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# Entrepreneurial ecosystems: towards a systemic approach to entrepreneurship?

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**ABSTRACT**
Despite its relative newness, entrepreneurial ecosystems (EEs) have attracted much attention from research and policy but they are recognized to be largely untheorized. It is claimed that one aspect which distinguishes the EE perspective from other perspectives related to business environments is its systemic approach; however, much of the systemic approach still needs to be investigated. The aim of this paper is therefore to investigate how the systemic and complex approach of EEs can be theoretically strengthened. We do this by investigating what values complex adaptive system theory holds for advancing the EE perspective. We highlight four propositions which are of particular importance for strengthening the systemic approach of EE: spatial and component boundaries of the system; self-governance; the relational dimension between system components and the system; and the evolution of the system. We propose that boundaries should be seen as a natural part of the system, that a complex system is too complex to capture all components and all interactions, and that studying only individual activities will not enable us to fully understand the system's behaviour.

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Entrepreneurial ecosystems; entrepreneurship; complex adaptive systems; systemic approach; complexity

## Introduction

Entrepreneurial ecosystems (EEs) is a relatively new concept in entrepreneurship research focusing on how local environmental conditions shape entrepreneurial behaviour. The concept has attracted much attention from both policy and research, which can be seen in the rapid increase of publications over the last six years, a large number of which have been non-scientific (Alvedalen & Boschma, 2017; Malecki, 2018; Stam, 2015). Owing to its relative newness, the concept is still in its formative stage and is therefore largely undertheorized, with little to no analytical framework (Roundy et al., 2018; Simatupang et al., 2015).

There is not yet a commonly accepted understanding of EEs but they are often described as complex structures or systems owing to the high number of different individuals and organizational stakeholders as well as the variety of factors influencing the interactions between them (Autio & Levie, 2017; Cavallo et al., 2019; Spigel, 2017). It is claimed that one aspect which distinguishes the EE concept from other concepts investigating business environments is its systemic approach (Cavallo et al., 2019; Malecki, 2018). So far, this systemic and complex approach of EE is still underdeveloped as primary attention has been given to the identification of the core components of established EEs (Roundy et al., 2018; Spigel, 2016).

The aim of this paper is therefore to investigate how the systemic and complex approach of EEs can be theoretically strengthened. In accordance with Roundy et al. (2018), we propose that EEs are best treated as complex adaptive systems (CASs). Such systems are made up of many components which may interact with each other in ways that are not always totally predictable and where systemic patterns both emerge from and influence component interactions (Holland, 2006; Levin, 2002). Taking the CAS literature as a starting point, we focus on four propositions which are of particular importance for strengthening the systemic approach of EE: spatial and component boundaries of the system, self-governance, the relational dimension between system components and the system, and the evolution of the system.

To the best of our knowledge, so far only one publication has attempted to link EEs with CAS literature. Roundy et al. (2018) investigated whether EEs possess the properties of CASs and which methods would be most suitable for studying EEs. We follow Roundy et al.'s (2018) argument that EEs possess the properties of CASs, but our paper differs in that we put forward how the systemic approach of EEs could be theoretically addressed by identifying the four propositions previously mentioned.

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We therefore do not suggest suitable research methods, such as Roundy et al. (2018) did, but want to focus on how the systemic and complex approach of EEs can be theoretically strengthened. If we want to claim that the systemic approach distinguishes EEs from other concepts, we need to go beyond the identification of EE components and focus on theorizing this systemic approach to legitimize EEs as a valuable concept in its own right. Strengthening the systemic approach will also allow for more holistic investigations on the geography and evolution of entrepreneurship and opens up space to address the relationality of the entrepreneurial process, as well as the interplay between the system and its environment.

The remainder of this paper is structured as follows. First, we review the current strand of literature on EEs, mainly focusing on extracting a common understanding of what it is that makes a place an EE according to the diverse literature. We then review the current strand of literature on CASs. Here we focus in particular on how the systemic and complexity approaches are treated. Based on the review of the CAS literature, we identify four propositions which help us to theorize how advances in CAS literature can contribute to strengthening the systemic and complexity approaches of EE. We conclude the paper with a discussion on how future research might be able to highlight this systemic approach more.

