Greening Pastures

Ecosystems for sustainable entrepreneurship

Jip Leendertse

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Groenere Weides

Ecosystemen voor Duurzaam Ondernemerschap

Proefschrift

Jip Leendertse

geboren op 15 juni 1993

te Amsterdam

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Proefschrift

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Introduction

1. General introduction

1.1 Preface

During a sunny May in 2017 Talinn, Estonia hosted the annual finals of the ClimateLaunchpad competition. This event brought together 105 start-ups, from 35 countries over the world, all working on climate mitigation and adaptation. These are so-called sustainable start-ups because they work on ideas that try to combine contributing to the environment with building fast growing businesses. The start-ups in attendance represented the cream of the crop as they formed the podium of national competitions in which over 1,000 start-ups participated. I attended this event and, as a result, I got to observe enthusiastic, passionate, and perhaps even brilliant people share their ideas.

On stage, the entrepreneurs talked about their current or future successes. They described how they overcame technological challenges, how they found their first customers, and how they would get many more. In the corridors, they talked about challenges and failures. Regulations that prevented them from selling their product, difficulties in finding partners, countless pitches to investors that still had not led to the finance they needed, and governments who were too scared to buy something from a start-up.

Travelling home I wondered how these stories would play out in the future. How many of these start-ups would become successful, which ones and why? What is the role of their technology? How much does the country they come from matter? And why were some countries stacked with sustainable start-ups while other countries had to scavenge to find some? These questions sparked an intrigue that has been front and center in my work life ever since, cumulating but not ending with this dissertation.

My first motivation to study ecosystems for sustainable entrepreneurship is purely academic, I want to understand them better. I also have a second, normative, motivation. Listening to the founders of sustainable start-ups it becomes clear that they envision a better future. I indeed believe that sustainable start-ups play a role in achieving a better future. As such, I am not neutral to environmental sustainability or to sustainable start-ups. I want them to succeed. Such an explicit normative stance can be frowned upon in academia, yet we all are constrained by our norms and values and hiding them does not make them go away. In this case, I am convinced that my normative stance is a strength. The first, academic motivation, requires combining academic relevance and academic rigor. And in this case, so does the second, normative motivation. The right support measures will only follow from the correct analyses and results. Academic relevance and academic rigor are thus of the essence, not only from an academic, but also from a normative perspective.

The result of the focus on relevance and rigor is that my dissertation contains findings that surprised me, that disappointed me, that had me smiling with joy, but most of all that intrigued me. This dissertation answers many of the questions I asked myself years ago. Hopefully, it also sparks your interest in the influence of context on sustainable entrepreneurship and answers many of the questions that come along with this interest.

1.2 Sustainable entrepreneurs

The sustainable entrepreneurship literature builds upon the Triple Bottom Line concept, which introduces people, planet, and profit as three dimensions of firm performance (Elkington, 1998). Sustainable entrepreneurship entails starting novel ventures that combine developing a business (profit) with sustaining the social (people) and natural (planet) environment (Johnson and Schaltegger, 2020; McMullen and Warnick, 2016; Munoz and Cohen, 2018; Stubbs, 2017). These novel ventures are so called sustainable start-ups. Sustainable start-ups can be divided into two distinct categories, social and environmental (Belz and Binder, 2017; Bocken, 2015; de Lange, 2017). In this dissertation I focus on those sustainable start-ups that address environmental sustainability. From now on I use the terms sustainable start-ups and sustainable entrepreneur to refer specifically to environmental sustainability.

Environmental sustainability is important because society faces several grand environmental challenges. Sustainable entrepreneurs play an important role in solving these challenges by introducing new sustainable technologies and business models (Bjornali and Ellingsen, 2014; Cohen and Winn, 2007; Tiba et al., 2021). This potential role of entrepreneurs is widely acknowledged, but to fulfil their potential two conditions must be met. First, sustainable start-ups need to be present, they need to exist (Cohen and Winn, 2007; Munoz and Cohen, 2018). Second, for sustainable start-ups to significantly contribute to solving societal challenges they need to grow, they need to maintain a healthy business performance (Bjornali and Ellingsen, 2014; Calel and Dechezlepretre, 2013; Meyskens and Carsrud, 2013). However, sustainable start-ups are constrained in several ways, and this causes them to encounter additional challenges in founding their business and in maintaining their business performance compared to regular start-ups. I identify four constraints.

First, many technology-based sustainable start-ups are constrained because they require more investment capital than other types of start-ups (Evans, 2018). "Hardware" sustainable start-ups, such as in clean-tech, often face higher costs due to the need to conduct large-scale R&D, or demonstration projects, as well as to set up production lines. As a result, the products or services of sustainable start-ups are more difficult to implement and have a higher chance of failure compared with other start-ups, which can deter investors to invest in sustainable start-ups (de Lange, 2017; Giudici et al., 2019; Martin and Moser, 2016). This makes it more difficult to attract capital.

The second constraint faced by sustainable start-ups is that they operate in imperfect or failing markets (Hoogendoorn et al., 2019; Pinkse and Groot, 2015). Sustainable start-ups offer solutions that reduce the negative externalities of existing products or services (Cohen and Winn, 2007). Reducing negative externalities creates public value that is often insufficiently accounted for in the prices of goods or services (Cohen and Winn, 2007; Dean and McMullen, 2007; Vedula et al., 2022). As a result, sustainable start-ups struggle to capture the value they create. Moreover, many prospective users often do not have the means to buy the goods or services that sustainable start-ups offer (Mair and Marti, 2006; Tiba et al., 2020). This makes it more difficult to sell their product or service.

Third, sustainable start-ups are often institutionally constrained (Hoogendoorn et al., 2019); their products or services do not always comply to market regulations, standards, norms, habits, or cognitive frames (Smink et al., 2015; Steinz et al., 2015). This makes it harder to get the product or service on the market and/or to subsequently sell it.

Fourth, sustainable start-ups are often hybrid organizations founded with a combination of economic and environmental aspirations (Hechavarría et al., 2017; Hörisch et al., 2017; McMullen and Warnick, 2016; Munoz and Cohen, 2018). These two motivations do not always align and sustainable start-ups therefore experience tension in balancing these goals (Austin et al., 2006; Jolink and Niesten, 2015; Leendertse et al., 2021; Stubbs, 2017). This means that they have to make trade-offs.

The ability of sustainable start-ups to contribute to solving societal challenges depends on the extent to which they are influenced by these constraints. In this dissertation I study how these constraints influence sustainable start-ups and what can be done to help sustainable start-ups overcome these constraints. Looking at these constraints it becomes clear that they are caused by a combination of both internal and external factors. Balancing environmental and economic aspirations is mostly an internal constraint. While the access to finance, the market, and the institutional constraints are mostly external. It is thus not sufficient to look only at the sustainable start-ups themselves. It becomes evident that the surrounding environment, the ecosystem in which they are embedded, plays a crucial role.

1.3 Entrepreneurial ecosystems

The surrounding environment for entrepreneurs is the core focus in the entrepreneurial ecosystem literature. An entrepreneurial ecosystem comprises a set of interdependent actors and factors that are governed in such a way that they enable productive entrepreneurship within a particular territory (Stam, 2015; Stam and Spigel, 2018). Productive entrepreneurship entails ‘any entrepreneurial activity that contributes directly or indirectly to net output of the economy or to the capacity to produce additional output” (Baumol, 1993, p. 30). I interpret this as entrepreneurial activities that create both societal and economic value (Acs et al., 2013; Baumol, 1990). The entrepreneurial ecosystem literature describes how entrepreneurs depend on other actors (incubators, governments, entrepreneurs, investors etc.) for resources and how their behavior is shaped by the institutions in which they are embedded (Alvedalen and Boschma, 2017; Audretsch and Belitski, 2017; Stam, 2015; Van Rijnsoever, 2022). These entrepreneurial ecosystems are considered to have spatial boundaries at the local, regional or national level (Wurth et al., 2022). The entrepreneurial ecosystem literature thus studies how the elements of entrepreneurial ecosystems, defined as the combination of the actors and factors, influences the presence and performance of productive entrepreneurship in a region.

The elements that make up an entrepreneurial ecosystem have been summarized in different frameworks with ten (cf. Stam, 2015; Stam and Spigel, 2018; Stam and van de Ven, 2021), five (Vedula and Kim, 2019), six (Isenberg and Onyemah, 2016), seven (Radosevic and Yoruk, 2013) and 14 elements (Ács et al., 2014). I use the framework with ten elements as it (1) presents a clear separation of inputs, outputs, and outcomes, (2) provides a balance between the other frameworks, and (3) is most frequently adopted in the literature (Stam and van de Ven, 2021; Wurth et al., 2022). This entrepreneurial ecosystem framework is presented in Fig. 1.1.

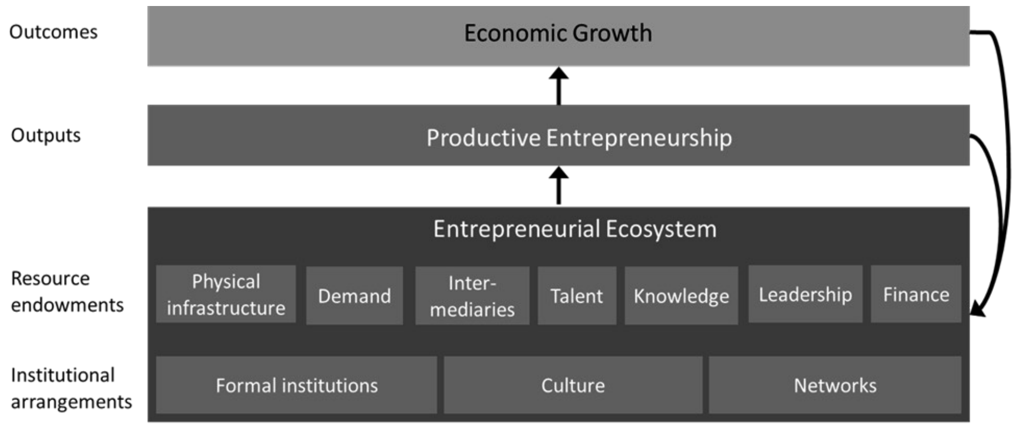


Fig. 1.1. Elements and outputs of the entrepreneurial ecosystem (adapted from Stam and Van deVen, 2021).

The ten individual elements of entrepreneurial ecosystems are divided in two categories: resource endowments and institutional arrangements. The resource endowments category covers physical infrastructure, demand, intermediaries, talent, knowledge, leadership, and finance. The institutional arrangements cover formal institutions, culture and networks. Wurth et al. (2022) identify five categories of mechanisms that play a role in the entrepreneurial ecosystem framework, (1) the interdependencies between the entrepreneurial ecosystem elements, (2) the entrepreneurial ecosystem influences the output, the presence of productive entrepreneurship through an upward causation, and (3) an upward causation where productive entrepreneurship consequently affects the outcome, economic growth (4) downward causation, and (5) interactions across the boundaries of entrepreneurial ecosystems.

Theoretically, the entrepreneurial ecosystem can be seen as a special case of an innovation system (van Rijnsoever, 2020; van Weele et al., 2018). An innovation system consists of (1) actors that interact and exchange resources in a network under an (2) institutional regime and using an (3) infrastructure (Carlsson and Stankiewicz, 1991; van Rijnsoever et al., 2015). The theoretical fit can also be seen in the two categories: resource endowments and institutional arrangements included in the entrepreneurial ecosystem framework by Stam and van de Ven (2021). The institutional arrangements cover both the informal (culture) and formal institutions that make up parts of the institutional regime. A closer look at the resource endowments category reveals that this covers the combination of actors (e.g. demand, leadership, intermediaries) and their resources (e.g. knowledge, finance, talent). In addition, Stam (2015) includes infrastructure as a resource endowment through the element physical infrastructure.

The strength of the entrepreneurial ecosystem compared to other frameworks such as regional innovation systems (Cooke, 2007; Cooke et al., 1997; Sternberg, 2007) and clusters (Delgado et al., 2010; Rocha, 2004; Rocha and Sternberg, 2005) is that it places the entrepreneur front and center. This makes the entrepreneurial ecosystem framework the most appropriate framework to study how the surrounding environment influences entrepreneurs, and thus for this dissertation.

Initially, the focus in the entrepreneurial ecosystem literature was on the contributions of entrepreneurship to economic growth as the output. However, the entrepreneurial ecosystem has since been extended to focus on well-being outcomes (Wurth et al., 2022), which includes resilience (Roundy et al., 2017), contributions to sustainable development (DiVito and Ingen-Housz, 2021; O'Shea et al., 2021; Theodoraki et al., 2022) and even societal missions (Volkmann et al., 2021). These extensions fit the focus of my dissertation on sustainable entrepreneurship.

