Cantner et al. (2021) in their theorized model of entrepreneurial ecosystems take a dynamic perspective, basing their arguments on the theories of Vernon (1966) and his product lifecycle theory as well as Klepper (1997) with his industry lifecycle model, describing the phases of birth, growth, maturity, decline, and re-emergence of entrepreneurial ecosystems. Following the lifecycle model of Cantner et al. (2021), entrepreneurial ecosystems are born through an idea, defined as an initial 'big bang', of a single entrepreneur, who decides to commercialize an idea, but can choose whether to exploit the idea through entrepreneurship or intrapreneurship. This decision is based on the opportunity costs given by the occupational choice of being an entrepreneur or an intrapreneur (Lucas, 1978).

The creation of spin-offs can lead to sudden changes and alteration of incumbent firms (Longhi, 1999; Feldman, 2001; Fleming and Frenken, 2007). Indeed, new ideas or innovations can create a new technological regime in which existing firms may not have the intention to take part (Breschi et al., 2000), resulting in inventors opting to start a new business, hence creating a spin-off. The phase of growth of entrepreneurial ecosystems in the lifecycle model of Cantner et al. (2021) underlines that there is a positive spillover effect of entrepreneurship, and in this way, the number of new ventures increases within the regions, creating an entrepreneurship culture and stimulating further entrepreneurial activities (Stuetzer et al., 2018). The increasing heterogeneity in newly created firms stimulates economic development within the regions (Menzel and Fornahl, 2010), thus creating the basic conditions for vibrant entrepreneurial ecosystems. Considering the dynamics over time of entrepreneurial ecosystems, in the last phases of the lifecycle, some of the previously newly created firms mature, becoming more structured and less flexible, or some of them leave the market (Cantner et al., 2021). Hence, as described by Audretsch et al. (2008, p. 1), entrepreneurial activities mature and enter a phase of a routinized regime, in which innovations are for the most part incremental and where 'innovation takes place within top-performing incumbents'. Simultaneously, the number of new entries decreases, thus increasing the opportunity cost of self-employment, and pushing for a return to employed work (Lucas, 1978). This, therefore, results in a phase of decline in entrepreneurial activities and growth in intrapreneurial activities, until the advent of innovations (such as radical innovations) that allows a return to the entrepreneurial regime (Audretsch and Acs, 1990; Audretsch and Fritsch, 2002; Audretsch et al., 2008) and leads to a re-emergence of entrepreneurship (Cantner et al., 2021).

In this vein, Cantner et al. (2021, p. 410) stress the evolution of entrepreneurial ecosystems over time and emphasize the need to consider the 'oscillation that occurs among entrepreneurs and intrapreneurs'. Colombelli et al. (2019) follow this idea, describing the entrepreneurial ecosystem of Turin in Italy and assessing how the evolution of an entrepreneurial ecosystem is influenced by different governance designs, considering a dynamic lifecycle model, in which they describe the phases of birth, transition, and consolidation. In sum, the existing studies on entrepreneurial ecosystems taking a dynamic perspective are limited and have, as Stam and van de Ven (2021) outline, their main focus is on different elements of entrepreneurial ecosystems and not on their transition.

2.3. The co-existence of entrepreneurial activities and intrapreneurial activities inside an entrepreneurial ecosystem

The literature has described entrepreneurship as a conduit for knowledge spillovers, enabling innovation and contributing to economic growth (Acs et al., 2013). Entrepreneurship is at the core of entrepreneurial ecosystems, where ideas are exploited for the creation of new business opportunities (Auerswald and Dani, 2017; Cantner et al., 2021). At least since Schumpeter (1934), entrepreneurship is interpreted as a core challenge for incumbent firms, changing existing technologies and inducing disruptive innovations. However, more recently, scholars such as Iacovone et al. (2013) have argued whether the presence of new ideas based on entrepreneurial activities is in the long run not completely negative for incumbent firms. Czarnitzki et al. (2014) show that new market entrants reduce R&D intensity for an average firm, whereas incumbent leaders increase their investments in R&D as a response to new entrants. Existing studies converge on a core premise that there is a diffusion of innovation following a growth of entrepreneurial activities, from which incumbent firms might also benefit through knowledge spillovers (see Wesseling et al., 2014; Diekhof, 2015). Hence, scholars postulate that entrepreneurial activities and existing firms – with intrapreneurial activities – are both parts of an entrepreneurial ecosystem that co-exist across industries within a regional economic system (Auerswald and Dani, 2017).

The postulate of a sheer co-existence of entrepreneurship and intrapreneurship in an entrepreneurial ecosystem leaves open questions about their interrelation and resulting dynamics. Or, in other words, whether intrapreneurship and entrepreneurship are interrelated or not and change over time. This study addresses the aspect of interrelation. Based on the convincing empirical and theoretical evidence that both intrapreneurship and entrepreneurship are interrelated in the regional context, contributing to an entrepreneurial ecosystem, we abstract from theorizing that both phenomena are not interrelated at all. For instance, Mason and Brown (2014) argue and show that incumbents are talent magnets for graduates, they train their employees in (intrapreneurial) innovation activities and are a source of new businesses *via* leaving staff. They also confirm that incumbent firms provide space and resources for local start-ups, create programs to encourage start-ups, and develop companies that enhance their own ecosystems and thus contribute to the development of an entrepreneurial ecosystem. Or as Isenberg (2013) puts it, 'you simply cannot have a flourishing entrepreneurship ecosystem without large companies to cultivate it, intentionally or otherwise'.

Abstracting from the assumption that intrapreneurship and entrepreneurship appear as two independent phenomena gives rise to the question of the direction of the interrelation, that is, whether intrapreneurship and entrepreneurship are complementary or substitute elements in an entrepreneurial ecosystem. They are complementary elements, when increasing one activity, say intrapreneurship, increases the returns of the other activity, say entrepreneurship. Then, intrapreneurship and entrepreneurship are positively related activities. They are substitutes when increasing one activity, say intrapreneurship, reduces the returns of the other activity, say entrepreneurship. Then, intrapreneurship and entrepreneurship are negatively related activities. This follows directly from the concept of complementarity introduced by Milgrom and Roberts (1990, 1992) and made popular in management and business studies by Bresnahan et al. (2002) among others.

If intrapreneurship and entrepreneurship are complementary, an increase in the return of one activity increases the level of the other. In this case, entrepreneurs and intrapreneurs would neither compete on inputs or outputs nor the transformation of inputs into outputs. They would use different resources and production technologies and would serve different clients and customers. This, however, is a rather heroic assumption that would only hold when the necessary resources, like knowledge spillovers, talents, finance, and the demand for the products and services produced are non-rival (or in abundance available). Thus, we argue that intrapreneurship and entrepreneurship are substitutes, and doing (more of) one activity reduces the attractiveness of doing (more of) the other (Roberts, 2012). However, the direction and causality still remains an open question: does entrepreneurship crowd out and substitute intrapreneurship or does the opposite hold?

We posit hypothesis 1 as follows:

Hypothesis 1 Innovative entrepreneurial activities negatively affect intrapreneurial activities within entrepreneurial ecosystems.

Hypothesis 1 expresses that increasing innovative entrepreneurial activities reduces the attractiveness of intrapreneurial activities, that is, entrepreneurship substitutes intrapreneurship. There are several arguments to support this hypothesis. First, as put forward by the knowledge spillover theory of entrepreneurship, entrepreneurial firms exploit knowledge spillovers from sources like universities and research centers, in particular by academic spin-offs (see Acs et al., 2013; Qian, 2018). By absorbing the most promising and fruitful ideas, they crowd out the absorption of knowledge spillovers by incumbent firms *via* intrapreneurship (see Audretsch et al., 2021). This phenomenon is called the 'knowledge filter', where new venture creation serves as a filter mechanism in fileting out the most promising and valuable ideas (see Qian and Jung, 2017). In addition, also inventors or employees of incumbent firms may pursue their ideas through spin-offs. Either by a spin-off with the incumbent firm partnering with the new venture by offering necessary and critical support (Fabel, 2004) or more or less involuntarily when the incumbent firm is reluctant to pursue and commercialize the ideas created[1]. Thus, the proposition that innovative entrepreneurial activities may be a substitute for intrapreneurial activities and that entrepreneurship crowds out intrapreneurship is convincing.