## What are EEs?

Due to their newness, various definitions of EEs can be found in the literature. Generally, the EE framework is described as a "*conceptual umbrella encompassing a variety of different perspectives on the geography of entrepreneurship*" (Spigel, 2017, p. 49). The EE literature draws from regional development literature, strategic management literature and system's literature (e.g., Bathelt et al., 2004; Cooke et al., 1997; Moore, 2006). Hence the EE framework offers no new insights on its own but provides a novel perspective by combining research outcomes from different streams of literature (Stam, 2015). Table 1 gives a short overview of how EEs are defined in the literature.

The definitions of EEs – not only those selected for Table 1 but also in general – might appear somewhat scattered and highlight different aspects of the concept. Acs et al.'s (2014) and Mack and Mayer (2016) definitions do not elaborate on specific components of the ecosystem but focus mainly on (entrepreneurial) individuals, new ventures and system-level resource allocation. Stam and Spigel (2017) and Mason and Brown (2014) imply the possibility for a planned system outcome, suggesting a role for policy and a hierarchical structure. In addition, Mason and Brown (2014) put more emphasis on established organizations than on individuals as possible actors in EEs.

Unsurprisingly, the term "entrepreneurship" is present in all EE definitions, but there are significant variations in how the term is understood. Entrepreneurship is used in both a narrower meaning – for the creation of new ventures (Acs et al., 2014) – and for established organizations, such as banks, firms and venture capitalists (Mason & Brown, 2014). In that sense, entrepreneurship might be defined differently in different EE papers. This might be somewhat problematic as results are not (fully) comparable if the phenomenon to be studied is defined differently.

Common to all definitions is the relational dimension of EEs. Entrepreneurship does not happen in isolation but is viewed as taking place within a community of interdependent actors (Stam, 2015). The relational dimension of entrepreneurship focuses on how these interactions enable entrepreneurs to access resources, infrastructure and knowledge. This relational dimension still seems to be missing in EE research since most research still focuses on the identification of components of successful EE rather than on the connections between them (Mack & Mayer, 2016; Spigel & Harrison, 2018). Table 2 gives a broad overview of identified components; it is very clear that the list is ever expanding. It seems that, so far, with each new case study new components have been added to the list.

Very few definitions have a more dynamic and evolutionary view of how these interactions might change. This might be a reflection of how most of the literature has dealt with the concept of EEs; the literature so far has been dominated by a static picture of EEs. Just recently, some have taken up a more evolutionary and dynamic perspective (Auerswald & Dani, 2017; Colombelli et al., 2019; Han et al., 2019; Johnson

**Table 1.** Definitions of the EE.

| Definition of EE | Authors |
|---|---|
| "Dynamic, institutionally embedded *interaction* between *entrepreneurial* attitude, ability, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures." (p. 479) | Acs et al. (2014) |
| "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." (p. 5) | Mason and Brown (2014) |
| "Entrepreneurial ecosystems (EE) consist of *interacting* components, which foster new firm formation and associated *regional entrepreneurial* activities." (p. 3) | Mack and Mayer (2016) |
| "A set of *interdependent* actors and factors coordinated in such a way that they enable productive *entrepreneurship* within *a particular territory*." (p. 1) | Stam and Spigel (2017) |

et al., 2019; Ryan et al., 2020). First, there is little discussion of how the importance of components changes over time (Mack & Mayer, 2016). Second, there has also been a focus on the components themselves rather than on the connections between them. And, third, past work has often ended up with an inclusive approach to any possible EE components, leading to an ever-expanding list (Motoyama & Watkins, 2014). But, if everything is included, the concept loses its analytical power. Acknowledging the relational dimension of EE makes it difficult to separate and isolate single components as key to success. Recently, scholars have been critical towards this production of identified key components of successful EEs (Nicotra et al., 2018). EEs are heterogeneous in nature and it is still unclear why some EEs thrive and others decline or fail to develop (Roundy et al., 2017). This suggests that it might be more fruitful to focus on the connections between the components rather than on the components itself.