1.4 Ecosystems for sustainable entrepreneurship

To understand how entrepreneurial ecosystems influence sustainable entrepreneurship, researchers have developed the sustainable entrepreneurial ecosystem concept (Cohen, 2006; Theodoraki et al., 2018; Tiba et al., 2020; Volkmann et al., 2021). The literature on sustainable entrepreneurial ecosystems aims to understand the factors that promote the presence of sustainable start-ups, and thus to help these start-ups overcome their constraints. The existing articles on sustainable entrepreneurial ecosystems build strongly on the factors identified in the entrepreneurial ecosystem literature, because sustainable entrepreneurship is, to a large extent, influenced by the same factors that enable regular entrepreneurship (Giudici et al., 2019; Tiba et al., 2021). However, the additional constraints faced by sustainable entrepreneurs mean that there are likely

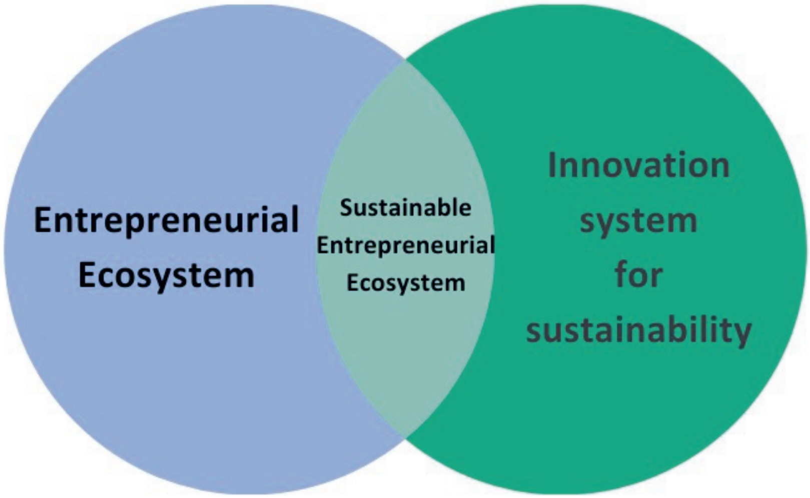


Fig. 1.2. Sustainable Entrepreneurial Ecosystems

several additional factors that are needed in an sustainable entrepreneurial ecosystem to help these start-ups overcome their constraints (Gibbs, 2006; Hart, 2006; Linnanen, 2002; Tiba et al., 2021).

To identify these additional factors, I use the related literature on innovation systems. Innovation systems approaches have already been used extensively to understand

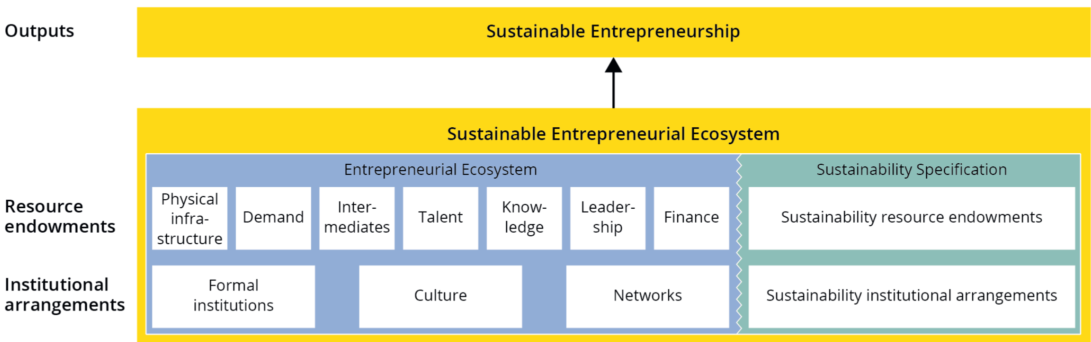


Fig. 1.3: Conceptual framework for Sustainable Entrepreneurial Ecosystems

sustainability (Carlsson and Stankiewicz, 1991; Hekkert et al., 2007) and I outlined the shared theoretical foundation between innovation systems and entrepreneurial ecosystems. This makes the innovation system approaches well suited to identify the sustainability component of sustainable entrepreneurial ecosystems.

To conceptualize sustainable entrepreneurial ecosystems, I combine the entrepreneurial ecosystem and the innovation system frameworks using the (1) actors and resources, and (2) institutional regime categories (Carlsson and Stankiewicz, 1991; van Rijnsoever et al., 2015). I argue that the sustainable entrepreneurial ecosystem can be found at the nexus between an innovation system for sustainability and an entrepreneurial ecosystem (see Fig. 1.2).

I present a new conceptual framework specifically for sustainable entrepreneurial ecosystems (Fig. 1.3) that is based on the entrepreneurial ecosystem framework of Stam (2015). The framework shows the ten original entrepreneurial ecosystem elements of Stam (2015), which are combined as the quality of Entrepreneurial Ecosystems, graphically depicted as a box. Combined with the sustainability specifications for the two layers these make up the sustainable entrepreneurial ecosystem.

I identify two additional elements for each layer of the sustainable entrepreneurial ecosystem. These two components are both an addition to the existing entrepreneurial ecosystem framework and a specification of the two layers. The first element in the actors and resources layer is the presence of fellow start-ups. Fellow start-ups are important because they help each other by exchanging knowledge (van Weele et al., 2018) and by providing network connections that increase the access to resources (Evans, 2018; van Rijnsoever, 2022, 2020). The second element is the presence of sustainability-oriented actors and resources. This concerns non-start-up actors (universities, firms, incubators etc.) with a specific focus on sustainability. For sustainable start-ups, actors with a specific focus on sustainability are extra important (DiVito and Ingen-Housz, 2021). They can help sustainable start-ups overcome their constraints, by supplying resources, or connecting them to other relevant public or private partners who in turn can provide the sustainable start-ups with resources (Clarysse et al., 2014; van Rijnsoever, 2022).

In the institutional arrangements layer, I add how favorable institutions are regarding sustainability. In line with the innovation systems literature, I make the distinction between formal and informal institutions (Douglass, 1990; Edquist and Johnson, 1997; Scott, 2008). For sustainable start-ups, formal institutions can consist of favourable and unfavourable policies. Favourable policies can be subsidy schemes or regulations that promote the use of sustainable technologies, while unfavourable policies can be tax benefits for existing technologies or regulations that prevent the use of sustainable technologies. Informal institutions are the norms or values about sustainability, such as the importance that a population gives to climate change. The degree to which the institutions are favorable towards sustainability can have a positive or negative effect on the presence of sustainable start-ups in a region as they can strengthen or reduce the constraints faced by sustainable start-ups (DiVito and Ingen-Housz, 2021; Giudici et al., 2019; Hoogendoorn et al., 2019)

The conceptualization of (1) resource endowments, and (2) institutional arrangements as the layers of sustainable entrepreneurial ecosystems also fits with studying the external constraints faced by sustainable start-ups. The need for finance and the tougher access to the market (demand) are closely linked to the resource endowments. The institutional constraints are, obviously, part of the institutional arrangements. This framework thus enables us to identify what factors influence sustainable start-ups and to study what can be done to reduce the impact of the constraints faced by sustainable start-ups.

This is important because sustainable entrepreneurs can play an important role in tackling grand environmental challenges and regional governments are increasingly implementing policies to support them. However, a systematic evaluation of which conditions influence the presence of sustainable start-ups is lacking (Theodoraki et al., 2018; Volkmann et al., 2021). Even though this is a necessary component to design effective policies. In this dissertation I address this research gap.

1.5 Research Question

Based on the literature I identified four common constraints faced by sustainable start-ups. The objective of this dissertation is to understand how these constraints influence sustainable start-ups and what can be done to help sustainable start-ups overcome their constraints. Three of these constraints are predominantly influenced by external factors. This indicates that the surrounding environment in which sustainable start-ups are embedded plays a crucial role. Therefore, I look at how the environment, in particular the entrepreneurial ecosystem, influences the presence of sustainable start-ups. As such the research question of my dissertation is:

How do entrepreneurial ecosystems influence the presence of sustainable start-ups?

To answer the research question, I study the surrounding entrepreneurial ecosystem and the individual organization, the sustainable start-up. The sustainable entrepreneurial ecosystem framework, as an extension of the entrepreneurial ecosystem framework, offers the opportunity to identify the factors that influence start-ups. However, there are several research gaps that need to be addressed before this framework can be used to study the main research question. The remainder of this dissertation consists of two parts. In the first part, I address research gaps regarding the generic entrepreneurial ecosystem framework that are needed to study the main research question. In the second part I address the research gaps that specifically relate to sustainable start-ups and the sustainable entrepreneurial ecosystem framework.

Regarding the generic entrepreneurial ecosystem framework there are four research gaps that I address. First, at the time of writing there was no large-scale operationalization of the entrepreneurial ecosystem framework and as a result the empiric evidence for the entrepreneurial ecosystem concept is limited to case studies. I provide such an operationalization and the following empiric evidence. Second, in recent work Coad & Srhoj (2023) question the validity of the entrepreneurial ecosystem framework based on a lack of persistence of high-growth firms. I address their criticism and further articulate the entrepreneurial ecosystem framework based on an extension of their analyses. Third, several authors (e.g. Fischer et al., 2022; Schäfer, 2021) question the lack of research on interactions across entrepreneurial ecosystem boundaries. I study how how both individual motivations and the embedding entrepreneurial ecosystem drive and hinder interactions across the boundaries of a focal entrepreneurial ecosystem. This research aims to understand how start-ups can get access to resources from outside their entrepreneurial ecosystem and thus helps to better understand how start-ups can overcome the constraints faced in the resource endowments layer. Fourth, there are no studies that specifically address how start-ups can overcome the constraints faced in the institutional arrangements layer. I discuss how entrepreneurial support organizations can change the institutions in an entrepreneurial ecosystem, thereby helping start-ups overcome institutional constraints.

These studies lay the groundwork for part two of this dissertation and for answering the main research question. In part two, I first address the research gap that there is limited evidence on how sustainable start-ups balance their environmental and business performance. Balancing these types of performances is a crucial part of combining the environmental and economic goals with which they are founded. I study how different sustainable start-ups characteristics influence both performance types. Second, I address the main research gap of this dissertation by studying how the generic and specific elements of sustainable entrepreneurial ecosystems influence the presence of sustainable start-ups. A summary of these research gaps and an overview of the chapters in which they will be addressed is provided in Table 1.1. on how sustainable start-ups balance their environmental and business performance. Balancing these types of performances is a crucial part of combining the environmental and economic goals with which they are founded. I study how different sustainable start-ups characteristics influence both performance types. Second, I address the main research gap of this dissertation by studying how the generic and specific elements of sustainable entrepreneurial ecosystems influence the presence of sustainable start-ups. A summary of these research gaps and an overview of the chapters in which they will be addressed is provided in Table 1.1.

Table 1.1. Overview of the research gaps addressed in this dissertation.

Research gap	**Chapter**
There is no operationalization of entrepreneurial ecosystems and no quantitative evidence on their influence on start-ups	Chapter 2
There is no clear evidence on whether there is persistence of productive entrepreneurship in regions	Chapter 3
There is a need to understand whether start-ups can interact across entrepreneurial ecosystem boundaries to overcome resource constraints	Chapter 4
It is unclear how the institutional constraints of start-ups can be addressed	Chapter 5
There is insufficient evidence on how the fact that sustainable start-ups balance economic and environmental aspirations influences both dimensions of performance	Chapter 6
There is no clear overview of which generic and specific entrepreneurial ecosystem elements influence the presence of sustainable entrepreneurship	Chapter 7

1.6 Overview of this thesis

In this section I outline the remaining chapters of this dissertation in more depth. I discuss their respective research questions[1]. Because the state-of-the art regarding each question is different I employ different data and methods for each study. I outline these shortly in this section and provide a summary in Table 1.2. Table 1.2 also includes the author teams for each chapter and the publication status of the respective chapters. Because all empirical chapters are co-authored I, in the remainder of the section and in all these chapters, use we instead of I to reflect the collaborative nature of the research.

Chapter 2:

There is a lot of theoretical and case study work already done on entrepreneurial ecosystems and their influence on entrepreneurs (Wurth et al., 2022). However, at the time of writing, there were very few empirical analyses and operationalizations of the entrepreneurial ecosystem framework. A notable exception was Stam & van de Ven (2021) who focus only on the Netherlands. The lack of an operationalization means that there was not yet systematic empiric evidence that confirms the relevance of the

1 As a result of path dependency during the publication process some research questions are formulated slightly different in the individual chapters than they are in the outline of my dissertation. However, the underlying objectives remain the same.

entrepreneurial ecosystem beyond theoretical work and case studies. This study will be the first to create a harmonized dataset to measure entrepreneurial ecosystems at the regional level in a large number of countries.