Moreover, incumbent firms are a major source of knowledge spillovers and intrapreneurship is a key task to fulfill a company's corporate entrepreneurship strategy. Intrapreneurial activities would then negatively affect entrepreneurial activities. Absorbing the most promising ideas inside the firm reduces the knowledge that spills over and thus reduces outside entrepreneurial activities. Intrapreneurship also leads to positive externalities within the boundaries of the firm. As Antoncic and Antoncic (2011) and Gawke et al. (2017) show, intrapreneurial activities have beneficial impacts on employees such as personal resources, higher levels of work engagement, employee satisfaction, and psychological capital (see Wesseling et al., 2014; Diekhof, 2015). Given these beneficial impacts, intrapreneurs may be less inclined to leave and become an entrepreneur through founding a venture. Finally, a negative causality between intrapreneurship and entrepreneurial activities is the result of the dynamic and lifecycle effects of entrepreneurial ecosystems, as developed by Cantner et al. (2021). It is in the nature of entrepreneurship that entrepreneurial activities are risky and entrepreneurial failure is the rule and not the exception. As Mason and Brown (2014) observe, entrepreneurial ecosystems also show the dynamic feature of entrepreneurial recycling as an interplay among entrepreneurial and incumbent firms. First, failing ventures do not disappear at all, instead, they are leaving valuable resources in the ecosystem. Second, employees but also the initial entrepreneurs and founders are valuable and highly welcome inputs in incumbent firms, increasing their intrapreneurial bases. Third, surviving and successful entrepreneurs reduce the entrepreneurial activity during an ecosystem's lifecycle as they are becoming 'incumbent' firms, interested in increasing their own intrapreneurial activities.

Hence, we posit that intrapreneurship substitutes or crowds out entrepreneurship, as expressed in hypothesis 2:

Hypothesis 2 Intrapreneurial activities negatively affect innovative entrepreneurial activities within entrepreneurial ecosystems.

Summing up, this study assesses the oscillation that occurs among entrepreneurs and intrapreneurs, based on two hypotheses about the causal effects of intrapreneurial and entrepreneurial activities through the different phases of an ecosystem's lifecycle and examines how entrepreneurial ecosystems emerge and evolve.

3. Description of data and methodology

To test our hypotheses, we rely on quantitative measures and a solid dataset. The following section describes our main variables analyzed, which in turn exhibit out-of-phase oscillations in time, the signature of a periodic interchange between innovative entrepreneurial activities and intrapreneurial activities. On the one hand, our 'entrepreneurial activities' variable is characterized by the number of high-technology start-ups per year. This choice is motivated by the fact that the number of high-technology start-ups is a good explanatory variable to understand the variation of entrepreneurial activities (Fritsch, 2013). On the other hand, our 'intrapreneurial activities' variable is characterized by the number of patent applications of large incumbent firms. Patents are often utilized in studies focusing on intrapreneurial activities (see Cantner and Graf, 2010; Fritsch and Zoellner, 2020). We deliberately select patents from existing large incumbent firms to define the intrapreneurial activities variable, while patents from small and medium-sized companies as well as patents from research institutes (including universities) are used in our analyses as control variables.

Our dataset captures a timeframe from 1993 to 2016 and consists of twenty-two German ecosystems (see Appendix A). We decided to look at medium-sized cities in Germany for a key reason: after the fall of the Berlin Wall in 1989, followed by the reunification between East and West Germany, the new nation's economy has experienced impressive growth; hence, the interdependencies between entrepreneurship and intrapreneurship can be observed within a relatively short time interval. Indeed, in our analyses, we deliberately include ecosystems from both East and West Germany, whereby especially East German ecosystems are optimal for our type of study as they have restarted their economy after 1990, the reunification of Germany. Furthermore, we have chosen these particular ecosystems and corresponding cities for several reasons: all ecosystems (and cities) are comparable in terms of the number of populations (approx. 95,000 to 125,000 inhabitants), and they have similar numbers of entry and incumbent firms, so that, on the one hand, they are large enough to have a presence of entrepreneurial activities, and on the other hand they are small enough to have a defined concentrated ecosystem. Data were collected from the OECD REGPAT database, which allowed access to all the lists of patent applications from 1993 to 2016 at the regional level, relative to the German cities under analysis. The data were filtered according to the applicant's name of the patents; in this way, it was possible to know the origin of the patents. In parallel, data were collected from the Mannheim Enterprise Panel (ZEW), enabling the construction of the variable 'entrepreneurial activities'.

Figure 1 exemplary illustrates our two dependent variables ('entrepreneurial activities' and 'intrapreneurial activities') and visually supports our posited hypotheses: in the initial period from 1993, a growth of 'entrepreneurial activities' was followed by an almost constant decrease. At the same time, 'intrapreneurial activities' show a slower growth trend over time, whereby its peak in most cases corresponds to when the new business registration curve hits its minimum. A very similar trend is revealed in all 22 analyzed entrepreneurial ecosystems. Hence, the plots suggest that our two variables of interest are negatively correlated.

We employ OLS panel regressions with fixed effects to assess the lifecycle of entrepreneurial ecosystems and the interdependencies between innovative entrepreneurial activities and intrapreneurial activities. For our first panel regressions (Model I

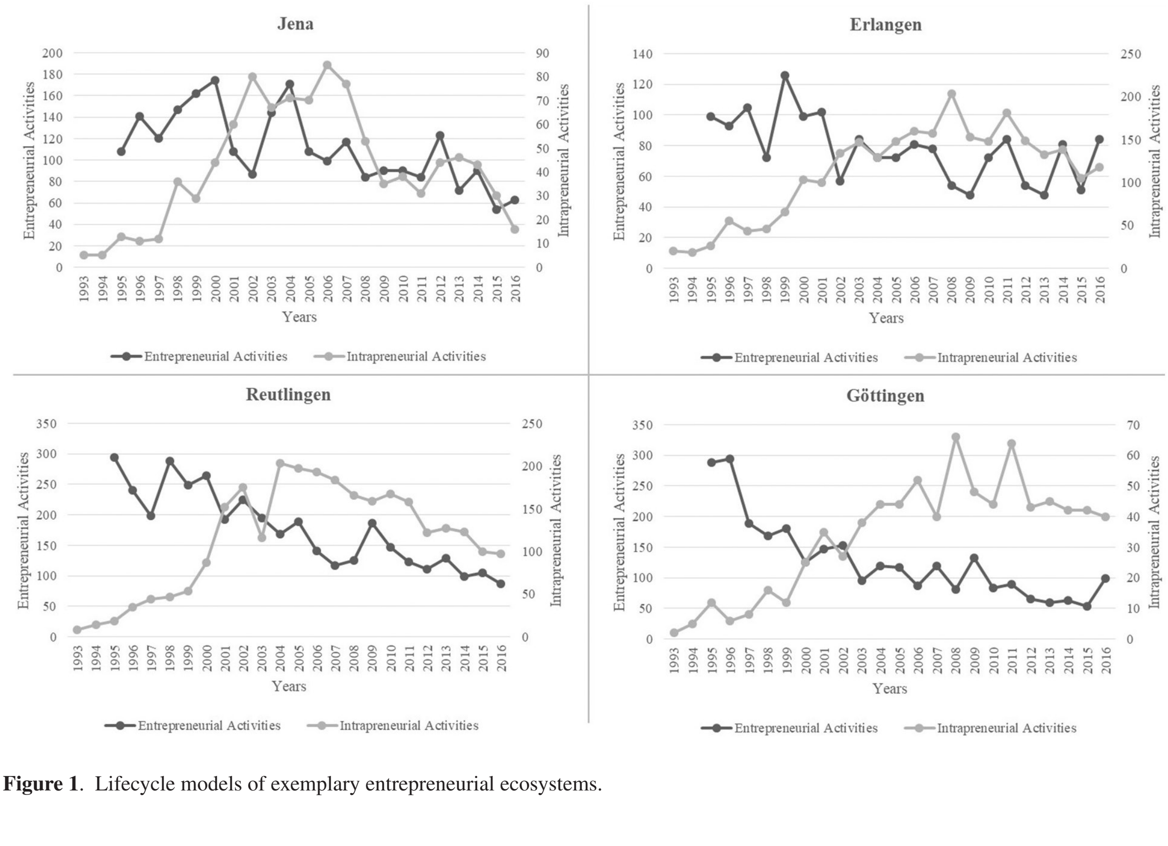


Figure 1. Lifecycle models of exemplary entrepreneurial ecosystems.