It is generally understood that EEs also have a spatial dimension, even if it cannot be found explicitly in all definitions. The spatial dimension highlights the unique characteristics of a particular location which influences the compositions of the EE. There is however no common agreement on the specific geographic scale of EEs. It ranges mainly from very limited geographic scales like university campuses (Breznitz & Zhang, 2019; Miller & Acs, 2017) to cities (Audretsch & Belitski, 2017; Feld, 2012; Motoyama & Watkins, 2014), to the regional level (Cohen, 2006; Mack & Mayer, 2016) and up to the national level (Acs et al., 2014; Frenkel & Maital, 2014).

We can conclude that the review of the current strand of literature on EE gives a somewhat scattered picture of how the systemic approach is treated. Although common dimensions emerge, these dimensions are either not addressed sufficiently or operationalized differently. The relational dimension is acknowledged, yet research has focused on the identification of system components rather than on the relations between them. Also, while the spatial dimension is acknowledged, it is treated very differently in different works. This makes it difficult to compare findings and extract common knowledge. The question arises whether and how these shortcomings in addressing this systemic approach could be theoretically strengthened by relating these to the CAS literature.

## What are CASs?

The theory of CASs emerged as a reaction to the mechanistic and equilibrium-based view of the world (Gell-Mann, 1994; Holland, 1998; Kauffman, 1993; Langton, 1996). It sought to understand the spontaneous, self-organizing dynamics of the world by using computer simulation as a research tool. CASs is a multi-disciplinary field crossing traditional disciplinary boundaries.

Holland (2006, p. 1) defines CAS as “systems that have a large number of components, often called agents, that interact and adapt or learn”. Other authors, such as Levin (2002) define CASs by three properties: (1) diversity and individuality of components; (2) localized interactions among those components and (3) an autonomous process that uses the outcomes of these interactions to select a subset of those components for replication or enhancement. Levin (2002, p. 5) also writes that the “*exploration of any complex adaptive systems involves the interplay between two processes – the emergence of pattern in a system of fixed entities, and the continual appearance of new kinds of entities*”. Another definition is provided by Plsek and Greenhalgh (2001, p. 625), who defined a CAS as “*a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent’s actions changes the context for other agents*”. This definition, in the same way as the previous ones, defines a CAS as involving many components and individuals that learn and adapt by interacting.

**Table 2.** List of components in EE.

| Domains of an EE | Components | Examples |
|---|---|---|
| Conducive culture | Tolerance of risk, mistakes, failures; ambition; international reputation; visible success stories; attitudes; | Feld (2012), Isenberg (2010), Neck et al. (2004) |
| Enabling policies and leadership | Research institutes; venture-friendly legislation; regulatory framework incentives; financial support; social legitimacy; entrepreneurship strategy; | Autio and Levie (2017), Stam (2015), Neck et al. (2004) |
| Availability of appropriate finance | Micro-loans; angel investors, friends and family; zero-stage venture capital; venture capital funds; private equity; public capital markets; debt; | Mason and Brown (2014), Isenberg (2011) |
| Quality human capital | Skilled and unskilled; serial entrepreneurs; later generation family; specific entrepreneurship training; general degrees (professional and academics); mentors and dealmakers; | Brown and Mason (2017), Stam (2015) |
| Venture-friendly markets for products | Multinational corporations; diaspora networks; distribution channels; reference customers; early adopters for proof-of-concept; local market; | Mason and Brown (2014), Spilling (1996) |
| A range of institutional supports | Accounting; investment bankers; technical experts, advisors; telecommunication; energy; transportation and logistics; university; patent lawyers. | Spigel (2017), Roundy et al. (2017), Isenberg (2011) |

With influences from many different disciplines, modern theories and models of CASs focus on four "bedrock principles" (Pascale, 1999): CASs are at risk when at equilibrium; CASs have the capacity of self-organization and emergent complexity; CASs move towards a state of chaos when facing challenging situations; and living systems cannot be managed.