Furthermore, operationalizing the entrepreneurial ecosystem is a necessary step to study the influence of sustainable entrepreneurial ecosystems on sustainable start-ups. In this chapter we address this research gap by operationalizing the entrepreneurial ecosystem framework and empirically testing whether the theorized framework indeed influences productive entrepreneurship. In doing so we address the following two research questions:

How can we operationalize the elements of entrepreneurial ecosystems?

How do the elements of entrepreneurial ecosystems influence the presence of start-ups?

Addressing these specific research questions will enable me to address the main research question in chapter 7. There is already a multitude of papers with conceptual work or case studies on entrepreneurial ecosystems, but there are very few quantitative analyses, hence this paper takes a quantitative approach in operationalizing the entrepreneurial ecosystem elements and in testing their influence on the presence of start-ups. We do so using data on 31,236 start-ups from 273 European NUTS-2 regions.

Chapter 3:

The entrepreneurial ecosystem approach rests on the assumption that the prevalence of productive entrepreneurship is enabled by regional entrepreneurial ecosystem conditions. However, Coad and Srhoj (2023) suggest that this assumption does not hold. They show that the prevalence of high-growth firms, a proxy for productive entrepreneurship, is hardly persistent at the regional level in Croatia and Slovenia. According to them the relationship between regional entrepreneurial ecosystem conditions and the prevalence of high-growth firms is so noisy that the entrepreneurial ecosystem approach is not a useful approach for policymakers with regards to generating high-growth firms. This is a substantial critique as its questions the validity of the entrepreneurial ecosystem framework. This questions whether the entrepreneurial ecosystem framework is suitable to address the main research gap of this dissertation. To study whether the entrepreneurial ecosystem framework can be used as a suitable approach we address the following question in this chapter:

What is the influence of entrepreneurial ecosystems on the persistence of productive entrepreneurship?

In this second study (chapter 3) we provide a rebuttal of the arguments by Coad and Srhoj (2023) by replicating and extending their study. We argue that their interpretation and generalization are incorrect. We introduce three hypotheses on the mechanism between EEs and their outputs and provide empirical evidence for these hypotheses. In contrast to the findings of Coad and Srhoj (2023) we find substantial persistence in the prevalence of high-growth firms. Based on these analyses, the findings by Coad and Srhoj (2023), and other empirical studies we further articulate the entrepreneurial ecosystem framework. We explain differential persistence in the prevalence of productive entrepreneurship based on the quality and size of entrepreneurial ecosystems. We do so using data on high-growth firms in the Netherlands at both the NUTS-2 and NUTS-3 level and data on innovative start-ups from 273 European NUTS-2 regions.

Chapter 4:

In this chapter, we focus on the interactions across entrepreneurial ecosystems and the resource endowments layer of the entrepreneurial ecosystem. We established that sustainable start-ups suffer from resource constraints, they need more resources than their regular counterparts. The entrepreneurial ecosystem literature does contain several studies that describe how entrepreneurs obtain access to resources (van Rijnsoever, 2020; van Rijnsoever et al., 2016; van Weele et al., 2019, 2017). However, this research currently stops at the pre-defined spatial boundaries of an entrepreneurial ecosystem (Cobben et al., 2022; Schäfer, 2021; Wurth et al., 2022). This entails the often-implicit assumption that start-ups only acquire resources from actors located within their own entrepreneurial ecosystem. The current approach of treating entrepreneurial ecosystems as isolated analytical units thus results in an incomplete understanding of how start-ups can get access to resources. It ignores the influence of outside actors, conditions, and other entrepreneurial ecosystems (Theodoraki and Catanzaro, 2022; Xu et al., 2023). This makes it particularly interesting to look across the boundaries of entrepreneurial ecosystems to understand when and how start-ups get access to resources across regional boundaries. These insights contribute to the main research question of my dissertation by delving into the specific role of resources in entrepreneurial ecosystems and whether start-ups can also get these resources from outside of their entrepreneurial ecosystem.

As a second contribution we engage with the existing debate on entrepreneurial ecosystem boundaries. Most research pre-defines the spatial boundaries of an entrepreneurial ecosystem as coinciding with administrative borders (Cobben et al., 2022; Schäfer, 2021; Wurth et al., 2022). An approach that my colleagues and I also follow in Chapters 2 and 3 and Chapter 7. However, several authors (e.g. Fischer et al., 2022; Schäfer, 2021) question the relevance of these regional boundaries. We find that several entrepreneurial ecosystem actors dynamically enact boundaries of the entrepreneurial ecosystem to coincide with the boundaries of the administrative units. This provides some validation for the use of these boundaries. We make these contributions by asking the following research question:

What drives and hinders interactions across the boundaries of entrepreneurial ecosystems?

We study cross-entrepreneurial ecosystem interactions in the entrepreneurial ecosystem rather than just the sustainable entrepreneurial ecosystem because resource interactions in entrepreneurial ecosystems will generate a more complete understanding of the possibilities for sustainable entrepreneurs to access resources from other (sustainable) entrepreneurial ecosystems. Hence, it is more valuable to look at all resources rather than just sustainability resources. This is also in line with the conceptualization of a sustainable entrepreneurial ecosystem as both nested in the generic entrepreneurial ecosystem and extending beyond it through a sustainability specification. On the topic of cross-entrepreneurial ecosystem interactions there is only some early theoretical work (Fischer et al., 2022; Schäfer, 2021; Theodoraki and Catanzaro, 2022). Therefore, we take an explorative approach and use qualitative methods to obtain in depth insights in the mechanisms. Sustainable start-ups face several resource constraints highlighted by market and financial constraints. We study when and how interactions across the boundaries of entrepreneurial ecosystem happen and how this influences the access to resources for start-ups. This provides insights in how start-ups, and sustainable start-ups can overcome resource constraints in their ecosystem. We do so by using data from interviews with 45 actors from three entrepreneurial ecosystems in the Netherlands.

Chapter 5:

In this chapter we focus on the institutional arrangements layer of the entrepreneurial ecosystem. We established that institutional constraints are an important barrier for sustainable start-ups. These institutional constraints could be reduced by actors who engage in institutional entrepreneurship, the process of creating new or changing existing institutions (Battilana et al., 2009; DiMaggio, 1988; Dorado, 2005; Gurses and Ozcan, 2015). However, start-ups are not the ideal actor to engage in institutional entrepreneurship due to their limited legitimacy (Hyytinen et al., 2015; Kuratko et al., 2017; Truong and Nagy, 2020). Entrepreneurial support organizations often do not encounter these same legitimacy issues. They are well-positioned to become institutional entrepreneurs since they occupy a central position in social networks (Theodoraki et al., 2018; van Rijnsoever, 2020) and possess the status and resources needed to act as institutional entrepreneurs (Aernoudt, 2004; Hansen et al., 2000). In this chapter we study how and when entrepreneurial support organizations change institutions in the entrepreneurial ecosystem. This provides insight in how entrepreneurial ecosystems can help sustainable start-ups overcome their institutional constraints which is a part of the main research question. In doing so we answer the following research question.

How do public and private entrepreneurial support organizations differ in the strategies that they use to change or create normative, regulative and cultural-

cognitive institutions in different institutional contexts?

Similar to chapter 4, we study institutional entrepreneurship in the entrepreneurial ecosystem rather than just the sustainable entrepreneurial ecosystem because studying the strategies employed by entrepreneurial support organizations in entrepreneurial ecosystems will generate a more complete understanding of the strategies that can be employed by entrepreneurial support organizations in sustainable entrepreneurial ecosystems. Hence, it is more valuable to look at institutional change rather than only at institutional change for sustainability. Because there is little prior work to build on regarding the topic of institutional change in entrepreneurial ecosystems this study employs a qualitative approach. This approach allows us to obtain in depth insight in the mechanisms. We do so using data from 29 interviews with 17 incubators located in seven cities in the Netherlands.

Chapter 6:

In this chapter we move from the entrepreneurial ecosystem to the individual sustainable start-ups. We have established that sustainable start-ups are internally constrained because they have to balance economic and environmental aspirations. This means that they balance their business and their environmental performance. In doing so, technology characteristics are a key component. Both because the technology is a part of the constraints faced by sustainable start-ups, and because technology characteristics are expected to influence both performance measures. In this chapter we study environmental performance by looking at the climate performance of a set of sustainable start-ups. This chapter takes a micro-perspective by looking at the performance of sustainable start-ups and in this we address the following research question:

What is the influence of the technology characteristics of sustainable start-ups on their business and climate performance?

Through this chapter we also provide insight in what defines a sustainable start-up and what factors influence its performance. This is a crucial step in understanding how entrepreneurial ecosystems influence sustainable start-ups, which is the main research question of my dissertation. There are several case studies and theoretical articles that cover how sustainable start-ups navigate the tensions between their performance objectives (Jolink and Niesten, 2015; Smith et al., 2013; Stubbs, 2017). We therefore use a quantitative approach to test which start-up characteristics influence both performance dimensions and whether this entails potential trade-offs between them. We do so using data on a set of 197 sustainable start-ups from eight European countries.

Chapter 7:

In this chapter we bring together the perspectives and insights of the studies on entrepreneurial ecosystems and on sustainable start-ups. We study how sustainable entrepreneurial ecosystems influence the presence of sustainable start-ups in regions. First, we combine innovation systems and entrepreneurial ecosystem literature to argue the structure of a sustainable entrepreneurial ecosystem. We then test if the resulting framework indeed predicts the presence of sustainable start-ups. In doing so we answer the following research question.

What is the influence of the generic and specific elements of sustainable entrepreneurial ecosystems on the presence of sustainable start-ups?

There are several conceptual papers and case studies that address the topic of sustainable entrepreneurial ecosystems (DiVito and Ingen-Housz, 2021; O'Shea et al., 2021; Volkmann et al., 2021). However, a systematic evaluation of which conditions influence the presence of sustainable start-ups is lacking (Theodoraki et al., 2018; Volkmann et al., 2021). We use quantitative analyses to perform such a systematic evaluation. We do so using data on 46,741 start-ups, 6% of which are sustainable, located in 273 European NUTS-2 regions.

Chapter 8:

In this chapter I first synthesize the main findings of this dissertation and answer the overall research question. I then discuss the empirical findings of the individual chapters and build on this by discussing the overarching theoretical and policy implications. Finally, I discuss relevant limitations and outline avenues for further research that build on the research of this dissertation.

Table 1.2. An overview of the data, methodology, author teams, and publication status for the chapters included in this dissertation.

Chapter	Data	Methodology	Authors	Publication status
Chapter 2	Operationalization of the ten entrepreneurial ecosystem elements and location of 31,236 start-ups for 273 European NUTS-2 regions.	Quantitative	Leendertse, J. Schrijvers, M. Stam, E.	Published in Research Policy
Chapter 3	HGF data for 12 NUTS-2 and 40 NUTS-3 regions in the Netherlands and start-up data for 273 European NUTS-2 regions.	Quantitative	van Dijk, J. Leendertse, J. Stam, E. van Rijnsoever, F.J.	Resubmitted to Research Policy after revisions
Chapter 4	Interviews with 45 entrepreneurial ecosystem actors from three entrepreneurial ecosystems in the Netherlands.	Qualitative	Leendertse, J. Baggen, Y. Mahdad, M. Dolmans, S.	Submitted to Small Business Economics
Chapter 5	29 interviews with 17 entrepreneurial support actors from seven cities in the Netherlands.	Qualitative	de Boer, T. Leendertse, J. van Rijnsoever, F.J.	Resubmitted to Small Business Economics after revisions
Chapter 6	Start-up characteristics and performance data from 197 sustainable start-ups from eight European countries.	Quantitative	Leendertse, J. Van Rijnsoever, F.J. Eveleens, C.P.	Published in Business, Strategy, and the Environment
Chapter 7	Operationalization of the elements of sustainable entrepreneurial ecosystems, and location of 46,741 start-ups for 273 European NUTS-2 regions. We used web scraping and text analyses to identify 6% of the start-ups as sustainable start-ups.	Quantitative	Leendertse, J. van Rijnsoever, F.J.	Resubmitted to Small Business Economics after revisions

2.

Measure Twice, Cut Once: Entrepreneurial Ecosystem Metrics

This chapter has been published in Research Policy as Leendertse, J., Schrijvers, M.T., Stam, E. 2022. Measure Twice, Cut Once Entrepreneurial Ecosystem Metrics. 51(9) 104336. Helpful comments have been received from seminar audiences at Utrecht University, University of Pecs, University of Torino, United Nations University – MERIT, Sant'Anna School of Advanced Studies Pisa, Southampton University, IMT Institute of Advanced Study Lucca, Strathclyde Business School.