and II), we consider 'entrepreneurial activities' as the dependent variable, and 'intrapreneurial activities' as the independent variable. We add some control variables (see Appendix B and C): to observe the regional impact we consider the 'SME intrapreneurial activities' (the number of patents by small and medium-sized companies) as they are institutional actors of the entrepreneurial ecosystems, that can support the entrepreneurial activities, together with large firms and research institutes including universities (Isenberg, 2010; Mason and Brown, 2014; Stam, 2015). The relationship between entrepreneurial and intrapreneurial activities can be also influenced by other regional factors, as underlined by previous studies in the regional entrepreneurship or regional networks literatures as well as by the existing empirical analyses of entrepreneurial ecosystems (see Bosma and Sternberg, 2014; Szerb et al., 2019; Graf and Menter, 2022). To this extent, from the regional perspective, we further take into account: 'economic performance' (GDP *per capita*), 'regional density' (population density measured by the number of citizens per square kilometer of land area), and the 'scientific orientation' of a region (share of research fellows at universities divided by the regional workforce). Moreover, to control for the impact of universities and public research, we include 'intrapreneurial activities by research institutes', the 'industry orientation' (university third-party funding by industry) and the 'scientific performance' of the universities (measured by the number of scientific publications). These control variables seem to explain well models in which innovation activities and entrepreneurial activities are considered (see Cunningham and Menter, 2021; Graf and Menter, 2022), as the collaborations among firms (or start-ups) and universities dynamically spread innovation at the regional level (Baptista, 1998).

In order to assess the relationship between innovative entrepreneurial activities and intrapreneurial activities, we estimate the following model:

$$\begin{aligned} Y_{it} = {} & \beta_1\, \textit{intrapreneurial activities}_{it} \\ & + \beta_2\, \textit{SME intrapreneurial activities}_{it} \\ & + \beta_3\, \text{regional } \textit{performance}_{it} + \beta_4\, \textit{regional density}_{it} \\ & + \beta_5\, \textit{scientific orientation}_{it} \\ & + \beta_6\, \textit{intrapreneurial activities by research institutes}_{it} \\ & + \beta_7\, \textit{industry orientation}_{it} \\ & + \beta_8\, \textit{scientific performance}_{it} + \varepsilon_{it} \end{aligned}$$

where Y is the dependent variable 'entrepreneurial activities' of ecosystem i at time t, β_1 indicates our independent variable 'intrapreneurial activities', β_2, β_3, β_4, β_5, β_6, β_7 and β_8 represent the control variables of our models, ε is the error term.

Our second-panel regression approach (Model III and IV) considers 'intrapreneurial activities' as the dependent variable, and 'entrepreneurial activities' as the independent variable. Again, we add the same control variables as described above. To assess the relationship between intrapreneurial activities and innovative entrepreneurial activities, we estimate the following model:

$$\begin{aligned} Y_{it} = {} & \beta_1\, \textit{entrepreneurial activities}_{it} \\ & + \beta_2\, \textit{SME intrapreneurial activities}_{it} \\ & + \beta_3\, \text{regional } \textit{performance}_{it} + \beta_4\, \textit{regional density}_{it} \\ & + \beta_5\, \textit{scientific orientation}_{it} \\ & + \beta_6\, \textit{intrapreneurial activities by research institutes}_{it} \\ & + \beta_7\, \textit{industry orientation}_{it} \\ & + \beta_8\, \textit{scientific performance}_{it} + \varepsilon_{it} \end{aligned}$$

where Y is the dependent variable 'intrapreneurial activities' of ecosystem i at time t, β_1 indicates our independent variable 'entrepreneurial activities', β_2, β_3, β_4, β_5, β_6, β_7 and β_8 represent the control variables of our models, ε is the error term.

For assessing the robustness of our model, we employ Poisson panel regressions with fixed effects. To test the co-existence of innovative entrepreneurial activities and intrapreneurial activities within entrepreneurial ecosystems and how they affect each other, we consider first 'entrepreneurial activities' as the dependent variable and 'intrapreneurial activities' as the independent variable (Model V and VI); and then, 'intrapreneurial activities' as the dependent variable and 'entrepreneurial activities' as the independent variable (Model VII and VIII). We thereby include the same control variables as described above.

4. Results

Table 1 shows the results of our first estimation approach analyzing the impact of 'intrapreneurial activities' on 'entrepreneurial activities'. The results in Model I reveal a negative significant sign in the coefficient (β_1 = –0.370; $P<0.05$). In Model II, adding the control variables, it is noted that the coefficient maintains a negative influence (β_1 = –0.290; $P<0.1$). Moreover, the variables 'economic performance', 'scientific orientation', and 'intrapreneurial activities by research institutes' show a negative and significance impact (β_3 = –0.001; $P<0.05$, β_5 = –2.665; $P<0.05$, β_6 = –1.155; $P<0.05$); while the variable 'regional density' has a positive and significance impact (β_4 = 0.025; $P<0.05$).

Table 1. OLS panel regression approach with fixed effects

	Entrepreneurial activities		Intrapreneurial activities	
	Model I	Model II	Model III	Model IV
Ecosystem dynamics				
Intrapreneurial activities	−0.370***	−0.290***		
	(0.064)	(0.079)		
Entrepreneurial activities			−0.182***	−0.107***
			(0.032)	(0.029)
Region				
SME intrapreneurial activities		0.523		0.960***
		(0.325)		(0.193)
Economic performance		−0.001***		0.0002
		(0.0002)		(0.0001)
Regional density		0.025*		−0.003
		(0.014)		(0.009)
Scientific orientation		−2.665***		−1.723***
		(0.988)		(0.601)
University				
Intrapreneurial activities by research institutes		−1.155**		0.828**
		(0.578)		(0.351)
Industry orientation		0.0001		0.001***
		(0.0004)		(0.0003)
Scientific performance		0.001		0.010***
		(0.004)		(0.002)
N	484	447	484	447
R^2	0.067	0.184	0.067	0.308
R^2 (adj.)	0.023	0.127	0.023	0.260

This table reports the results of our fixed-effects OLS panel regression estimation approach. We rely on a sample of 22 German entrepreneurial ecosystems ranging from 1993 to 2016. The dependent variable is entrepreneurial activities measured by the number of high-tech start-ups and intrapreneurial activities measured by the number of patents from large incumbent firms, respectively. Robust standard errors are in brackets. The asterisks *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

In the second estimation approach, we use the same regression technique but interchange the dependent variable with the independent variable, that is, analyze the impact of 'entrepreneurial activities' on 'intrapreneurial activities'. Model III reveals a negative and significant sign in the coefficient (β_1 = −0.182; $P<0.01$). In Model IV, adding the control variables, it is evident that the coefficient of the independent variable maintains a negative influence (β_1 = −0.107; $P<0.01$). Moreover, the variable 'SME intrapreneurial activities' (β_2 = 0.960; $P<0.05$) shows a positive and significant influence and the variable 'scientific orientation' shows a negative and significant impact (β_5 = −1.723; $P<0.01$), 'intrapreneurial activities by research institutes' and 'industry orientation' are positive and significant (β_6 = 0.828; $P<0.01$, β_7 = 0.001; $P<0.01$), and also the variable 'scientific performance' (β_8 = 0.010; $P<0.1$) is positive and statistically significant.