CASs are at risk when at equilibrium, a stage a system reaches before its activity ends. CASs operate under conditions far from equilibrium, which means there is continual change and response to the constant flow of energy into the systems (Nicolis & Prigogine, 1977). Or, as Cilliers (1998, p. 4) stated, "*[e]quilibrium is another word for death*"; therefore, change and adaptability are of central importance from a CAS perspective. Change takes place from within the system but also through the interactions with the environment. Therefore, CAS addresses systems as open systems, though nevertheless ones with boundaries. It is these boundaries that define the system and also differentiate the system from the infinite complexity of the surrounding environment. As Holland (2006, p. 6) put it, "*[a]ll cas [lowercase letters in original] have a hierarchical organization of boundaries enclosing boundaries, with signals that are attuned to those boundaries. Without boundaries there cannot be individual histories, and without individual histories selection for fitness is not possible*." Hence, one cannot talk about a system if boundaries are non-existent; it is the boundaries that define the system and the boundaries are a building block of the system. CASs are open systems with feedback loops, both enhancing (positive) and inhibiting (negative) further actions. Both kinds are necessary for the systems to change.

CASs are characterized by non-linear relationships, meaning that small actions can have large outcomes and small differences in the initial conditions or variables can lead to large differences in outcome. This phenomenon is known as "emergence" (Kauffman, 1993; Lansing, 2003; Sterman, 2000). CASs exist in quasi-equilibrium and show an emergent behaviour. Emergence is one of the core phenomena, defined as "*the creation of new 'order' – structures, processes, and system-wide properties that come into being within and across system levels*" (Lichtenstein, 2011).

CASs exhibit self-organizing behaviour (Barton, 1994). Their behaviour is induced and determined by the simultaneous and parallel actions of agents within the system itself "producing large numbers of simultaneous signals" (Holland, 2006). Self-organization is a process by which agents mutually adjust their behaviour in a way that allow them to cope with changing internal or external environmental forces (Cilliers, 1998). If variation and heterogeneity were "noises" in linear system theory, complex theory would understand these phenomena as integral parts of a system.

CASs move towards a state of chaos when facing challenging situations. Chaotic systems are unpredictable but they are not random or completely disordered. Internal interactions and feedback processes, learning and adaptability serve as controlling mechanisms; they either decrease disorder if the systems become too chaotic or increase disorder if the system shows signs of order or equilibrium. Hence, CASs are self-organizing, capable of reaching order without external management.

Moreover, the behaviour of CASs is emergent; change and development in CASs are ongoing processes and are the outcome of adaptation and learning. Adaptation and evolution imply that agents in a CAS change over time (based on experience) and, as previously discussed, change is of central importance for the system as a way to avoid equilibrium. Hence, agents not only respond to the environment but are embedded in and change the environment. It is not only the agents adapting and evolving; CAS argues for a dynamic co-evolution of both agents and the environment. A challenge for CAS is to understand the interrelationships between microscopic processes and macroscopic patterns, as well as the evolutionary forces that shape the system (Levin, 2002).

The CAS approach argues that living systems cannot be managed. CASs are embedded in the context of their own histories and no single component or agent can know, comprehend or predict actions and effects operating within the systems as a whole. CASs comprise a large number of interdependent components and are influenced by a large number of independent forces inside and outside the system. It is therefore impossible to comprehend or predict possible outcomes of the system processes.

## EEs as CASs

As stated in the introduction, the aim of this paper is to investigate how the systemic approach of EEs can be theoretically strengthened. In the review over the current strand of the literature on EEs, four main shortcomings were identified. The review showed that a relational and a spatial dimension could be found, albeit operationalized rather differently in different studies. These are two important dimensions when discussing the systemic approach of EEs. Furthermore, the review also showed that the EE literature is struggling with aspects related to EE governance and how it can be managed, but also with aspects concerning the evolution of the system. These shortcomings served as the rationale for selecting the four themes where advances in CAS theory could also advance the theorizing of the systemic approach of EE. We apply CAS theory to advance the theorizing of EE for two reasons. First, in order to highlight the relational dimension of EE, CAS theory explains how dynamic interactions among different components produce more than the sum of individual ones and how simple effects can have unpredictable consequences (Anderson, 1999). Second, CAS theory also allows us to emphasize the spatial dimension of EEs, since CASs include components, interactions and the environment where the discussion about boundaries is important.