Abstract

Despite the popularity of the entrepreneurial ecosystem approach in science and policy, there is a scarcity of credible, accurate and comparable metrics of entrepreneurial ecosystems. This is a severe shortcoming for both scientific progress and successful policy. In this paper, we bridge the entrepreneurial ecosystem metrics gap. Entrepreneurial ecosystems consist of the actors and factors that enable entrepreneurship. We use the entrepreneurial ecosystem approach to quantify and qualify entrepreneurial economies. We operationalize the elements and outputs of entrepreneurial ecosystems for 273 European regions. The ecosystem elements show strong and positive correlations with each other, confirming the systemic nature of entrepreneurial economies and the need for a complex systems perspective. Our analyses show that physical infrastructure, finance, formal institutions, and talent take a central position in the interdependence web, providing a first indication of these elements as fundamental conditions of entrepreneurial ecosystems. The measures of the elements are used to calculate an index that approximates the quality of entrepreneurial ecosystems. This index is robust and performs well in regressions to predict entrepreneurial output, which we measure with novel data on productive entrepreneurship. The entrepreneurial ecosystem approach and the metrics we present, provide a lens for public policy to better diagnose, understand and improve entrepreneurial economies.

2.1 Introduction

Even though the academic literature on entrepreneurial ecosystems has been flourishing recently, it does not yet provide an actionable framework for economic policy. An important reason for this is the scarcity of credible, accurate and especially comparable metrics of entrepreneurial ecosystems. An entrepreneurial ecosystem comprises a set of interdependent actors and factors that are governed in such a way that they enable productive entrepreneurship within a particular territory (Stam, 2015; Stam and Spigel, 2018). The entrepreneurial ecosystem approach has become popular due to the gradual shift from managerial economies to entrepreneurial economies (Thurik et al., 2013). In these entrepreneurial economies, entrepreneurship is considered a key driver of economic change (Schumpeter, 1934).

The entrepreneurial ecosystem approach offers a lens to empirically trace the systemness of entrepreneurial economies and the degree to which economic systems produce entrepreneurship as an emergent property of the system (Brown and Mason, 2014; Isenberg, 2010; Stam, 2015). It is instrumental to synthesize and integrate a large variety and quantity of data to measure the (changing) nature, outputs and outcomes of (regional) economies (Stam, 2015). The entrepreneurial ecosystem approach thus has the potential to provide an actionable framework that guides policymaking.

However, the scarcity of sufficient metrics on entrepreneurial ecosystems makes it difficult to have adequate diagnosis and monitoring in the policy cycle. The lack of adequate diagnosis and monitoring is one reason why economic policy often fails to achieve its objectives and learn from previous mistakes. The objective of this paper is to quantify and qualify regional economies with an entrepreneurial ecosystem approach. We address the metrics gap by developing and applying entrepreneurial ecosystem metrics to analyze entrepreneurial economies. These metrics enable adequate diagnosis of entrepreneurial economies and allow for the monitoring of economic change generated by policy and other dynamics. This paper thus takes heed of the old carpenter's adage "measure twice, cut once", by reducing policy failures with better measurement tools.

While the entrepreneurial ecosystem approach has become very prominent over the last decade, it still lacks empirical evidence. The existing empirical studies are often qualitative case studies, such as those by Spigel (2017) in Canada and Mack and Mayer (2016) in the US. There are earlier attempts to measure entrepreneurial ecosystems with quantitative data, such as the study by Ács et al. (2014). However, these studies focus on the national level (Ács et al., 2014; Radosevic and Yoruk, 2013). In this study we instead focus on the regional level, because entrepreneurship is largely a regional event(Feldman, 2001), and there is substantial variation in entrepreneurship between regions within countries (Fritsch and Wyrwich, 2014; Sternberg, 2009). The level of the (city-)region is generally seen as the more adequate level from a policy (Katz and Bradly, 2013; Spigel, 2020) and entrepreneurship practice (Feld, 2012; Feldman, 2001) point of view. This study will be the first to create a harmonized dataset to measure entrepreneurial ecosystems at the regional level in a large number of countries.

Developing entrepreneurial ecosystem metrics encompasses quantification and qualification. Quantification involves measuring the key elements with a wide range of data sources (Credit et al., 2018). Qualification involves developing a methodology that provides insight into the extent to which these elements are interdependent, into the overall quality of entrepreneurial economies, and how this relates to entrepreneurial outputs. We have three main research questions.

First and foremost, how can we compose a harmonized dataset to measure the quality of key elements of entrepreneurial economies? We develop a universal set of constructs for each entrepreneurial ecosystem element, and we source data from a large variety of datasets to compose credible, accurate, and especially comparable metrics of entrepreneurial ecosystems. We measure entrepreneurial ecosystems with a harmonized dataset in the context of 273 regions in 28 European countries. Europe provides an excellent laboratory for analyzing entrepreneurial economies because it contains a large number of regions that exhibit striking variation in socio-economic conditions, entrepreneurial activity, and economic growth.

Second, to what extent and how are the elements of entrepreneurial economies interdependent? Interdependence is a key aspect of complex systems (Aghion et al., 2009; Simon, 1962). Studying if there are strong interdependencies between the elements thus helps answer the question whether entrepreneurial economies can be seen as complex systems. Using multiple statistical methods, we show to what extent and how the elements of entrepreneurial economies are interdependent.

Third, how can we determine the quality of entrepreneurial economies? We answer this question with a synthesis of our entrepreneurial ecosystem element metrics into an entrepreneurial ecosystem index. We then analyze the relation of the entrepreneurial ecosystem index to entrepreneurial outputs. Entrepreneurial output is an indicator of the emergent property of entrepreneurial economies. We use multiple data sources and metrics to determine entrepreneurial outputs at the regional level. Using novel methods, including web scraping and geocoding, we determine entrepreneurial outputs per region in the form of the number of (Crunchbase listed) innovative new firms and unicorns – young private firms with a valuation of more than $1 billion.

The outline of our paper is as follows. First, we discuss the key mechanisms that explain the prevalence of entrepreneurship and economic development. Second, we discuss and develop the measures needed to approximate the key elements of entrepreneurial economies. These measures allow us to quantify the elements and to qualify entrepreneurial economies. Third, we relate the developed metrics to entrepreneurial outputs. The final sections conclude, reflect on the findings and policy implications, and set out an agenda for further research.

2.2 Entrepreneurship and economic development

In this section, we discuss the state of the art of empirical research on the (inter) relation between entrepreneurship and (regional) economic development, synthesize this into an entrepreneurial ecosystem framework, and advance our understanding of entrepreneurial ecosystems with a complex systems perspective. The empirical literature on entrepreneurship and (regional) economic development can be divided into the economic growth literature[1], focusing on the aggregate economic growth effects of entrepreneurship, and the geography of entrepreneurship literature, focusing on the causes of the spatial heterogeneity of entrepreneurship. In the following two sections, we summarize the insights from these two types of literature.

2.2.1 Entrepreneurship and economic growth

The role of entrepreneurship in economic development has been studied for a long time, going back to Schumpeter (1934), Leibenstein (1968) and Baumol (1990). The economic growth literature is mainly concerned with the question of how and to what extent entrepreneurship affects economic growth. Even though the literature does not provide full consensus on the positive effects of entrepreneurship, there seems to be more evidence in favor of than against positive (causal) effects of entrepreneurship on economic growth (Audretsch et al., 2006; Bosma et al., 2018; Carree and Thurik, 2010; Fritsch, 2013). Key causal mechanisms are the creation and diffusion of innovations and the competition created by entrepreneurs (Bosma et al., 2018). The direction and strength of the effect of entrepreneurship on economic growth depend on the type of context and the type of entrepreneurship. Ambitious, opportunity and growth-oriented types of entrepreneurship are more likely to lead to economic growth than self-employed, necessity-based entrepreneurship (Bosma et al., 2018, 2011; Fritsch, 2013; Stam et al., 2011; Stam and Van Stel, 2011). In addition, entrepreneurship is most productive in contexts with inclusive and growth-enhancing institutions (Bosma et al., 2018; Sobel, 2008). Entrepreneurship does not occur in a vacuum but is very much a local event (Feldman, 2001). There is also substantial regional variation in the prevalence of entrepreneurship, with underlying causes being very much spatially bound (Alvedalen and Boschma, 2017; Guzman and Stern, 2015).

1 While this literature is very extensive, we focus exclusively on the studies measuring the effects of (different types of) entrepreneurship.

2.2.2 The geography of entrepreneurship

The literature on the geography of entrepreneurship has provided numerous insights into the role of different factors enhancing the prevalence of entrepreneurship in regions (Bosma et al., 2011; Stam, 2010; Stam and Spigel, 2018; Sternberg, 2009). We summarize the empirical literature on the geography of entrepreneurship with ten elements affecting the prevalence of entrepreneurship (cf. Stam, 2015; Stam and van de Ven, 2021). The first element, formal institutions, provides the fundamental preconditions for economic action (Granovetter, 1992)and for resources to be used productively (Acemoglu et al., 2005). Formal institutions are not only a precondition for economic action to take place; they also affect the way entrepreneurship is pursued and the welfare consequences of entrepreneurship (Baumol, 1990). Informal institutions - in particular an entrepreneurship culture, which reflects the degree to which entrepreneurship is valued in society - also have substantial effects on the prevalence of entrepreneurship (Fritsch and Wyrwich, 2014). Networks of entrepreneurs provide an information flow, enabling an effective distribution of knowledge, labor and capital (Malecki, 1997). A highly developed physical infrastructure (including both traditional transportation infrastructure and digital infrastructure) is a key element of the context to enable economic interaction and entrepreneurship in particular (Audretsch et al., 2015). Access to finance - preferably provided by investors with entrepreneurial knowledge - is crucial for investments in uncertain entrepreneurial projects with a long-term horizon (see e.g. Kerr and Nanda, 2009). Leadership provides direction for the entrepreneurial ecosystem. This leadership is critical in building and maintaining a healthy ecosystem (Feldman, 2014) and involves a set of 'visible' entrepreneurial leaders committed to the region (Feldman and Zoller, 2012). The high levels of commitment and public spirit of regional leaders might reflect underlying norms dominant in a region (Olberding, 2002). Perhaps the most important condition for entrepreneurship is the presence of a diverse and skilled group of workers ('talent': see e.g. Acs and Armington, 2004; Glaeser et al., 2010; Lee et al., 2004; Qian et al., 2013). An important source of opportunities for entrepreneurship can be found in knowledge from both public and private organizations (see e.g. Audretsch and Lehmann, 2005). In addition, the presence of financial means in the population to purchase goods and services - preferably locally, but possibly also at a further distance - is essential for entrepreneurship to occur at all. The presence of demand thus is an important element of the entrepreneurial ecosystem. Income and purchasing power in a region is both a cause and an effect of entrepreneurship in a region (Berkowitz and DeJong, 2005), hinting at the role of feedback effects in the evolution of entrepreneurial ecosystems. Finally, the supply of support services by various intermediaries can substantially lower entry barriers for new entrepreneurial projects, and reduce the time to market of innovations (Clayton et al., 2018; Howells, 2006; Zhang and Li, 2010).

2.2.3 An entrepreneurial ecosystem framework

It is necessary to combine the approaches of economic growth and geography of entrepreneurship to understand the long-term development of economies and the role of entrepreneurship. Entrepreneurship plays a double role: it is the output variable in the geography of entrepreneurship approach, and it is the input variable in the economic growth approach. To complicate matters even more, entrepreneurship and economic growth also affect the inputs of the geography of entrepreneurship approach, for example with serial entrepreneurs becoming venture capitalists and creating networks; and with economic growth leading to growth in demand, investments in knowledge, and congestion effects in the physical environment. One solution to these conceptual complications is to build on complex systems approaches (Arthur, 2013; Hidalgo and Hausmann, 2009; Ostrom, 2010; Simon, 1962) to develop and use a complex systems perspective on the evolution of entrepreneurial economies (Feld and Hathaway, 2020; Roundy et al., 2018; Stam and van de Ven, 2021). A complex systems perspective is able to integrate the geography of entrepreneurship and economic growth literature. We build on the integrative model of entrepreneurial ecosystems by Stam and van de Ven (2021), which includes institutional arrangements and resource endowment elements (see Fig. 2.1). The model consists of three key mechanisms: interdependence and coevolution of elements, upward causation of the ecosystem on entrepreneurship, and downward causation of entrepreneurial outputs on the quality of the ecosystem (Stam and van de Ven, 2021).