Our alternative estimation approach (Poisson panel regressions) confirms all our results (see Appendix D). Hence, our results support our two hypotheses: the existence of intrapreneurial activities seems to negatively affect innovative entrepreneurial activities and the existence of innovative entrepreneurial activities seems to negatively affect intrapreneurial activities within entrepreneurial ecosystems. We thus claim that entrepreneurship and intrapreneurship are different parts that coexist and affect each other within an entrepreneurial ecosystem.

5. Discussion

The purpose of this paper is to examine the longitudinal dynamics within entrepreneurial ecosystems responding to calls such as Stam and van de Ven (2021, p. 829) who posit that 'future research should study entrepreneurial ecosystems over a longer period of time'. In this study, we investigate the impact of entrepreneurial activities on intrapreneurial activities, and *vice versa*. Hence, we investigate the oscillation that occurs among entrepreneurs and intrapreneurs over time within an entrepreneurial ecosystem. Taking a dynamic approach, our study thereby addresses one of the core criticisms concerning the static definition of entrepreneurial ecosystems posited in the literature (see Alvedalen and Boschma, 2017; Spigel, 2017; Acs et al., 2018).

Existing studies that have taken an evolutionary perspective have mainly used qualitative research designs with a case-based approach using data collection approaches such as semi-structured interviews or archive data (see Neck et al., 2004; Mack and Mayer, 2016; Radinger-Peer et al., 2018; Colombelli et al., 2019) with Auerswald and Dani (2017) using descriptive statistics. This is further affirmed by Cho et al.'s (2022) systematic literature review on evolutionary entrepreneurial ecosystems emphasizing the need for future studies to use extended time frames. We directly address this call and provide the first empirical evidence from an evolutionary perspective of the dynamics of entrepreneurial ecosystems over time. Our analyses reveal the interplay between entrepreneurship and intrapreneurship. We observe a negative impact of entrepreneurial activities on intrapreneurial activities, and *vice versa*; hence a trade-off between entrepreneurship and intrapreneurship exists.

Our results empirically demonstrate that the lifecycle of an entrepreneurial ecosystem is characterized by different phases (Cantner et al., 2021), in which entrepreneurship and intrapreneurship, influenced by the actors present in the ecosystem, substitute each other. To this extent, an initial growth of high-technological entrepreneurial activities, in which entrepreneurship drives the ecosystem, is followed by a phase of maturation and a routinized regime where the same start-ups have grown and have evolved into large incumbent firms or have exited the market (Audretsch and Acs, 1990). Thus, existing firms take over, with intrapreneurship driving the ecosystem. This dynamic creates a kind of balance in the ecosystem that allows it to keep alive. Indeed, the oscillation between entrepreneurship and intrapreneurship enables and ensures the efficiency of the entrepreneurial ecosystem in the regional context, as new ideas can be exploited by both entrepreneurs and intrapreneurs (Cantner et al., 2021). Our results further confirm that entrepreneurship favors regional development and economic growth (Audretsch et al., 2006), with new high-technological start-ups and spin-offs representing the foundation for the establishment of an entrepreneurial ecosystem within a region. We empirically advance Cantner et al.'s (2021) theoretical propositions about the transitions that occur between entrepreneurship and intrapreneurship within entrepreneurial ecosystems along their lifecycle; but also, how different configurations of actors inside an entrepreneurial ecosystem can lead to different outcomes (Wurth et al., 2022).

Furthermore, our dynamic lifecycle model highlights how an entrepreneurial environment can foster innovation. And *vice versa*, how a favorable environment of innovation can transfer business opportunities into economic growth (Audretsch and Link, 2018). We advance Colombelli et al.'s (2019) study by taking an evolutionary dynamics perspective of entrepreneurial ecosystems and demonstrate how the interaction between agents and institutions constitutes the basis for creating a favorable entrepreneurial ecosystem, and how the presence of established firms at the local level is encouraging the development of a flourishing entrepreneurial ecosystem. As high-technology start-ups are gaining more and more attention since the birth of Silicon Valley, both in research and policymaker communities, we show that they play a crucial role within entrepreneurial ecosystems by empirically witnessing the transition from innovative entrepreneurial activities toward intrapreneurial activities, and *vice versa*. This is in line with the finding that high-technology start-ups create knowledge networks, which include alliances that tend to have a resonance with incumbent firms (Clarysse et al., 2014).

6. Conclusion

Our study is not without limitations. Our variable 'entrepreneurial activities' operationalized by the number of high-technology start-ups per year only captures a specific type of newly created ventures, that is, knowledge-intensive ventures. We yet appreciate that this is only one measure of entrepreneurial activities. Our variable 'intrapreneurial activities' also does not differentiate the various types of incumbent firms (average firms vs. incumbent leaders) and this is an issue that future empirical studies could address. Third, our model is contextualized over a study of German ecosystems but should be extended with entrepreneurial ecosystems of other countries – developed and less developed economies.

The empirical evidence of the dynamics of entrepreneurial ecosystems based on our study raises some important implications for policymakers. First, our study provides longitudinal evidence of how regions evolve and grow concerning entrepreneurship and intrapreneurship. Such evidence provides policymakers with a means to consider the evolution and dynamics of their entrepreneurial ecosystems taking a wider scope that complements as well as challenges the existing contextual policy assumptions. Moreover, it enables policymakers to consider both entrepreneurship and intrapreneurship together rather than in isolation given their important contributions to contextual/place-based vibrancy and economic growth. Our evidence and approach can be used by policymakers to contribute to more effective place- and evidence-based policy planning that takes into account contextual factors and considerations. For mid-sized cities and for regions this can support policy-making to address immediate technological, social, and societal challenges and provide further foresight to effectively plan for future anticipated entrepreneurial ecosystem challenges, complexity, and chaos.

Second, insights from our dynamic lifecycle model can enable policymakers to provide timely and appropriate policy interventions to ensure ecosystem growth, vibrancy, and resilience (Roundy et al., 2017). Indeed, the transition between entrepreneurship and intrapreneurship fuels the vitality of the entrepreneurial ecosystems. Policymakers may thus better understand that promoting a favorable environment for entrepreneurship may generate a vibrant entrepreneurial environment that, considering its evolution over time, may also foster the development of a promising intrapreneurial environment. To this extent, understanding the phases of the ecosystem's lifecycle can be helpful to construct specific policies oriented toward entrepreneurship and intrapreneurship. The transition period from entrepreneurship- to intrapreneurship-based entrepreneurial ecosystems may thereby create specific policy challenges for all actors, being additionally chaotic and having an impact on the resilience of ecosystem elements (Stam and van de Ven, 2021).

Third, given that entrepreneurial opportunities and innovation capital appear to be the key to creating a vibrant ecosystem (Cantner et al., 2021), fostering and promoting those characteristics can allow policymakers to implement appropriate policy measures and tools that support the prosperity of entrepreneurial ecosystems. Consequently, for policymakers having a clear sense of where each ecosystem is in its evolution allows for more tailored place-based policy instruments that are designed to address the specific needs of entrepreneurs and firms that are engaged in intrapreneurial activities. For the transition phases within and across regions, evolutionary approaches mean that policymakers have evidence-based insights to enact policy instruments that deal with and mitigate against contextual trade-offs that arise from the evolution of entrepreneurial ecosystems and therein the oscillation between entrepreneurial and innovation activities and the potential harms that can be accrued to society or individual entrepreneurial ecosystems (Elert and Stenkula, 2022).