### Spatial and component boundaries of the ecosystem

EEs clearly have a spatial dimension, even if this is sometimes understood more implicitly than explicitly. EEs are generally understood as place-based, implying the uniqueness of each EE (Isenberg, 2011; Simatupang et al., 2015), but a discussion of boundaries is surprisingly absent. In theoretical papers, the words "place" and "environment" are often used in a very abstract way without discussing what this "place" or "environment" actually is. In empirical papers it seems that these places are administrative units, e.g., Edinburgh, UK, Phoenix, USA, Lillehammer, Norway, and Italian provinces (Ghio et al., 2019; Mack & Mayer, 2016; Spigel, 2016; Spilling, 1996). Any researcher dealing with a spatial dimension faces the challenge of how this spatial dimension can be operationalized. There are various definitions of regions, which even can contradict each other. The issue is not to simply draw a line randomly but to decide where the line should be drawn to capture the spatial dimension of the phenomenon under study in the most appropriate way.

The CAS literature contributes a broader and more nuanced discussion on boundaries. Boundaries define the system and a system does not exist without boundaries. However, boundaries are not fixed and determined but rather permeable and flexible. There is also a hierarchical dimension to how boundaries are organized. As Holland (2006, p. 6) writes, all CASs "*have a hierarchical organization of boundaries enclosing boundaries*". Above we argued that for EEs the issue is demarcating the system (drawing the border) in a way that is appropriate to the spatial dimension of the phenomenon under study. Hence, drawing borders has, from a theoretical perspective at least, an analytical function, allowing the researcher to deal with the phenomenon at hand. By following Holland's (2006) line of argument, that boundaries have a hierarchical dimension of boundaries enclosing boundaries, the analytical power of borders are enhanced and different operationalizations of an "environment" will lead to different results.

The discussion about boundaries includes not only the spatial dimension of EEs but also their components. A large part of the EE literature has focused on identifying the key components of particular EEs in the past (Isenberg, 2010; Klingler-Vidra et al., 2016; Spigel, 2016; Stam & van de Ven, 2019). Although some studies go beyond listing components of EEs (e.g., Feldman, 2001; Mack & Mayer, 2016; Malecki, 2018), this is identified as one of the main limitations of the current EE literature (Auerswald, 2015; Mack & Mayer, 2016; Roundy et al., 2018). If we follow our line of argument that each place is unique, we could indeed conclude that different EEs consist of different components. As a result, past work has often ended up with an inclusive approach to any possible components (Motoyama & Watkins, 2014). Isenberg (2011) argues that the search for generic circumstances or causes of successful EE is a lost endeavour owing to the uniqueness of the case. But must we not assume that there are some generic components which form the backbone of ecosystems, albeit on a very abstract level? An approach which includes everything does not allow for systematic comparisons and has therefore little to no analytical power. Defining EEs as CASs implies defining EEs as systems with a large number of components (that interact, learn and adapt), components that can be understood as systems within the system (subsystems?) defined depending upon which phenomenon within the EE is under scrutiny or at which level we want to address the specific phenomenon. Moreover, the boundaries of complex systems are characterized as a component part of the system itself. The discussion about boundaries also includes the relation between the system and its context or surrounding environment. One of the main assumptions is that the system changes and adapts through interaction between the parts of the systems and between the system and its environment. This implies that open borders necessarily characterize complex systems. It is through borders that the system interacts and communicates with the surrounding environment. Therefore, open borders are significant for learning, and for the system's capability to change and adapt.

### Self-governance

In most of the EE literature there seems to be a place for some sort of governance and even policy intervention. Many definitions include that EEs can be governed, coordinated or fostered (e.g., Leceta & Könnölä, 2019; Stam & Spigel, 2017). This possible intervention is not a new approach; several streams of research have investigated how policy might create more favourable conditions for entrepreneurship. For example, it has been discussed to what extent clusters can be planned for (e.g., Sydow et al., 2010) or how regional advantages can be constructed through policies (e.g., Asheim et al., 2011). A whole special issue was recently dedicated to the role of public policy in the shaping of EEs (Jolley & Pittaway, 2019). Keeping in mind that so far EEs have often been dealt with within administrative units, there certainly seems a place for some sort of policy intervention. It has also been stressed that the biological ecosystems metaphor should not be taken too seriously since EEs include purposeful actors which can initiate strategic activities which would also leave room for possible governance activities. The question is, though, whether something as complex as EEs can be meaningful governed or coordinated and to what extent it can be done.