The empirical literature on the geography of entrepreneurship and economic growth reveals several factors to be relevant in explaining the spatial heterogeneity in entrepreneurship. This suggests that there is a limited set of factors that affects the prevalence of entrepreneurship in a region. The insights from the empirical literature on the geography of entrepreneurship and economic growth can be integrated into one figure (see Fig. 2.1), reflecting an entrepreneurial ecosystem framework with ten elements (cf. Stam, 2015; Stam and Spigel, 2018; Stam and van de Ven, 2021). This framework with ten elements (cf. Stam, 2015; Stam and Spigel, 2018; Stam and van de Ven, 2021), five (Vedula and Kim, 2019), six (Isenberg and Onyemah, 2016), seven (Radosevic and Yoruk, 2013) and 14 elements (Ács et al., 2014).

We build on these frameworks and develop them further by separating system inputs and outputs, providing an academically grounded set of elements, and using empirical indicators more closely reflecting productive entrepreneurship (Baumol, 1990; Schumpeter, 1934).

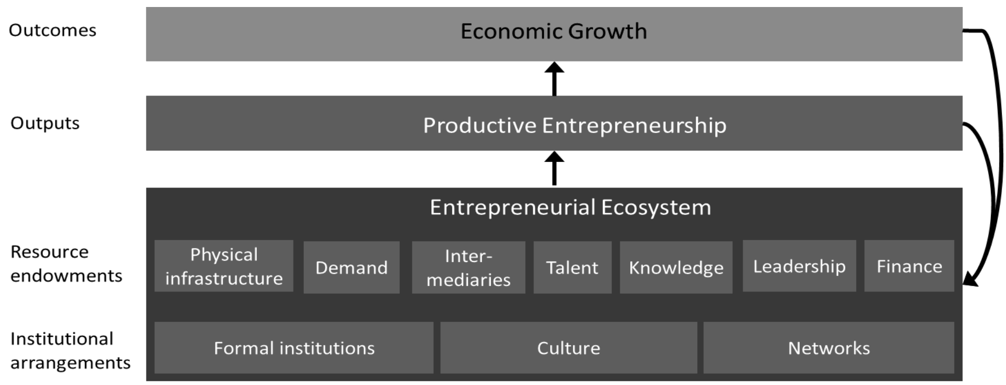


Fig. 2.1. Elements, outputs and outcomes of an entrepreneurial ecosystem (adapted from Stam, 2015; Stam and van de Ven, 2021).

2.3 Measuring entrepreneurial ecosystems

The ecosystem framework discussed above identifies ten key elements of an entrepreneurial ecosystem. Based on previous literature (Stam, 2015; Stam and van de Ven, 2021; Wurth et al., 2022), these ten ecosystem elements should be able to capture the most essential conditions for entrepreneurship to flourish. In this section, we discuss how we source data from a large variety of datasets to compose credible, accurate and especially comparable metrics of entrepreneurial ecosystems. Since there is no perfect dataset available for measuring entrepreneurial ecosystems, we have to compose one, with imperfections that we will discuss. This is also an invitation for follow-up research to improve our metrics when new data becomes available.

Several existing metrics studies on the regional level focus on themes closely related to entrepreneurship, especially in the European Union. For example, the Regional Competitiveness Index (RCI) (Annoni and Dijkstra, 2019) measures the general competitiveness of a region, including factors such as human capital and infrastructure. While the RCI and other studies such as the Regional Innovation Scoreboard (RIS) include several key indicators related to entrepreneurship, none of these explicitly focus on entrepreneurship. Therefore, a study starting from a clearly defined framework and explicitly focusing on productive entrepreneurship provides a novel and valuable contribution to understanding entrepreneurial conditions in a region.

We thus set out to operationalize the entrepreneurial ecosystem elements into measurable variables at the appropriate geographical level. We start by discussing the boundaries of an ecosystem to determine the appropriate level of analysis. Then we shortly illustrate the main data sources and describe the operational measures of each ecosystem element (for an overview, see Table 2.1).

2.3.1 Level of analysis

The outputs and outcomes of entrepreneurial ecosystems result from a complex set of actors and factors that occur in a temporal and varying regional setting. As Feldman and Lowe (2015, p. 1785)rightly state, there is often a disconnect "between the theoretical definition of a region as integrated contiguous space and the political and census geography for which data are readily available". In addition, since ecosystems are continuously evolving and are not limited to a specific sector, it is hard to precisely determine their boundaries (Stam and van de Ven, 2021). The primary demarcation criterium should be the spatial reach of the causal mechanisms involved. This does not lead to one straightforward unit or spatial level of analysis.

First, given the multiplicity of causal mechanisms involved in nurturing entrepreneurship, there will be different spatial reaches: for talent, it may be the daily urban system (within a 50-mile radius), while for credit it may be the local bank, and for venture capital a two-hour drive radius (which may overlap with the regional level in large countries, but might be beyond the national level for small countries).

Second, there is a spatial nestedness of contexts: formal institutions at the municipal, regional, national, and supranational level might be important context conditions. These first two considerations make it difficult to delineate the spatial boundary of entrepreneurial ecosystems from a causal mechanism point of view.

From a practitioners' point of view, the stakeholders of entrepreneurial ecosystems, the relevant boundaries will again differ depending on their role in the ecosystem. For civil servants, it will be a particular jurisdiction, while for entrepreneurs it may be a multiplicity of layered (regional, national) or connected ecosystems (different city-regions). To determine the spatial level of analysis (although almost always imperfect), we therefore search for a common spatial denominator in combination with data availability (to allow for comparisons). It should be kept in mind that even though we choose a spatial unit to represent the entrepreneurial ecosystem, entrepreneurial ecosystems are not closed containers but open systems.

In the European context, the most relevant spatial level of analysis is between the municipal and national level, since the spatial reaches of the different elements are most likely to overlap with regional boundaries (e.g., the 50-mile radius for talent). The regional level in Europe is best defined through the NUTS 2 classification, which identifies 281 geographical regions[2] over the 27 member states and the United Kingdom. The boundaries of NUTS 2 regions are based on existing administrative boundaries and population thresholds. The population of a NUTS 2 unit is roughly between 800,000 and 3 million people (European Commisson, 2018).

2 We remove seven French and Spanish regions that are located in either Africa or South America as there is limited data available for these regions, and we perceive them as significantly different from the European regions.

While for some countries and/or indicators, data is available on the more fine-grained NUTS 3 level; this was not the case for most countries or indicators we are interested in. We therefore decide to keep the unit of analysis at NUTS 2 as this would enable us to cover a larger set of regions all over Europe. It is important to include a large set of regions because it enables comparison, which is one of the main goals of this paper. This is the first step, and future studies could dive deeper into certain topics or countries and use more detailed data to do so. By defining entrepreneurial ecosystems at the NUTS 2 level, we use the same region size as the recent study by Stam and van de Ven (2021) but instead of one country, we include all countries in the European Union and the United Kingdom.

A disadvantage of looking at regions is that data on a regional level is, for most countries, scarcer than national data. However, the European Union performs several large data collection exercises on the regional level to inform regional policy, which results in the availability of a fairly large amount of regional data. Furthermore, we use web scraping to create new metrics at the regional level. Finally, we use several national measures to account for the aforementioned spatial nestedness of, for example, institutions. This combination of data on different geographical levels is discussed in detail for each element below and summarized in Table A1 in the Appendix.

2.3.2 Data sources and element construction

To measure the entrepreneurial ecosystem elements, we combine data from various sources and complement this with data obtained by web scraping. For most elements, we use very specific datasets, e.g., for finance we use the regional venture capital data of Invest Europe and for formal institutions the Quality of Government Survey. For other elements, we use specific indicators from existing datasets on related topics, e.g., the accessibility of a region from the Regional Competitiveness Index (RCI) for physical infrastructure or the percentage of innovative SMEs that collaborate from the Regional Innovation Scoreboard (RIS) for networks. The data sources used for each element are described in detail below.

When operationalizing the ecosystem elements, we aim to get the most robust measure possible with the lowest number of indicators. In doing so, we consider and combine the accuracy – do they accurately capture what we aim to measure? – the credibility – can the sources be confidently relied on? – and the comparability of data sources – is comparable data available for all regions? For accuracy reasons, we choose to measure some elements with multiple indicators, but we sometimes have to resort to one indicator per element for credibility and comparability reasons. In the discussion, we will elaborate on how the operationalization of the elements can be improved in the future.

We choose to measure some elements with multiple indicators for two reasons. First, some elements such as institutions are multi-faceted and hard to capture in one variable. In particular, there is a certain spatial nestedness when studying regional ecosystems. Second, some elements can be measured on a more general level and in a more specific manner for entrepreneurs, such as the workforce's education level and specific entrepreneurial skills. We thus combine variables to capture these various dimensions of one element.

Seven of the ten elements are constructed by combining multiple indicators. For those elements, we calculate the element score by first standardizing the individual measures (mean of 0 and standard deviation of 1). This ensures that the different measures each have a proportionate influence on the composite indicator. We then take the average of the standardized measures.

To measure four of our variables, high-growth firms, unicorns, leadership, and the number of incubators, we use the location of individual organizations to calculate a regional aggregate measure. The methodology of geocoding and region allocation for these measures is as follows. First, we use the nominatim package in R to geocode the given locations using OpenStreetMap (OpenStreetMap, 2019; Rudis, 2019). This is an online map that allows users to pass a list of locations into the software and obtain their coordinates. For the few regions without a match in this procedure, we manually search and add their coordinates. Subsequently, we used Eurostat shapefiles to determine in which NUTS 2 region these coordinates are located. These shapefiles contain an exact overview of the NUTS 2 boundaries (Eurostat, 2019). We then use the rgdal package in R to assign the coordinates to the corresponding NUTS 2 region (Bivand et al., 2019; Eurostat, 2019). With this procedure, we can assign 99.9% of the organizations to a region. We manually searched the remaining organizations and located the remaining geocodes through the browser tool of OpenStreetMap. After this, we were able to assign all organizations for all four variables to a region. For each of the four variables, we then count the number of organizations in each NUTS 2 region and divide this by the region's population to obtain our final measure.

For a few indicators, in some countries, data is only available at the NUTS 1 level. In those cases, we follow the approach of previous measurement studies and impute the NUTS 1 values for the NUTS 2 regions (Annoni and Dijkstra, 2019; Hollanders et al., 2019; Léon et al., 2016). While this is a second-best strategy, we only had to do this imputation for a maximum of five countries for seven (of the 33) indicators. Table A1 clearly describes these cases. Since the number of observations affected is relatively small, we do not expect this to affect our results significantly. Future research efforts to collect data for these indicators at NUTS 2 level would clearly improve our dataset. Table 2.1 provides an overview of each element's empirical indicators and data source, while Table A1 in the Appendix provides a more detailed description for each measure.

Table 2.1. Operationalization of the indicators of entrepreneurial ecosystem elements and output.

Elements	**Description**	**Empirical indicators**	**Data source**
Formal institutions	The rules of the game in society	Two composite indicators measuring the overall quality of government (consisting of scores for corruption, accountability, and impartiality) and the ease of doing business	Quality of Government Survey (QOG) and the World Bank Doing Business Report
Entrepreneurship culture	The degree to which entrepreneurship is valued in a region	A composite measure capturing the regional entrepreneurial culture, consisting of entrepreneurial motivation, cultural and social norms, importance to be innovative, and trust in others	Global Entrepreneurship Monitor (GEM) and European Social Survey (ESS)
Networks	The connectedness of businesses for new value creation	Percentage of SMEs that engage in innovative collaborations as a percentage of all SMEs in the business population	Regional Innovation Scoreboard (RIS)
Physical Infrastructure	Transportation infrastructure and digital infrastructure	Four components in which the transportation infrastructure is measured as the accessibility by road, accessibility by railway and number of passenger flights and digital infrastructure is measured by the percentage of households with access to internet	Regional Competitiveness Index (RCI)
Finance	The availability of venture capital and access to finance	Two components: The average amount of venture capital per capita and the percentage of SMEs that is credit constrained	Invest Europe and European Investment Bank (EIB)
Leadership	The presence of actors taking a leadership role in the ecosystem	The number of coordinators on H2020 innovation projects per capita	Community Research and Development Information Service (CORDIS)
Talent	The prevalence of individuals with high levels of human capital, both in terms of formal education and skills	Four components: The percentage of the population with tertiary education, the percentage of the working population engaged in lifelong learning, the percentage of the population with an entrepreneurship education, the percentage of the population with e-skills	Eurostat and the Global Entrepreneurship Monitor (GEM)

New Knowledge	Investments in new knowledge	Intramural R&D expenditure as a percentage of Gross Regional Product	Eurostat
Demand	Potential market demand	Three components: disposable income per capita, potential market size expressed in GRP, potential market size in population. All relative to EU average.	Regional Competitiveness Index (RCI)
Intermediate services	The supply and accessibility of intermediate business services	Two components: the percentage of employment in knowledge-intensive market services and the number of incubators/accelerators per capita	Eurostat and Crunchbase
Output	Entrepreneurial output	The number of Crunchbase firms founded in the past five years per capita	Crunchbase
	Unicorn output	The absolute number of unicorns in the region founded in the last ten years	CB Insights and Dealroom

2.3.3 Formal institutions

Well-functioning institutions are essential for entrepreneurship (Granovetter, 1992). Even when fundamental conditions of the institutional framework, e.g. property rights, are in place, the quality of these institutions affects entrepreneurship (Baumol, 1990; Boudreaux and Nikolaev, 2019; Webb et al., 2019). To operationalize this element, we use a generic and an entrepreneurship specific indicator. These indicators cover two different aspects of the institutional environment, namely the overall quality of government and the regulatory framework for businesses.