Finally, with this study, policymakers can address specific directions on how to favor incumbent firms and therefore the consequent regional economic development, helping the development of entrepreneurial activities in a particular area; indeed, our analyses suggest how small and medium entrepreneurial ecosystems emerge and develop over time, considering the oscillation between entrepreneurial and intrapreneurial activities. There is a need to invest in building data for specific regional contexts from multiple sources that enable policymakers to undertake necessary analyses and evidence-based decision-making. Without such resources, more institutional voids are created that could trigger unintended negative consequences (see Cunningham et al., 2019, 2021).

We hope that our study will motivate other researchers to explore the evolution of ecosystems, addressing existing calls within the literature. As we have acknowledged in our limitations, there is a need to add more variables concerning entrepreneurial ecosystems, appreciating the multifacetedness of ventures and businesses, and also taking into consideration ecosystems with different sizes and structures. New and innovative methodological approaches and data should be embraced as suggested by Wurth et al. (2022) and Cho et al. (2022) that further this evolutionary perspective of entrepreneurial ecosystems. In particular, future studies might investigate the oscillation and the transition periods that occur among entrepreneurial and intrapreneurial activities at the level of technology classes, in accordance with Schmoch's (2008) industry classification. During transition periods, researchers should explore the elements of entrepreneurial ecosystems to better understand how they reconfigure and adapt to a new co-existent relationship post this period. Furthermore, the interconnectedness of ecosystems, particularly during the transition phase, needs further research attention. Building on such foci, further empirical studies are warranted to investigate the trigger event(s) and the wider antecedent contextual conditions that prevail ahead of oscillation periods. We need a broader understanding of the adaption that occurs among actors during such trigger and transitional periods. This also implies further examinations of the impact of policy interventions on entrepreneurial ecosystems. As discussed in the previous sections, taking an entrepreneurial ecosystem perspective has some distinct advantages as it enables policymakers to fully focus on entrepreneurial and intrapreneurial activities and design more tailored place-based policy instruments, addressing specific local needs inside the entrepreneurial ecosystem. Finally, we hope that our study motivates micro-level examinations of various actors of entrepreneurial ecosystems and how they evolve over time to support both entrepreneurship and intrapreneurship.

Acknowledgments

We want to thank the participants of the R&D Management Conference 2021 for their valuable feedback that has helped us in strengthening our line of argument and the overall quality of our paper. The authors wish to acknowledge and thank the Special Issue editors and three anonymous reviewers for their constructive feedback that has shaped this paper.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Acs, Z.J., Audretsch, D.B., and Lehmann, E.E. (2013) The knowledge spillover theory of entrepreneurship. *Small Business Economics*, **41**, 4, 757–774.

Acs, Z.J., Audretsch, D.B., Lehmann, E.E., and Licht, G. (2016) National systems of entrepreneurship. *Small Business Economics*, **4**, 46, 527–535.

Acs, Z.J., Autio, E., and Szerb, L. (2014) National systems of entrepreneurship: measurement issues and policy implications. *Research Policy*, **43**, 3, 449–476.

Acs, Z.J., Estrin, S., Mickiewicz, T., and Szerb, L. (2018) Entrepreneurship, institutional economics, and economic growth: an ecosystem perspective. *Small Business Economics*, **51**, 2, 501–514.

Acs, Z.J., Stam, E., Audretsch, D.B., and O'Connor, A. (2017) The lineages of the entrepreneurial ecosystem approach. *Small Business Economics*, **49**, 1, 1–10.

Alvedalen, J. and Boschma, R. (2017) A critical review of entrepreneurial ecosystems research: towards a future research agenda. *European Planning Studies*, **25**, 6, 887–903.

Antoncic, J.A. and Antoncic, B. (2011) Employee satisfaction, intrapreneurship and firm growth: a model. *Industrial Management & Data Systems*, **111**, 4, 589–607.

Audretsch, D.B. and Acs, Z.J. (1990) The entrepreneurial regime, learning, and industry turbulence. *Small Business Economics*, **2**, 2, 119–128.

Audretsch, D.B., Cunningham, J.A., Kuratko, D.F., Lehmann, E.E., and Menter, M. (2019) Entrepreneurial ecosystems: economic, technological, and societal impacts. *The Journal of Technology Transfer*, **44**, 2, 313–325.

Audretsch, D. B., Falck, O., Feldman, M. P., and Heblich, S., 2008. The lifecycle of regions. SSRN 1141662.

Audretsch, D.B. and Fritsch, M. (2002) Growth regimes over time and space. *Regional Studies*, **36**, 2, 113–124.

Audretsch, D.B., Keilbach, M.C., and Lehmann, E.E. (2006) *Entrepreneurship and Economic Growth*. Oxford: Oxford University Press.

Audretsch, D.B., Lehmann, E.E., Menter, M., and Wirsching, K. (2021) Intrapreneurship and absorptive capacities: the dynamic effect of labor mobility. *Technovation*, **99**, 102129.

Audretsch, D.B. and Link, A.N. (2018) Innovation capital. *The Journal of Technology Transfer*, **43**, 6, 1760–1767.

Auerswald, P.E. (2015) Enabling entrepreneurial ecosystems: insights from ecology to inform effective entrepreneurship policy. Kauffman Foundation Research Series on city, metro, and regional entrepreneurship.

Auerswald, P.E. and Dani, L. (2017) The adaptive life cycle of entrepreneurial ecosystems: the biotechnology cluster. *Small Business Economics*, **49**, 1, 97–117.

Autio, E., Kenny, M., Mustar, P., Siegel, D., and Wright, M. (2014) Entrepreneurial innovation: the importance of context. *Research Policy*, **43**, 7, 1097–1108.

Autio, E. and Levie, J. (2017) Management of entrepreneurial ecosystems. In: Ahmetoglu, G., Chamorro-Premuzic, T., Klinger, B., and Karcisky, T. (eds), *The Wiley Handbook of Entrepreneurship*. Hoboken, NJ: Wiley-Blackwell.

Baptista, R. (1998) Clusters, innovation and growth: a survey of the literature. In: Swann, G.M.P., Prevezer, M., and Stout, D. (eds), *The Dynamics of Industrial Clusters: International Comparisons in Computing and Biotechnology*. Oxford: Oxford University Press. pp. 13–51.

Boschma, R. and Frenken, K. (2011) The emerging empirics of evolutionary economic geography. *Journal of Economic Geography*, **11**, 2, 295–307.

Bosma, N. and Sternberg, R. (2014) Entrepreneurship as an urban event? Empirical evidence from European cities. *Regional Studies*, **48**, 6, 1016–1033.

Breschi, S., Malerba, F., and Orsenigo, L. (2000) Technological regimes and Schumpeterian patterns of innovation. *The Economic Journal*, **110**, 463, 388–410.

Bresnahan, T., Brynjolfsson, E., and Hitt, L.M. (2002) Information technology, workplace organization and the demand for skilled labor: firm-level evidence. *Quarterly Journal of Economics*, **117**, 1, 339–376.

Brown, R. and Mason, C. (2017) Looking inside the spiky bits: a critical review and conceptualization of entrepreneurial ecosystems. *Small Business Economics*, **49**, 1, 11–30.

Brown, R. and Mason, S. (2019) Entrepreneurial ecosystems and public policy in action: a critique of the latest industrial policy blockbuster. *Cambridge Journal of Regions, Economy and Society*, **12**, 3, 347–368.

Cantner, U., Cunningham, J.A., Lehmann, E.E., and Menter, M. (2021) Entrepreneurial ecosystems: a dynamic lifecycle model. *Small Business Economics*, **57**, 1, 407–423.

Cantner, U. and Graf, H. (2010) Growth, development and structural change of innovator networks – the case of Jena. In: Boschma, R. and Martin, R. (eds), *The Handbook of Evolutionary Economic Geography*. Cheltenham, UK: Edward Elgar Publishing.