When considering EEs as CASs, one has to consider behaviour in an EE as induced not by a single component (i.e. policymakers) but by the simultaneous and parallel actions of all actors in the system. CASs are not managed from above but are self-organized. CASs are characterized as being emergent phenomena, which means that higher level regularities are often the result of simple rules and local interactions at the lower level (Choi et al., 2001). If an EE is a CAS, then it is emergent, therefore disqualifying therefore the belief that an EE can be managed towards intended effects. Emergent properties often result from unintended effects of action. Effects that are intended are, by definition, not emergent. Hence, when considering EEs as CASs, the focus is on the unintended.

CASs are self-organizing as their behaviour is induced and determined by the simultaneous and parallel actions of agents within the system itself. Seeing EEs as an emergent phenomenon also implies that they have a life of their own, with their own rules, laws and possibilities (Goldstein, 2011). Moreover, in the EE literature, the role of policymakers has been discussed, but EEs house different components (see Table 2), for example, stakeholders with a large heterogeneity of goals. EEs should therefore be seen more as an arena where many different stakeholders initiate different activities with different intentions.

An EE is an emergent phenomenon. The phenomenon of entrepreneurship is an emergent process in itself. An entrepreneur exhibits an adaptive behaviour when taking action; it is an adaptive answer to market opportunities. Entrepreneurship is not a solitary action but entrepreneurs engage with a variety of different actors (see for example, Table 2) on entering a complex network. Moreover, an entrepreneur is dependent upon a variety of other actors and requires collaborations with different other actors and institutions. The entrepreneur becomes part of a complex network.

## *The relation dimension between system components and the system*

As we have seen above, the relational dimension of EE is discussed in the EE literature more implicitly than explicitly. Past work has focused on the identification of components but neglected the connections between them. From a CAS perspective, a system is defined by both the components and the relations between those components. The rate of connectivity between the different components determines the level of complexity.

Entrepreneurs are only one possible component of EEs; hundreds of possible components have been identified. Recently, efforts have been made to go beyond the identification of different components and study how different components of the system are linked together and how they have emerged (Auerswald & Dani, 2018; Feldman, 2001; Mack & Mayer, 2016; Malecki, 2018; Roundy et al., 2018) and to measure how some of these EE components are statistically related (Stam & van de Ven, 2019). One aspect which deserves more attention is how entrepreneurship is dealt with from a relational view. If no relations exist between the different agents or components of an EE, then actors behave independently of each other and there will be no behaviour or answer at the system level. Following CAS, the level of relational activity is also an aspect to be considered; at a high rate of connectivity/relationality the number of new relations increases, while at a low level of connectivity the number of new relations between the actors of the system decreases (Dooley & Van de Ven, 1999). Furthermore, the strength of the relations – but also the diversity of the actors – impacts upon the dynamics of the system. Another aspect that the CAS literature emphasizes is the interplay between the system and its environment and the co-evolution of both the system and the environment.

Entrepreneurship is mentioned both as a component and as the system's outcome. It is, however, not perfectly clear how entrepreneurs' activities feed back into the EE. Studies have highlighted the role of mentors and coaches (Clarysse & Bruneel, 2007; Ramaciotti et al., 2017) but we cannot assume that all or even most entrepreneurs are willing to provide guidance for others. While it is important to understand how different components related to each other, it is equally important to understand how the components feed back into the system as a whole. It seems that this latter aspect is still neglected in the EE literature. In line with this, from a CAS perspective, understanding the complexity of the systems implies understanding how individual behaviours and actions are transformed into systemic behaviours and actions and how these behaviours and actions feed back at the individual level. A CAS comprises a large number of interdependent components and is influenced by a large number of independent forces inside and outside the system. It is therefore impossible to comprehend or predict the possible outcomes of the system processes. An EE is often addressed in a rather static manner, where the focus is mainly on identifying and describing the different components of the ecosystem. Hence, the focus is on what Levin (2002) calls for *microscopic interactions*, on what happens at the individual level. But this does not help one to understand the behaviour of the system, the *macroscopic phenomena*.