To operationalize the quality of government, we use the Quality of Government study (QOG), which is the largest subnational governance study that has been performed (Charron et al., 2019). The Quality of Government study has been used in numerous other studies and is a reliable measure of institutional quality (Charron et al., 2019). The quality of government indicator consists of three components: corruption, accountability, and impartiality. These are each measured by a large regional citizen survey and complemented by the World Governance Indicators on a national level. The survey questions measure both experiences and perceptions of institutions in the particular region of the respondent (Charron et al., 2019). This measure thus accounts for the nestedness of the regional variation in the quality of government within national institutions.

To measure the entrepreneurship specific regulatory framework, we use a composite indicator: the Ease of doing business index from the World Bank, which incorporates seven elements concerning business regulations at the national level (World Bank, 2014). These elements are highly linked to national regulations, and as such, a national measure is sufficient for this indicator. By combining this entrepreneurship specific national measure with the regional measure for the quality of governance, we arrive at a measure capturing a combination of general and entrepreneurship specific institutions.

2.3.4 Entrepreneurship culture

The next element, culture, represents an informal institution. Entrepreneurship culture can be described as how much entrepreneurship is valued and stimulated in a society (Fritsch and Wyrwich, 2014). The cultural context can have a substantial effect on entrepreneurship by influencing the aspirations of entrepreneurs and whether people are likely to become an entrepreneur at all (Wyrwich et al., 2016).

To measure entrepreneurship culture, we use four indicators: entrepreneurial motivation and cultural and social norms encouraging new business activity from the Global Entrepreneurship Monitor (GEM) measured at the country level (Bosma and Kelley, 2019), and the perceived importance of being innovative and creative, and trust in others from the European Social Survey[1] measured at the NUTS 2 level (Norwegian Center for Research Data, 2014)[2]. Again, we combine entrepreneurship specific measures with a more general measure of the regional culture (trust). This general indicator is important because in societies where people trust others it is, for example, easier to have economic interaction and invest in the first place (Zak and Knack, 2001).

2.3.5 Networks

When actors in a region are well connected in networks, this allows information, labor and knowledge to flow to firms that can use it most effectively (Malecki, 1997). Networks are essential for entrants as it helps new firms to build social capital, which firms can leverage to access resources, information and knowledge (Eveleens et al., 2017; van Rijnsoever, 2020). The connections between firms can be measured through their cooperation projects. Our focus on entrepreneurship entails that we specifically want to measure cooperation on innovative projects. Therefore, we measure networks as the number of Small and Medium Enterprises (SMEs) that collaborate

1 Data on these variables is missing for six regions; for these regions we calculated the culture score based on the two indicators for which data was available. We performed robustness checks in which we set the value for these indicators to the European average and in which we removed these regions. Both did not significantly affect our results, proving the robustness of this choice.

2 Stam and Van de Ven (2021) use the number of new firms per 1,000 inhabitants as an alternative measure of culture. We initially aimed to combine our current indicator with this data. However, there is not (yet) a harmonized dataset on this variable for all European NUTS 2 regions, and we thus had to use a combination of OECD, Eurostat, and national statistics offices to construct this variable (see Table A1). These data sources were not consistent in their definitions and data demarcations. Hence, we deemed the validity of this alternative measure to be questionable, and we excluded this measure from our analyses. We did perform a robustness test in which we combined the birth rate of new firms with our current culture measure. The results of our analyses remained largely identical.

on innovation projects as a percentage of all SMEs in a specific region. These SMEs will not all necessarily be entrepreneurial firms, but the focus on innovation projects means this measure captures the kind of productive collaboration that is likely to contribute to entrepreneurial output. We therefore believe that this is the best data currently available. In addition, the size of SMEs (enterprises with between 10 and 250 employees) matches our focus on entrepreneurial growth since it does not include micro firms (less than ten employees) or large firms, both of which are less relevant for our research goal. We use the data from the RIS, complemented with the European Innovation Scoreboard (EIS) for countries with only one NUTS 2 region. The RIS and EIS base their data on the Community Innovation Survey, a large survey on innovation activity including thousands of enterprises in every country in the European Union (Arundel and Smith, 2013).

2.3.6 Physical infrastructure

Physical infrastructure is essential for economic interaction between actors and thus essential for entrepreneurship as well (Audretsch et al., 2015). In this highly digital world, not only physical infrastructure enables this interaction but also digital infrastructure. Digital infrastructure provides the opportunity to meet other actors, even if they are not in close physical proximity. Therefore, it is important to include this when creating an empirical measure of infrastructure. For our indicator, we follow the approach of the RCI, which uses accessibility by road, accessibility by railway and the number of passenger flights to measure the physical (transportation) infrastructure of a region (for details, see Table A1). To this, we add a measure for the digital infrastructure of a region, which is the percentage of households with internet access and also available from the RCI (Annoni and Dijkstra, 2019).

2.3.7 Finance

An important condition for starting a new firm and growing an existing firm is access to capital. (see e.g. Kerr and Nanda, 2009; Samila and Sorenson, 2010). We measure the availability of capital with two indicators: the amount of venture capital and the percentage of SMEs that is financially constrained. Again, this is a combination of an entrepreneurship specific and a general measure. It is valuable to add a measure of finance constrained firms because this is not limited to one specific form of finance and thus takes into account that firms may use different financial resources in different countries (Criscuolo and Menon, 2015).

Venture capital is measured as the average amount of venture capital in the last five years per capita. The data for this variable is from Invest Europe, an association of private capital providers which conducts research on private equity activity in Europe (Invest Europe, 2020). The percentage of finance constrained SMEs is taken from the investment survey by the European Investment Bank (Alanya et al., 2019). SMEs are enterprises with less than 250 employees. They are considered financially constrained when they were either rejected for loans or received less than applied for, or were discouraged from applying because it was too expensive or they expected to be turned down. The use of data on SMEs does, similarly to the measure for networks, not fully overlap with our focus on productive entrepreneurship but is again the best data available.

2.3.8 Leadership

Leadership in an entrepreneurial ecosystem is necessary to provide the actors in the ecosystem with a certain direction or vision to work towards and make the ecosystem function more effectively (Normann, 2013). Leadership can be provided by individual leaders but also by collaborative efforts that try to guide the system in a certain direction. Since leadership is an intangible concept, it is quite hard to measure and remains understudied (Sotarauta et al., 2017). Our study operationalizes leadership as the number of project coordinators of Horizon 2020 innovation projects in a region.[3] We thus follow the approach of Stam and van de Ven (2021), who use the number of innovation project leaders as their operationalization for leadership. Although this measure is not limited to entrepreneurial leaders, it does capture whether organizations in a region are willing to initiate new and innovative projects. These organizations, either public or private, are likely to create collective action in entrepreneurial ecosystems. To construct this variable, we use the CORDIS database, which contains data on 23,693 innovation projects that are subsidized as part of the Horizon 2020 program of the European Union (CORDIS, 2019; European Commission, 2019). We then use the geocoding approach outlined in section 3.3 to create our leadership indicator, the number of innovation leaders per capita.

2.3.9 Talent

Human capital (or talent) encompasses individuals' skills, knowledge and experience (Stam and van de Ven, 2021). Human capital is a critical input for entrepreneurship and has been shown to be linked to new firm formation (see e.g. Acs and Armington, 2004; Glaeser et al., 2010). It is clearly a broad concept that asks for several empirical measures to cover its different facts adequately. We break human capital down into two different components: general human capital and entrepreneurship specific human capital (Becker, 1964; Rauch and Rijsdijk, 2013). We use two measures for the general human capital component, both from Eurostat (Eurostat, 2020). The first measure is the percentage of the population having completed tertiary education and the second

3 Horizon 2020 is the research and innovation program funded by the European Commission. It encompasses private-public partnerships working on innovation projects with the aim to stimulate economic growth in the European Union (European Commission, 2019).

measure is the percentage of the population aged 25-64 that participates in education or training (lifelong learning).

Entrepreneurship specific human capital is directly related to start-up activities (Brüderl et al., 1992; Rauch and Rijsdijk, 2013). We include two measures: the quality of entrepreneurship and business education from the GEM (Bosma and Kelley, 2019), and the percentage of the population with high-level e-skills from Eurostat (Eurostat, 2020). The inclusion of digital skills is important because digital literacy is essential for working in any type of enterprise in the current digital society. In addition, a lot of productive forms of entrepreneurship currently involve some digital aspects.

2.3.10 Knowledge

The creation of new knowledge by either private or public organizations provides new business opportunities (Kim et al., 2012; Qian et al., 2013). It is therefore an important source of entrepreneurship. We measure this element as the intra-mural R&D expenditure as a share of the total Gross Regional Product (GRP). This measure includes R&D spending in both the public and private sectors. The higher the investment in R&D, the more knowledge is likely to be produced, which can then be translated into business opportunities. The data for this variable is available in both the Regional Competitiveness Index (Annoni and Dijkstra, 2019) and Regional Innovation Scoreboard (Hollanders et al., 2019). We choose to use the data from the RCI as this is available at the NUTS 2 level for a larger number of regions.

2.3.11 Demand

The purchasing power and potential demand for goods and services are important for entrepreneurs since it will only be interesting to market new products if the population has the financial means to buy them. Several studies have shown that market growth increases firm entry (Eckhardt and Shane, 2003; Sato et al., 2012). Even though most firms nowadays serve larger markets than just those in their own region, it is important for start-ups to have a potential regional market which they can easily access (Cortright, 2002; Reynolds et al., 1994; Schutjens and Stam, 2003). We measure the demand using data from the RCI, which combines three measures (Annoni and Dijkstra, 2019). The measures are disposable income per capita, potential market size expressed in GRP, and potential market size expressed in population. This measure captures both consumer demand and demand from existing businesses in the region.

2.3.12 Intermediate services

Intermediate services or producer services can help producers to start a new enterprise and market an innovation. This support can substantially lower entry barriers for new entrepreneurial projects and speed up the introduction of innovations (Howells, 2006; Zhang and Li, 2010). For this element, we again combine a general and an entrepreneurship specific measure. We operationalize the general measure as employment in knowledge-intensive market services representing the general availability of intermediate services, such as legal, marketing, accountancy, and consultancy services. The required data is available in Eurostat (Eurostat, 2020).

For the entrepreneurship specific measure, we look at incubators and accelerators as intermediate service providers. These organizations specifically aim to help people with innovative ideas to start their own companies. Incubators and accelerators typically provide various services such as access to networks of entrepreneurs and training in business skills (Cohen et al., 2019b; Eveleens et al., 2017; van Weele et al., 2017). Several studies have shown that incubators and accelerators can significantly contribute to the success of start-ups (see Ayatse et al. (2017) and Eveleens et al. (2017)). Since these organizations are put in place to support entrepreneurs and can improve the performance of new firms, it is important to include them in the analysis. For this variable we scraped a total of 950 incubators and accelerators from the Crunchbase website (Crunchbase, 2019). We then use the geocoding approach outlined in section 3.3 to determine the number of incubators per capita in a specific region. Note that we measure the prevalence of intermediate services in general and incubators and accelerators in particular, but not the quality of these services per se.

2.3.13 Entrepreneurial Ecosystem Index

To determine the quality of entrepreneurial ecosystems, we explore the option of combining the measures of the ten elements of the entrepreneurial ecosystem to calculate an index. The calculation is done using the same method applied in Stam and van de Ven (2021). This approach relies on the crucial assumption that all ten elements are of equal importance in the ecosystem as we standardize the value for the different elements. This is clearly a very agnostic approach since one could think of reasons why certain elements should be given more weight than others. Some studies have investigated this and found that certain factors matter more than others (see e.g. Corrente et al. (2019)). However, these studies used other elements and data, and it is therefore not possible to directly transfer these weights to our data. We are aware that the index we create in this manner will not be a final solution. Instead, we present it here as a first step to determine the quality of entrepreneurial ecosystems using the metrics we have developed in the previous sections. We also perform a principal components analysis in the next section, which does not rely on the assumption that all components are equally important, as an alternative method of combining the elements. Subsequently, we also perform a series of robustness checks on the index. Finally, we present a future research agenda on ways to further improve the measurement of the quality of entrepreneurial ecosystems that includes weighting the different elements.