Carayannis, E.G., Grigoroudis, E., Campbell, D.F., Meissner, D., and Stamati, D. (2018) The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as quadruple/quintuple helix innovation models. *R&D Management*, **48**, 1, 148–162.

Cavallo, A., Ghezzi, A., and Balocco, R. (2019) Entrepreneurial ecosystem research: present debates and future directions. *International Entrepreneurship and Management Journal*, **15**, 4, 1291–1321.

Cho, D.S., Ryan, P., and Buciuni, G. (2022) Evolutionary entrepreneurial ecosystems: a research pathway. *Small Business Economics*, **58**, 4, 1865–1883.

Clarysse, B., Wright, M., Bruneel, J., and Mahajan, A. (2014) Creating value in ecosystems: crossing the chasm between knowledge and business ecosystems. *Research Policy*, **43**, 7, 1164–1176.

Colombelli, A., Paolucci, E., and Ughetto, E. (2019) Hierarchical and relational governance and the life cycle of entrepreneurial ecosystems. *Small Business Economics*, **52**, 505–521.

Cooke, P. (2002) Regional innovation systems: general findings and some new evidence from biotechnology clusters. *The Journal of Technology Transfer*, **27**, 133–145.

Cumming, D., Werth, J.C., and Zhang, Y. (2019) Governance in entrepreneurial ecosystems: venture capitalists vs. technology parks. *Small Business Economics*, **52**, 2, 455–484.

Cunningham, J.A., Lehmann, E.E., Menter, M., and Seitz, N. (2019) The impact of university focused technology transfer policies on regional innovation and entrepreneurship. *The Journal of Technology Transfer*, **44**, 5, 1451–1475.

Cunningham, J.A., Lehmann, E.E., Menter, M., and Seitz, N. (2021) Regional innovation, entrepreneurship and the reform of the Professor's privilege in Germany. In: Guerrero, M. and Urbano, D. (eds), *Technology Transfer and Entrepreneurial Innovations*. Cham: Springer. pp. 175–205.

Cunningham, J.A. and Menter, M. (2021) Transformative change in higher education: entrepreneurial universities and high-technology entrepreneurship. *Industry and Innovation*, **28**, 3, 343–364.

Czarnitzki, D., Etro, F., and Kraft, K. (2014) Endogenous market structures and innovation by leaders: an empirical test. *Economica*, **81**, 321, 117–139.

Diekhof, J. (2015) Do entrants increase incumbents' innovation activity? Escaping the lock-in, stimulating technological change and the transition towards environmentally friendly vehicles. *Journal of Innovation Economics & Management*, **1**, 1, 101–137.

Doloreux, D. and Parto, S. (2004) Regional innovation systems: a critical review. *Maastricht, Merit*, **190**, 1, 1–26.

Dosi, G. (1988) Institutions and markets in a dynamic world. *The Manchester School*, **56**, 2, 119–146.

Edquist, C. (2004) Systems of innovation – a critical review of the state of the art. In: Fagerberg, J., Mowery, D., and Nelson, R. (eds), *Handbook of Innovation*. Oxford: Oxford University Press. pp. 181–208.

Elert, N. and Stenkula, M. (2022) Intrapreneurship: productive and non-productive. *Entrepreneurship Theory and Practice*, **46**(5), 1423–1439.

Fabel, O. (2004) Spinoffs of entrepreneurial firms: an O-ring approach. *Journal of Institutional and Theoretical Economics*, **160**, 3, 416–438.

Feldman, M.P. (1999) The new economics of innovation, spillovers and agglomeration: a review of empirical studies. *Economics of Innovation and New Technology*, **8**, 1–2, 5–25.

Feldman, M.P. (2001) The entrepreneurial event revisited: firm formation in a regional context. *Industrial and Corporate Change*, **10**, 861–891.

Fleming, L. and Frenken, K. (2007) The evolution of inventor networks in the Silicon Valley and Boston regions. *Advances in Complex Systems*, **10**, 1, 53–71.

Fritsch, M. (2013) New business formation and regional development – a survey and assessment of the evidence. *Foundations and Trends in Entrepreneurship*, **9**, 3, 249–364.

Fritsch, M. and Zoellner, M. (2020) The fluidity of inventor networks. *The Journal of Technology Transfer*, **45**, 4, 1063–1087.

Gawke, J.C., Gorgievski, M.J., and Bakker, A.B. (2017) Employee intrapreneurship and work engagement: a latent change score approach. *Journal of Vocational Behavior*, **100**, 88–100.

Glaeser, E.L., Kerr, W.R., and Ponzetto, G.A.M. (2010) Clusters of entrepreneurship. *Journal of Urban Economics*, **67**, 1, 150–168.

Graf, H. and Menter, M. (2022) Public research and the quality of inventions: the role and impact of entrepreneurial universities and regional network embeddedness. *Small Business Economics*, **58**, 1187–1204.

Haarhaus, T., Strunk, G., and Liening, A. (2020) Assessing the complex dynamics of entrepreneurial ecosystems: a nonstationary approach. *Journal of Business Venturing Insights*, **14**, e00194.

Hayter, C.S. (2017) A trajectory of early-stage spinoff success: the role of knowledge integration within an entrepreneurial university ecosystem. *Small Business Economics*, **47**, 3, 633–656.

Henry, N. and Pinch, S. (2001) Neo-Marshallian nodes, institutional thickness, and Britain's "motor Sport Valley:" thick or thin? *Environment and Planning A*, **33**, 1169–1183.

Iacovone, L., Rauch, F., and Winters, L.A. (2013) Trade as an engine of creative destruction: Mexican experience with Chinese competition. *Journal of International Economics*, **89**, 2, 379–392.

Isenberg, D. (2010) How to start an entrepreneurial revolution. *Harvard Business Review*, **88**, 40–50.

Isenberg, D. (2011) The entrepreneurship ecosystem strategy as a new paradigm for economic policy: principles for cultivating entrepreneurship. *Presentation at the Institute of International and European Affairs*, **1**, 781, 1–13.

Isenberg, D. (2013) When big companies fall, entrepreneurship rises. *Harvard Business Review*. Retrieved from https://hbr.org/2013/03/when-big-companies-fall-entrep.

Julien, P.A. (2008) *A Theory of Local Entrepreneurship in the Knowledge Economy*. Cheltenham: Edward Elgar Publishing.

Kelley, M.R. and Helper, S. (1999) Firm size and capabilities, regional agglomeration, and the adoption of new technology. *Economics of Innovation and New Technology*, **8**, 1–2, 79–103.

Klepper, S. (1997) Industry life cycles. *Industrial and Corporate Change*, **6**, 1, 145–182.

Liguori, E., Bendickson, J., Solomon, S., and McDowell, W.C. (2019) Development of a multi-dimensional measure for assessing entrepreneurial ecosystems. *Entrepreneurship & Regional Development*, **31**, 1–2, 7–21.

Löfsten, H. and Lindelöf, P. (2003) Determinants for an entrepreneurial milieu: science parks and business policy in growing firms. *Technovation*, **23**, 1, 51–64.

Longhi, C. (1999) Networks, collective learning and technology development in innovative high technology regions: the case of Sophia Antipolis. *Regional Studies*, **33**, 333–342.

Lucas, R.E. (1978) On the size distribution of business firms. *The Bell Journal of Economics*, **9**, 2, 508–523.

Mack, E. and Mayer, H. (2016) The evolutionary dynamics of entrepreneurial ecosystems. *Urban Studies*, **53**, 10, 2118–2133.

Malecki, E.J. (2018) Entrepreneurship and entrepreneurial ecosystems. *Geography Compass*, **12**, 3, e12359.

Marshall, A. (1890) *Principles of Economics*. London: Macmillan.

Mason, C. and Brown, R. (2014) Entrepreneurial ecosystems and growth oriented entrepreneurship. *Paris: Final Report to OECD*, **30**, 1, 77–102.