### The evolution of EE

As we have seen above, the identification of internal EE components while neglecting the relations between them has been subject to criticism. If the relations have been neglected, little can then be said about the dynamics and evolution of the EE. Recently, some have started to address this evolutionary aspect of EEs by suggesting different lifecycles of EEs and their adaptive evolution (e.g., Colombelli et al., 2019; Mack & Mayer, 2016). An EE is often described as a complex system owing to the large number of actors and their activities. The presence of key components is therefore important for the evolution of EE, as well as the nature of their interaction (Malecki, 2018). With a CAS perspective on EEs, the process of change over time is of central interest. And it is through the interaction between the system and the environment that change is induced in the system. The system evolves through learning and adaptation, two core process for a CAS. As we mentioned earlier, the borders of the system are important components for the evolution process of an EE, as the permeability and flexibility of borders permits interaction and communication with the environment. Change is, however, unpredictable; it is almost impossible to foresee what might happen. As Dooley (1997, p. 85) writes, "*the quickest way to predict the future of a complex system is to let it evolve and see what happens*". This can be related to the discussion on the governance of EE.

When discussing the evolution of EEs, much focus seems to lie on the ecosystem itself, where the system's outcome, productive entrepreneurship, is also seen as a vital component of EEs in form of role models and serial entrepreneurs (Stam, 2015). Here the outcomes become the input pointing towards a more evolutionary perspective. Less attention has been given to the surrounding environment. Some researchers have been pointed out that EEs are flawed, in particular during their formation phase, but that this can be compensated for through global pipelines or national networks (Malecki, 2018). These inputs from outside the system are important not only in the formation phase but during the whole life cycle of the EE. New knowledge and new ideas from outside are needed to keep the dynamic of a place going. The smaller the geographic scale of the EE, the more important this external input becomes in order to compensate for the relatively smaller number of actors and their activities.

If we then consider EE to be constantly evolving owing to a constant inflow of new knowledge and ideas, whether through external or internal input, we must also assume that the importance of components and their relations will change. Some components might be essential at the early formation stage of the EE but might have a negative influence at a later stage. The lack of some components in the formation stage of the EE might be compensated through external input, but as the EE matures some components might be at the heart of EEs and should be local assets. Levin (2002, p. 17) describes this as follows: "*Understanding the evolution and development of complex adaptive systems [...] involves understanding how cooperation, coalitions and networks of interaction emerge from individual behaviours and feed back to influence those behaviours*." EEs have a spatial dimension and the local conditions will therefore have a strong impact on how an EE evolves and some missing component might only be partly imported. If we follow the argument that each EE is unique, the importance and interaction between the components might also differ.

## Conclusions: what value does CAS literature hold for EE?

The concept of EEs emerged as a way to understand the complexity of the entrepreneurial process, bringing together different theoretical perspectives of the geography of entrepreneurship. Still in its infancy, the concept is characterized by a lack of a theoretical framework and rather scattered definitions and understandings. Nevertheless, EEs are often addressed as complex structures or systems and it is claimed that one aspect which distinguishes the ecosystem concept from other concepts related to business environments is its systemic approach. Much of this systemic approach still needs to be investigated. Based on the review of the CAS literature we then theorize how advances in the CAS literature can contribute to strengthening the systemic and complexity approach of EE. These discussions have led us to the following conclusions, which are summarized in Table 3.

**Table 3.** Towards a systemic approach to EE.

| Systemic approach | Open research questions | Focus for future studies |
|---|---|---|
| *Borders are a natural part of the system* | What are the boundaries of an EE? | Entrepreneurial networks are not bound by administrative boundaries. Boundaries should be perceived as open and fluid. |
| *Studying individual activities will not enable us to fully understand the ecosystems behaviour* | How can individual activities give rise to macroscopic phenomena? | Nonlinear interactions make it difficult to translate individual activities to systemic outcome. EE studies need to focus more on the emergence aspect of complex systems. |
| *A complex system is too complex to capture all components* | How can an EE be created, governed or coordinated? | The limited effects of top-down policy should be recognized. EE studies should focus less on how an EE can be governed and more on the self-organization of the system. |
| | What are the main components of EEs? | Less focus on the identification of components and more focus on adaptability. |

## *Borders are a natural part of the system*

An explicit discussion on spatial boundaries is surprisingly absent in the EE literature. Especially if stressing the systemic approach, system boundaries are important since these system boundaries determine what should be studied. A system or an ecosystem ceases to exist without borders, as it otherwise disappears in the infinite. Borders define and tell the story of the system, as Holland (2006) expresses it. It is through the borders that the system communicates with other systems, subsystems and the surrounding environment, and borders are therefore important components for the adaptation and learning of the system. Since boundaries are not discussed, it is often not perfectly clear whether EEs are within administrative boundaries or could transcend them. Administrative boundaries might not be the most appropriate for studying EEs, especially if it is understood that entrepreneurship is not happening in isolation but is viewed as taking place within a community of interdependent actors.