To calculate the index, we first standardize the composite indicators which we have created for each element. This ensures that all elements get similar weights in the creation of the index. Subsequently, to normalize the standardized values, we take the inverse natural log of the standardized values. This is necessary because normalizing requires division by the mean, which is 0 after standardization. We then normalize the element values by setting the European average of each element to 1 and by letting all other regional values deviate from this. If an element in a region performs less than average, this results in a value between 0 and 1; above-average performing regions have a value above 1. This allows us to compute an index value based on the ten elements and compare the quality of different entrepreneurial ecosystems. We calculate the Entrepreneurial Ecosystem Index in three ways. First, in an additive way (E1 + E2 +...+E10) where regions with an average value on each element will thus score an index value of 10. Second, to better account for the systemic nature of the entrepreneurial ecosystem, we also calculate the index in a multiplicative manner (E1*E2*...*E10). The disadvantage of the normalization around 1 in both these indices is that values above 1 have a stronger effect on the index than below-average values, which are between 0 and 1. We therefore take the natural logarithm to let the values oscillate symmetrically around 0; this logarithmic way (log(E1) + log(E2) +....+log(E10)) is our third index value.

2.3.14 Output

The output of the entrepreneurial ecosystem is productive entrepreneurship (see Fig. 2.1). This kind of entrepreneurship contributes to the economy's output and consequently leads to aggregate value creation, which is the outcome of the system (Baumol, 1990). Previous research has shown that proxies of productive entrepreneurship have strong positive effects on economic growth and job creation (Criscuolo et al., 2014; Haltiwanger et al., 2013; Stam et al., 2011; Wong et al., 2005). Productive entrepreneurship is a subset of total entrepreneurship and thus requires another measure than, for example, the total number of new firms.

In this study, we take the number of new firms (i.e. founded less than five years ago) that are registered in Crunchbase as our measure for entrepreneurial output (Crunchbase, 2019; Dalle et al., 2017). Crunchbase predominantly captures venture capital oriented innovative entrepreneurial firms and largely ignores companies without a growth ambition and is thus a good source for data on productive entrepreneurship (Dalle et al., 2017). We choose the five-year timeframe to ensure that we select firms that experience their growth phase during the same time period (2015-2019) as most of our indicators are measured (see Table A1). This time period also helps to limit our sample towards innovative new firms as Crunchbase also includes incumbent, long-established, innovative firms. Our sample includes 31,236 innovative new firms. The data on Crunchbase mostly comes from two channels, a community of contributors and an extensive investor network. This data is then validated with other data sources using AI and machine-learning algorithms.

A limitation of the Crunchbase dataset is that it is uncertain if the coverage of start-ups is equal among the different countries. Overall, we find that around 0.2% of all new European firms are registered in Crunchbase.[4] This varies between 0.003% and 1.5% and follows a (zero-inflated) normal distribution.[5] We further acknowledge that not all start-ups are innovative (cf. Autio et al., 2014), and are also aware that our measure of entrepreneurial output does not capture all innovative activity in the economy. Nevertheless, Crunchbase is currently the most comprehensive dataset available to measure innovative new firms as entrepreneurial output (Dalle et al., 2017). Crunchbase is increasingly used for academic research (Dalle et al., 2017; Nylund and Cohen, 2017). We also explored using the ORBIS data of Bureau Van Dijk as an alternative (Bureau van Dijk, 2020; Dalle et al., 2017). However, we perceived this data to be inadequate for our purposes. First, the serial correlation between the different years in the database was very low. Second, the data also contained disproportionally large differences between countries, which were hard to render and would thus impede cross country regional comparisons. We did perform a robustness test on our measure of entrepreneurial output using data provided by Dealroom (Dealroom, 2021). Similarly to Crunchbase, Dealroom provides data on start-ups.[6] The correlation between the Crunchbase and Dealroom output measures was 0.841, and regressions using the Dealroom data resulted in nearly identical results (Table A2).

In addition to the Crunchbase output measure, we use a measure for extreme entrepreneurial output in the form of unicorns, which are young private firms valued above $1 billion. Data was collected from CB Insights which keeps a list of current unicorn companies all over the world (CB Insights, 2020). As these firms are so rare, all (49) firms founded in the last ten years that acquired unicorn status were included. This was done by scraping data from historical web pages of the internet archive and cross-checking this with Dealroom data (Dealroom, 2021).[7] We then used the geocoding procedure to allocate these 49 unicorns to a total of 20 NUTS 2 regions. As such, unicorns are a scarce and selective form of productive entrepreneurship that is only present in a small number of regions. Besides unicorns being a scarce type of

4 The data sources for the number of new firms in each country are outlined in Table A1.

5 However, one specific region (UKI3 – Inner London West) has an extreme value of 11,3%. This extreme value is also reflected in our Crunchbase output measure. Further research showed that this was partly the result of all central London based start-ups being assigned to UKI3 instead of to both UKI3 and UKI4 (UKI4 – Inner London East) due to these regions having the same name in Crunchbase. We therefore decided to combine these regions to form one Inner London region. Nevertheless, this region remained an extreme value and to achieve a normal distribution for the regression analyses, we performed a Tukey transformation ($\lambda = 0.2$) on this variable. In the next section, we discuss the remaining transformations in our data preparations.

6 We obtained data from Dealroom on 31,761 start-ups founded between 2016 and 2020.

7 We used Dealroom data for the unicorn variable because Dealroom keeps a list of all European unicorns.

organization, the value of unicorns as a measure of productive entrepreneurship has also been a topic of discussion (see for example Aldrich and Ruef, 2018; Economist, 2019), which is why we only use this as an additional output measure.

2.3.15 Extreme values

Since the European Union covers a large and diverse set of regions, the data show a lot of variety. In particular, for the measures of knowledge, intermediate services, leadership, and entrepreneurial output there are a few regions with very high values (up to 14 times the standard deviation). Even though this variation is plausible, these outliers do disproportionally influence the correlation results and regression results. Most importantly, for the regions that score extremely high on one particular indicator, the index for the quality of the entrepreneurial ecosystem is disproportionally influenced by that indicator. This does not reflect the systemic nature of entrepreneurial ecosystems as argued in the existing academic literature (Spigel, 2017; Stam, 2015). Therefore, we performed two transformations on the data to provide better interpretable results. First, before the standardization of the composite indicators, we cap the maximum value at four standard deviations of the mean (for more information on the standardization procedure, see section 3.14 on index calculation).[8] In practice, this means that we change the values for UKI3&4 (Inner London) of the Crunchbase output, leadership, and intermediate services measures, for DE91 (Braunschweig) of knowledge (as a result of the high R&D intensity), and DK01 (Hovedstaden) of leadership. Without these transformations, the high deviations of these values skew the outcomes of the normalization process in such a way that only a few regions achieve above-average scores.

Second, we set the maximum score for any single element to five to prevent a disproportionate influence of strong performing ecosystem elements on the overall index. We perform several robustness checks on the construction of our index, which we discuss in Appendix

2.4 Quantifying and qualifying entrepreneurial ecosystems in Europe

2.4.1 Descriptive statistics

The descriptive statistics of the empirical measures for the ten ecosystem elements, entrepreneurial outputs, and index scores are shown in Table 2.2. In total, our data covers 273 NUTS 2 regions divided over the 27 EU member states and the United Kingdom.

8 We performed a robustness test in which we implemented a cap at three standard deviations; this required capping a total of twelve regional values but did not significantly change our findings.

Table 2.2. Descriptive statistics

	N	Mean	Standard Deviation	Minimum	Maximum
Crunchbase output	273	0.852	1.018	0.014	5.000 (31.958)
Unicorn output	273	0.179	1.051	0.000	15.000
Formal institutions	273	1.000	0.812	0.098	3.497
Culture	273	0.990	1.072	0.026	5.000 (6.219)
Networks	272	0.984	1.147	0.117	5.000 (6.110)
Physical infrastructure	272	0.907	1.060	0.058	5.000 (8.916)
Finance	273	0.993	0.823	0.053	5.000 (6.907)
Leadership	273	0.703	1.111	0.181	5.000 (25.751)
Talent	273	0.968	0.964	0.072	5.000 (11.913)
Knowledge	273	0.722	1.031	0.109	5.000 (33.503)
Demand	273	1.000	0.932	0.032	4.761
Intermediate services	273	0.697	1.014	0.082	5.000 (56.011)
EE index additive	272	8.934	6.462	1.262	35.081
EE index multiplicative	272	323.444	2778.293	0.000	39364.109
EE index logarithmic	272	-6.061	7.157	-21.962	10.581

Notes: The uncorrected maximum value of each element is presented between brackets. We do not have data for all elements for Aland, a small island region of Finland, so the total number of regions for which we calculate the index is 272.

We see a large variation for several variables, from regions with less than 2 percent of the EU average to regions with over 56 times the average value. These findings are nevertheless in line with our expectations since we study regions across different countries and levels of development. Looking at the three index values that we calculated using the methods of Stam and van de Ven (2021), we find that the difference between the smallest and largest value for the multiplicative index is a factor 10^{15}. This difference is disproportionately large compared to the actual variation in the data, as a result of the multiplicative way of calculating the index. Hence, we deem the external validity of the multiplicative index to be insufficient and instead use the additive and the logarithmic indices in our further analyses. Throughout the remainder of this study, we primarily focus on the additive index due to the intuitiveness of its interpretation.

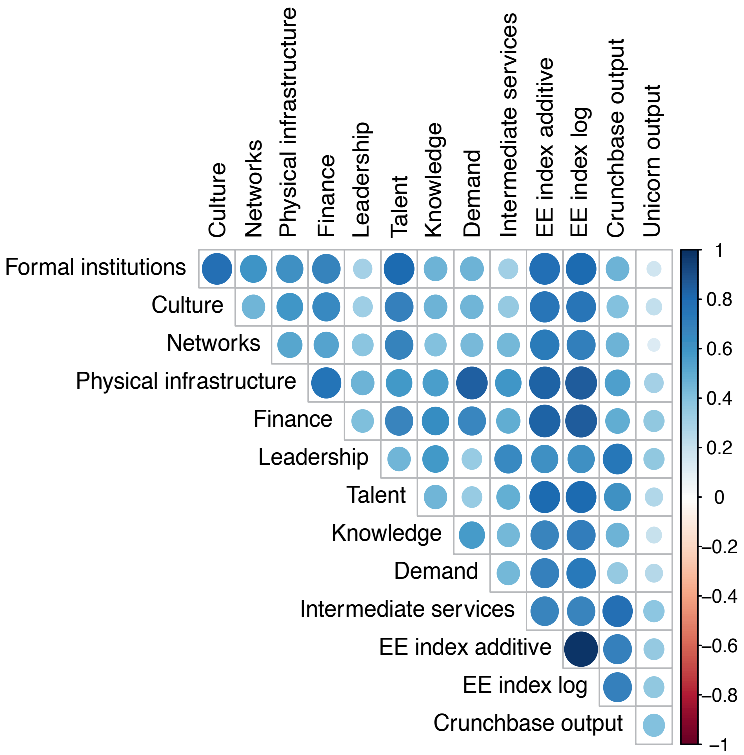
2.4.2 Interdependence between entrepreneurial ecosystem elements

Table 2.3 shows the correlations between the different elements of the entrepreneurial ecosystem, the index, and the outputs. We see high, positive, and significant correlations between all of the elements of the ecosystem.[9] The strong positive correlations illustrate the interdependencies in the entrepreneurial ecosystem. This corresponds to the results shown in Stam and van de Ven (2021) and confirms the systemic nature of

9 For an overview of the numeric correlation coefficients with p-values see Table A2.

entrepreneurial ecosystems. Considering the entrepreneurial output measures, we see positive and significant correlations with all elements, and with the entrepreneurial ecosystem indices we constructed.

Table 2.3. Correlation matrix. Correlation coefficient is indicated by color and the significance level by size, only correlations that are significant at 5% level are shown.