Menzel, M.P. and Fornahl, D. (2010) Cluster life cycles – dimensions and rationales of cluster evolution. *Industrial and Corporate Change*, **19**, 1, 205–238.

Milgrom, P. and Roberts, J. (1990) The economics of modern manufacturing: technology, strategy, and organization. *American Economic Review*, **80**, 511–528.

Milgrom, P. and Roberts, J. (1992) *Economics, Organization, and Management*. Englewood Cliffs, NJ: Prentice Hall.

Moore, J.F. (1993) Predators and prey: a new ecology of competition. *Harvard Business Review*, **71**, 3, 75–86.

Neck, H.M., Meyer, G.D., Cohen, B., and Corbett, A.C. (2004) An entrepreneurial system view of new venture creation. *Journal of Small Business Management*, **42**, 2, 190–208.

Porter, M.E. (1998) Clusters and the new economics of competitiveness. *Harvard Business Review*, **76**, 6, 77–90.

Qian, H. (2017) Knowledge base differentiation in urban systems of innovation and entrepreneurship. *Urban Studies*, **54**, 7, 1655–1672.

Qian, H. (2018) Knowledge-based regional economic development: a synthetic review of knowledge spillovers, entrepreneurship, and entrepreneurial ecosystems. *Economic Development Quarterly*, **32**, 2, 163–176.

Qian, H., Acs, Z.J., and Stough, R.R. (2013) Regional systems of entrepreneurship: the nexus of human capital, knowledge and new firm formation. *Journal of Economic Geography*, **13**, 4, 559–587.

Qian, H. and Jung, H. (2017) Solving the knowledge filter puzzle: absorptive capacity, entrepreneurship and regional development. *Small Business Economics*, **48**, 1, 99–114.

Radinger-Peer, V., Sedlacek, S., and Goldstein, H. (2018) The path-dependent evolution of the entrepreneurial ecosystem (EE)–dynamics and region-specific assets of the case of Vienna (Austria). *European Planning Studies*, **26**, 8, 1499–1518.

Ritala, P. and Gustafsson, R. (2018) Q&a. innovation and entrepreneurial ecosystem research: where are we now and how do we move forward. *Technology Innovation Management Review*, **8**, 7, 52–57.

Roberts, J. (2012) *The Modern Firm*. Oxford: Oxford University Press.

Rocha, H.O. and Sternberg, R. (2005) Entrepreneurship: the role of clusters theoretical perspectives and empirical evidence from Germany. *Small Business Economics*, **24**, 3, 267–292.

Rosenthal, S.S. and Strange, W.C. (2020) How close is close? The spatial reach of agglomeration economies. *Journal of Economic Perspectives*, **34**, 3, 27–49.

Roundy, P.T., Brockman, B.K., and Bradshaw, M. (2017) The resilience of entrepreneurial ecosystems. *Journal of Business Venturing Insights*, **8**, 99–104.

Schmoch, U. (2008) *Concept of a Technology Classification for Country Comparisons*. Geneva: Final Report to the World Intellectual Property Organisation (WIPO).

Schumpeter, J.A. (1934) *The Theory of Economic Development*. Cambridge, MA: Cambridge University Press.

Smith, T.M. and Smith, R.L. (2015) *Elements of Ecology*. Essex: Pearson Publishers.

Song, A.K. (2019) The digital entrepreneurial ecosystem – a critique and reconfiguration. *Small Business Economics*, **53**, 3, 569–590.

Spigel, B. (2017) The relational organization of entrepreneurial ecosystems. *Entrepreneurship Theory and Practice*, **41**, 1, 49–72.

Spigel, B. and Harrison, R. (2018) Toward a process theory of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal*, **12**, 1, 151–168.

Stam, E. (2015) Entrepreneurial ecosystems and regional policy: a sympathetic critique. *European Planning Studies*, **23**, 9, 1759–1769.

Stam, E. and van de Ven, A. (2021) Entrepreneurial ecosystem elements. *Small Business Economics*, **56**, 809–832.

Stathopoulou, S., Psaltopoulos, D., and Skuras, D. (2004) Rural entrepreneurship in Europe: a research framework and agenda. *International Journal of Entrepreneurial Behavior & Research*, **10**, 6, 404–425.

Stuetzer, M., Audretsch, D.B., Obschonka, M., Gosling, S.D., Rentfrow, P.J., and Potter, J. (2018) Entrepreneurship culture, knowledge spillovers and the growth of regions. *Regional Studies*, **52**, 5, 608–618.

Sussan, F. and Acs, Z.J. (2017) The digital entrepreneurial ecosystem. *Small Business Economics*, **49**, 1, 55–73.

Szerb, L., Lafuente, E., Horváth, K., and Páger, B. (2019) The relevance of quantity and quality entrepreneurship for regional performance: the moderating role of the entrepreneurial ecosystem. *Regional Studies*, **53**, 9, 1308–1320.

Tsvetkova, A. (2015) Innovation, entrepreneurship, and metropolitan economic performance: empirical test of recent theoretical propositions. *Economic Development Quarterly*, **29**, 4, 299–316.

Van de Ven, H. (1993) The development of an infrastructure for entrepreneurship. *Journal of Business Venturing*, **8**, 3, 211–230.

Vernon, R. (1966) International investment and international trade in the product life cycle. *Quarterly Journal of Economics*, **80**, 2, 190–207.

Wesseling, J.H., Faber, J., and Hekkert, M.P. (2014) How competitive forces sustain electric vehicle development. *Technological Forecasting and Social Change*, **81**, 154–164.

Wright, M., Siegel, D.S., and Mustar, P. (2017) An emerging ecosystem for student start-ups. *The Journal of Technology Transfer*, **42**, 4, 909–922.

Wurth, B., Stam, E., and Spigel, B. (2022) Toward an entrepreneurial ecosystem research program. *Entrepreneurship Theory and Practice*, **46**, 3, 729–778.

Note

[1]Examples are the case of the traitorous eight leaving Shockley Semiconductors in 1957 and founding Fairchild Semiconductors, or the five engineers leaving IBM in 1972 to found SAP, the largest non-American software company by revenue.

Martina Buratti is a doctoral student at the Chair of Business Dynamics, Innovation and Economic Change at Friedrich Schiller University Jena. She has a double master's degree in Economics awarded in 2021, with specialization area in Economics of Innovation, at the University of Insubria Varese, Italy and at Friedrich Schiller University, Jena. Her research interests are focused on entrepreneurial ecosystems and their dynamics, with a particular focus on how the flow of knowledge between and within them changes.

Uwe Cantner is full professor of Economics at Friedrich Schiller University Jena, Professor of Economics at the University of Southern Denmark/Odense, Vice President for Young Researchers and Diversity Management at FSU Jena, Chairman of the Commission of Experts for Research and Innovation (EFI: *Expertenkommission Forschung und Innovation*) at the Federal German Government and Spokesman of the DFG-GRK 1411 – The Economics of Innovative Change. His main fields of interest are economics of innovation, evolutionary economics, industrial economics, productivity: theory and measurement and public economics, public finance. His research has been published in leading international journals such as *Research Policy, Industrial and Corporate Change, Regional Studies, Small Business Economics, Technovation*, *Journal of Technology Transfer* among others.

James A. Cunningham is professor of Entrepreneurship and Innovation at Newcastle University Business School, Newcastle University. His research intersects the fields of entrepreneurship, innovation and strategic management. His research focuses on strategy issues with respect to scientists as principal investigators, university technology transfer commercialization, academic, public sector and technology entrepreneurship, entrepreneurial universities and business failure. He has papers published in leading international journals such as *Research Policy, Long Range Planning, Journal of Small Business Management, Industrial Marketing Management Journal of Technology Transfer, Small Business Econonmics, Journal of Business Research, Studies in Higher Education* among others.