CAS theory also stresses the importance of open boundaries. While boundaries are important to determine what is part of the system and what is the surrounding environment, these boundaries should not be seen as closed. Open borders are what defines a CAS, meaning that the system is in a continuous process of exchange with the surrounding environment. So far, the EE literature has mostly been focused within EEs by identifying their components, but both local and global activities can be of importance for the system.

We can therefore conclude that how the boundaries of an EE should be drawn is one of the open research questions in EE literature. How the boundaries of the system are drawn influences what can be studied, but so far, no studies include a discussion on boundaries. Mainly administrative boundaries have been chosen. The requirement for a mindful selection of boundaries does not mean that these boundaries are constant. As the system and its components adapt and evolve also the boundaries might change. Boundaries should be perceived as open and fluid.

## *Studying individual activities will not enable us to fully understand the ecosystems behaviour*

Understanding the complexity of an EE implies moving beyond understanding the reasons and actions of individual entrepreneurs to understanding the behaviour of the system. A CAS is formed by the interactions between the agents in the system, and, if we perceive an EE as a CAS, then we can suggest that an EE emerges from the infinite actions and interactions of its individual members. However, the question is how the actions at the individual level give rise to *macroscopic phenomena*. One cannot explain the behaviour of the system by studying the behaviour or activities of the individual entrepreneurs. Entrepreneurs might have quite different profiles and reasons for becoming entrepreneurs, which might give the impression that the region is characterized, for example, by diversity, while addressing the entrepreneurial activity of the region at the system level would show a rather homogenous entrepreneurial profile.

EE has become increasingly popular among politicians, who readily initiate polices in the hope of creating and fostering successful entrepreneurial environments. But how individual activities can give rise to macroscopic phenomena remains an open research question in EE literature until now. Nonlinearity is an important feature of EEs which means that individual activities can have disproportional outcome on the system's level; both in a positive or a negative way. This corresponds with the emergence aspect of complex adaptive systems where emergent structures are other than the sum of their parts. In that sense, we need to focus less on individual activities and more on the feedback loops which allow individual activities to grow to systemic patterns.

### *A complex system is too complex to capture all components*

We have discussed that the EE is still rather static in its approach as much effort has been put into identifying the components of the system. The argument for the place-based uniqueness of EE has led to an inclusive approach towards any possible system components. An EE comprises a large variety of interdependent components and is influenced by a large number of independent forces inside and outside the system. The list is ever expanding, with each new case study adding more components to the list. However, the CAS literature argues that a complex system is far too complex to capture all components. Therefore, the focus of CAS is less on identifying which are the components of the system and more on the system's capacity for adaptation and evolution. Change is unpredictable and difficult to foresee, which means that an EE is in a state of continuous transformation and adaptability. This also means that the system's components are constantly changing, appearing and disappearing, making the search for a complete list of system components a continuous quest. The complexity of the system resides in its capacity to adapt and learn. Furthermore, this implies, from a CAS perspective, that the system is self-organized and capable of reaching order by itself. Such a perspective raises challenges for the literature addressing EEs as being coordinated or governed. It is perhaps more helpful wiser to focus upon creating conditions for learning than on attracting or creating new system components.

One of the open research questions of the EE literature is how an EE can be created, governed or coordinated. The endeavour of identifying the components of an EE rests in a belief that one can create and manage an EE. The focus on the merely identification of components and adding up to the list of components is a static approach and fails to capture the complexity of an EE. Research should focus more on the adaptability of and the dynamics between the elements of the system. As a complex adaptive system, an EE is a system in a continuous process of learning and adaptability. In this sense, an EE is self-organized meaning that the different components mutually adjust their behaviour making the system difficult to be managed or governed. In this respect, the limited effects of top-down policy should be recognized. EE studies should focus less on how an EE can be governed and more on the self-organization of the system.

## Disclosure statement

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