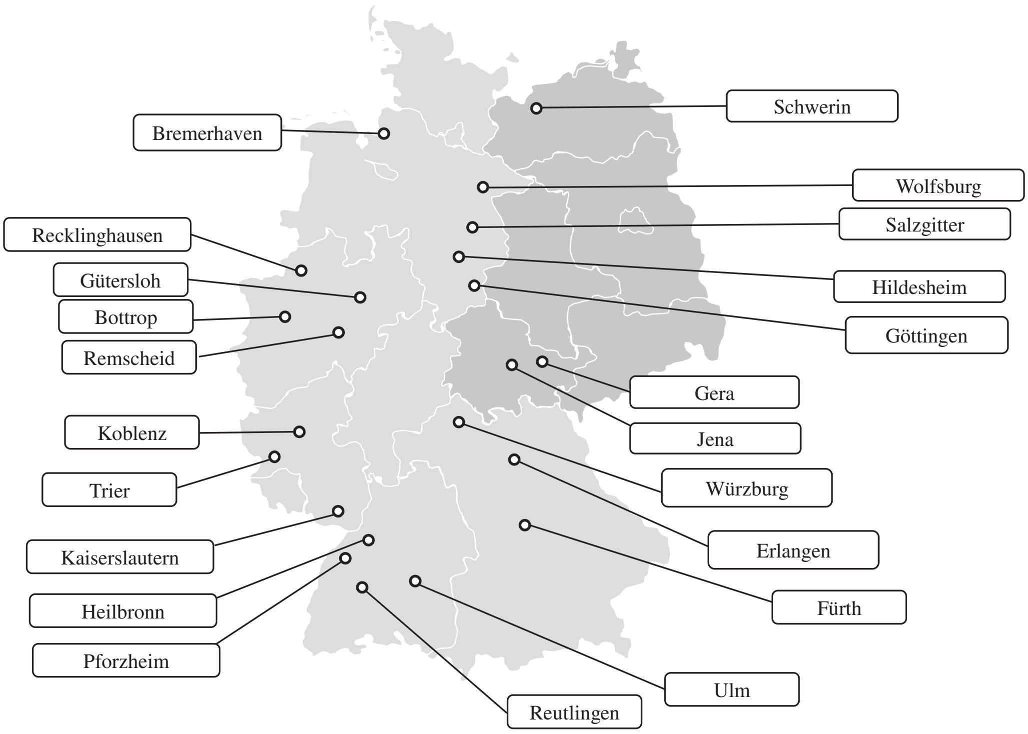
Erik E. Lehmann is a Full Professor of Management and Organization at Augsburg University, Germany and Director of the Program Global Business Management (GBM), and Dean of Student Affairs. He received his doctoral degree 1999 from Rostock University and his habilitation (venia legendi) from Konstanz University in 2005. From 2004 to 2005 he joined the Max Planck Institute (Jena) as an assistant director. Together with Silvio Vismara (University of Bergamo/Italy) he directs the CISAlpino Institute for Comparative Studies in Europe (CCSE). Lehmann's research is focused on the links between corporate governance in family and entrepreneurial firms, innovation, public policy, education and innovation systems, financial constraints and regional and global competition. He serves as an associate editor of Small Business Economics: An Entrepreneurial Journal. His research has been published in leading academic journals such as *Review of Finance, Research Policy,*

Entrepreneurship Theory and Practice, Journal of Economic Behavior and Organization, Small Business Economics: An Entrepreneurship Journal, Journal of Small Business Management, Review of Accounting and Finance, Journal of Technology Transfer among others.

Matthias Menter is an assistant professor of business dynamics, innovation, and economic change at the Friedrich Schiller University Jena, Germany. He is further a research fellow at the Institute for Development Strategies (IDS) at Indiana University at the School of Public and Environmental Affairs (SPEA), United States. His research focuses on aspects of entrepreneurial and innovative ecosystems, academic entrepreneurship, university–industry collaborations, and public policy. His research has been published in leading international journals such *as Small Business Economics, R&D Management, Economics of Innovation and New Technology, Industry and Innovation, Entrepreneurship & Regional Development, Technovation*, and the *Journal of Technology Transfer*.

APPENDIX A

List of the analyzed entrepreneurial ecosystems (cities)



APPENDIX B
Descriptive statistics

Variable	Obs.	Mean	SD	Min	Max	Operationalization
Entrepreneurial activities	528	90.53	64.42	9.00	417.00	Number of high-technological start-ups *Source*: Mannheim Enterprise Panel (ZEW)
Intrapreneurial activities	528	40.56	47.86	0	208.00	Number of patents from large incumbent firms *Source*: OECD REGPAT database
SME intra-preneurial activities	528	5.678	7.195	0	48.000	Number of patents from small and medium-sized firms *Source*: OECD REGPAT database
Intrapreneurial activities by re-search institutes	528	2.326	5.279	0	36.000	Number of patents from research institutes *Source*: OECD REGPAT database
Economic performance	528	37,363	19,445	11,585	178,706	Gross domestic product *per capita* *Source*: German Statistics Office
Regional density	528	2,067	5,118	227.00	25,834	Citizens per square kilometer *Source*: German Statistics Office
Industry orientation	528	4,421	9,486	0	58,984	University third-party funding by industry *Source*: German Statistics Office
Scientific performance	528	219.30	616.55	0	3,331	Scientific publications by universities *Source*: German Statistics Office
Scientific orientation	528	9.78	14.93	0	57.43	Share of research fellows of universities divided by the total workforce *Source*: German Statistics Office

APPENDIX C
Correlation matrix

Variable	1	2	3	4	5	6	7	8	9
1. Intrapreneurial activities by large firms									
2. SME intrapre-neurial activities	0.436***								
3. Intrapreneurial activities by re-search institutes	0.332***	0.189***							
4. Entrepreneurial activities	0.319***	0.449***	0.017						
5. Economic performance	0.202***	−0.22***	0.210***	−0.253***					
6. Regional density	−0.112*	0.043	−0.084	−0.082	0.075				
7. Industry orientation	0.441***	0.05	0.765***	0.006	0.362***	−0.09			
8. Scientific performance	0.399***	0.121*	0.609***	0.037	0.161***	−0.089	0.657***		
9. Scientific orientation	0.264***	0.074	0.712***	0.037	0.247***	−0.109*	0.778***	0.587***	

The asterisks *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

APPENDIX D
Poisson panel regression approach with fixed-effects

	Entrepreneurial activities		Intrapreneurial activities	
	Model V	Model VI	Model VII	Model VIII
Ecosystem dynamics				
Intrapreneurial activities	–0.003***	–0.001***		
	(0.0002)	(0.0002)		
Entrepreneurial activities			–0.003***	–0.002***
			(0.0002)	(0.0002)
Region				
SME intrapreneurial activities		0.003***		0.018***
		(0.001)		(0.001)
Economic performance		–0.00002***		0.00000*
		(0.00000)		(0.00000)
Regional density		0.0003***		–0.0002**
		(0.0001)		(0.0001)
Scientific orientation		–0.015***		–0.031***
		(0.003)		(0.005)
University				
Intrapreneurial activities by research institutes		–0.012***		0.006***
		(0.002)		(0.002)
Industry orientation		0.00000		0.00002***
		(0.00000)		(0.00000)
Scientific performance		0.00000		0.0001***
		(0.00001)		(0.00001)
N	484	447	484	447
Pseudo R^2	0.037	0.230	0.299	0.492
Pseudo R^2 (adj.)	0.038	0.232	0.300	0.493

This table reports the results of our fixed-effects Poisson panel regression estimation approach. We rely on a sample of 22 German entrepreneurial ecosystems ranging from 1993 to 2016. The dependent variable is entrepreneurial activities measured by the number of high-tech start-ups and intrapreneurial activities measured by the number of patents of large incumbent firms, respectively. Standard errors are in brackets. The asterisks *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