We use a network methodology to show the interdependencies between the ten elements in Fig. 2.2. Physical infrastructure and finance take the most central position in the interdependence web. This central role is supported by the finding that physical infrastructure and finance have respectively eight and six interdependencies with a correlation above 0.5 (Fig. 2.3), followed by formal institutions and talent that each have five. When looking at the interdependencies with correlations above 0.6, formal institutions and finance are the most central in the interdependence web, with each of the five correlations above 0.6 (Fig. 2.3). Physical infrastructure, culture, and talent also have central positions with four correlations above 0.6. Finally, formal institutions and physical infrastructure each have two interdependencies with correlations above 0.7 (see also Table A3). This provides an indication for a potential role of these elements as fundamental conditions of the entrepreneurial ecosystem.

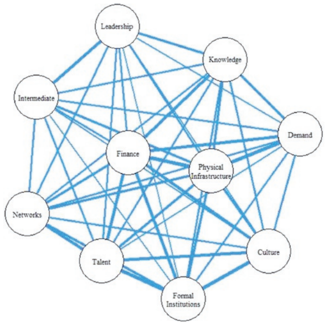


Fig. 2.2. Interdependence web of entrepreneurial ecosystem elements with the blue lines indicating positive correlations. The edge weight is defined based on the correlation strength.

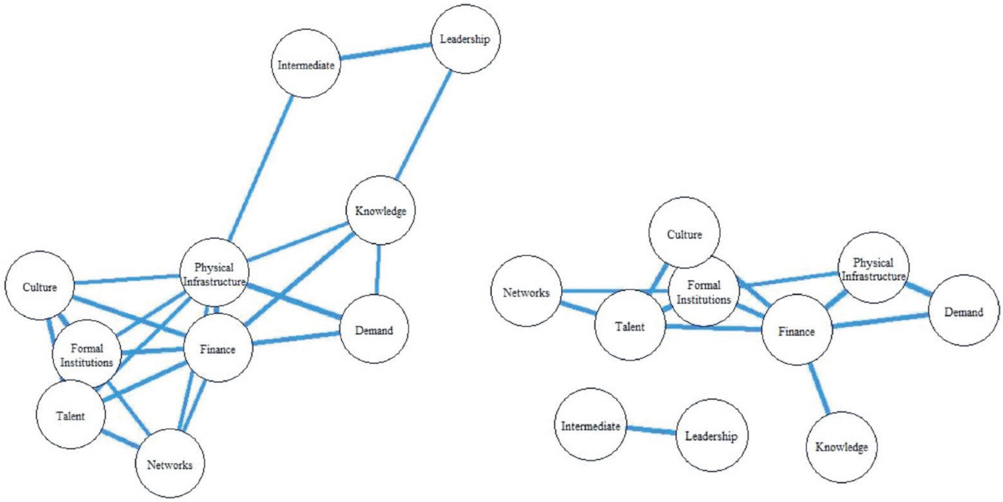


Fig. 2.3. Interdependence webs of entrepreneurial ecosystem elements with correlations above 0.5 (left) and 0.6 (right)

To further explore the interdependencies, we performed principal component analysis (PCA) on the ten individual elements. This method does not assume that all elements are equally important as the elements are assigned different loadings. The results are presented in Table 2.4; the first component explains 44.9% of the variance and has loadings of 0.21 or higher for all components. The four elements with the highest loadings are finance (0.40), physical infrastructure (0.38), talent (0.36), and formal institutions (0.35). This result confirms our findings from the interdependence graphs, which show a strongly connected set of elements with a central role for the elements of finance, physical infrastructure, talent, and formal institutions. The second component, which explains an additional 12.8% of the variation, has loadings of 0.21 or higher for six components. Similarly, the third component explains 12.4% of the variation and here six elements have loadings above 0.24. The results of the PCA thus confirm the strong interdependencies between the entrepreneurial ecosystem elements. The high loadings of all elements also show that all elements are related to the underlying dimensions of the data and are thus likely to be relevant to the entrepreneurial ecosystem.

Table 2.4. Principal components analysis

	PC1	PC2	PC3
Proportion of Variance	0.449	0.128	0.124
Standard Deviation	2.119	1.132	1.113
Cumulative Variance	0.449	0.577	0.701
Formal institutions	0.348	-0.476	0.161
Culture	0.308	-0.164	0.437
Networks	0.212	-0.393	-0.367
Physical infrastructure	0.379	0.041	-0.381
Finance	0.397	0.133	-0.041
Leadership	0.249	0.478	0.154
Talent	0.356	-0.256	0.357
Knowledge	0.222	0.207	0.240
Demand	0.334	0.039	-0.541
Intermediate	0.297	0.484	0.032

2.4.3 Entrepreneurial Ecosystem Index

We now use the Entrepreneurial Ecosystem Index to determine the strongest and weakest entrepreneurial ecosystems in Europe. The scores for the ten highest (Fig. 2.4) and lowest ranking (Fig. 2.5) regions are shown in the bar graphs below. The highest scoring regions are, as expected, mainly Western European and densely populated, while the lowest scoring regions are mainly Bulgarian and Greek rural regions. To look at the different entrepreneurial ecosystems in more detail, Fig. 2.6 shows the map of Europe with all NUTS 2 regions colored based on the value of the Entrepreneurial Ecosystem Index. The highest index values can be found in European capital regions, including London, Helsinki, and Stockholm. Many regions in Eastern Europe show very low index values, as do some of the more rural areas in Spain. The map also shows that there is a substantial difference between urban and rural areas. Most of the high-scoring regions include large cities. In section 4.6, we will compare our index to existing variables and rankings (including GDP and the RCI) to discuss the added value of the Entrepreneurial Ecosystem Index.

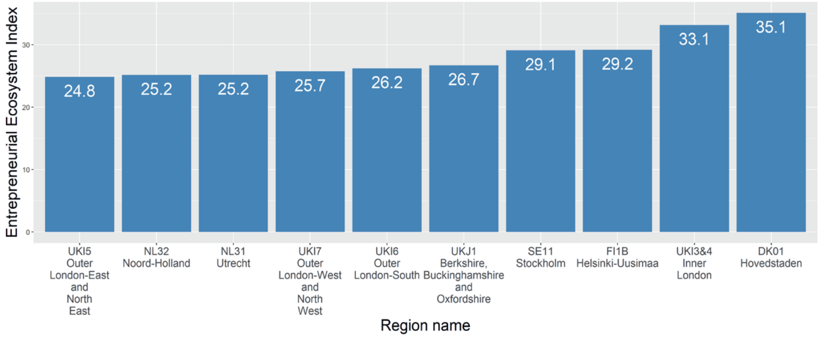


Fig. 2.4. NUTS 2 regions with the highest Entrepreneurial Ecosystem Index scores.

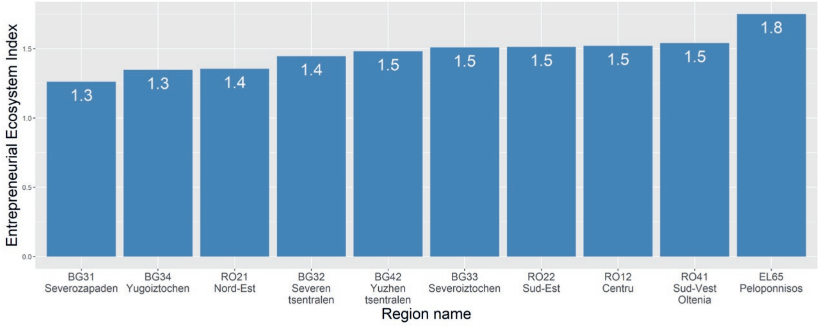


Fig. 2.5. NUTS 2 regions with the lowest Entrepreneurial Ecosystem Index scores.

The Entrepreneurial Ecosystem Index adds the different elements and subsequently creates a ranking based on the total value of the ten elements. A different approach to classify regions is to use cluster analysis on the ten ecosystem elements, which creates groups of regions closest to each other on the scores for each element. Particularly, we use k-means clustering, which minimizes the total intra-cluster variation (sum of squared errors) using Euclidean distance measures for an a priori fixed number of clusters (Tan et al., 2018). K-means clustering is the most popular clustering technique and was originally proposed by MacQueen (1967). The number of clusters is a parameter that has to be set by the researcher. After considering the total intra-cluster variation, the average silhouette of clusters, the gap statistic, and the interpretability of the outcomes, we selected the approach with three clusters. The results (Table 2.5) show a sizeable first cluster that includes low-performing regions, including for example Athens, Budapest, and Sicily. The second cluster forms a middle group and includes Manchester, Cologne, and Luxembourg. Finally, the third cluster is the smallest group with high performing regions, including Berlin, London, and Brussels. Table 2.5 shows a clear pattern in the average index values of the regions across the clusters. This is further confirmed through the visual representation of the clusters, which shows that the cluster distribution closely aligns with the scores of the Entrepreneurial Ecosystem Index (Fig. A1 in the Appendix). Using clustering as an alternative method to classify regions, we thus find highly similar results to the index.

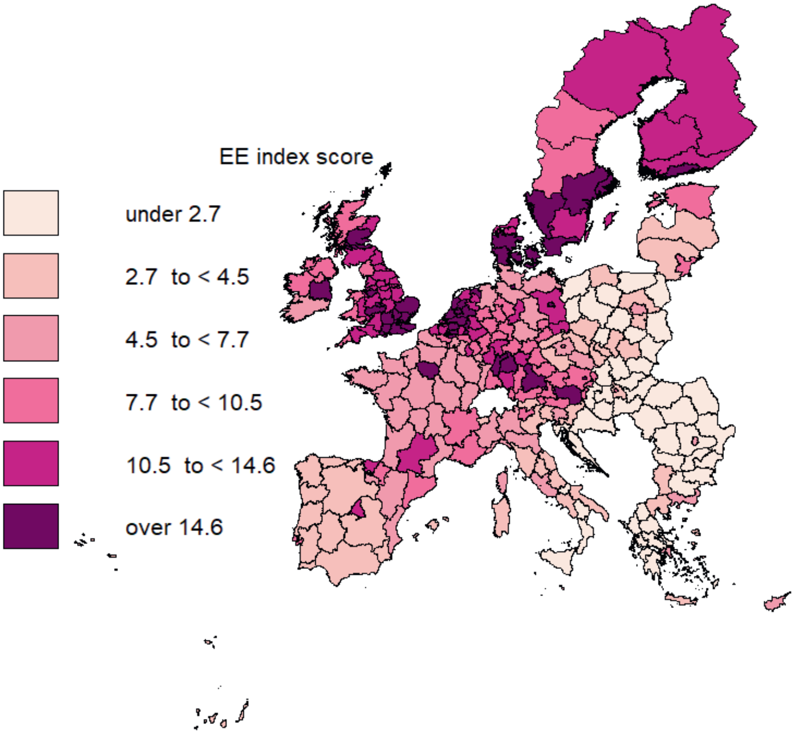


Fig 2.6. Map of NUTS 2 regions showing Entrepreneurial Ecosystem Index (273 regions are divided among groups of equal size).

Table 2.5. Summary statistics of index and output by cluster

	Cluster 1 (N=148)	**Cluster 2 (N=95)**	**Cluster 3 (N=29)**	**Overall (N=272)**
Crunchbase output				
Mean (SD)	0.575 (0.767)	0.777 (0.554)	2.51 (1.64)	0.852 (1.02)
Median [Min, Max]	0.337 [0.0143, 5.00]	0.685 [0.178, 4.47]	2.18 [0.288, 5.00]	0.466 [0.0143, 5.00]
EE index additive				
Mean (SD)	4.34 (2.25)	12.0 (2.62)	22.3 (5.13)	8.93 (6.46)
Median [Min, Max]	3.58 [1.26, 11.4]	11.8 [7.58, 19.1]	21.4 [14.4, 35.1]	7.66 [1.26, 35.1]

EE index log				
Mean (SD)	-11.3 (4.75)	-1.39 (2.34)	5.32 (2.52)	-6.06 (7.16)
Median [Min, Max]	-11.5 [-22.0, -1.56]	-1.52 [-6.34, 3.51]	5.09 [0.970, 10.6]	-5.29 [-22.0, 10.6]
Unicorn output				
Mean (SD)	0.0203 (0.183)	0.0316 (0.176)	1.48 (2.91)	0.180 (1.05)
Median [Min, Max]	0 [0, 2.00]	0 [0,1.00]	0 [0, 15.0]	0 [0, 15.0]

2.4.4 Entrepreneurial Ecosystem Index and entrepreneurial output

After discussing the creation and reliability of the Entrepreneurial Ecosystem Index, we now use regression analysis to study if regions with better ecosystems indeed have higher entrepreneurial outputs. Table 2.5 shows that the regions in the third cluster with a high Entrepreneurial Ecosystem Index score have significantly higher outputs than the middle and laggard clusters. This indicates that the relation between the index and entrepreneurial output is not linear. A scatter plot of the Entrepreneurial Ecosystem Index and Crunchbase output confirms this suggestion (Fig. 2.7).

An increase in performance on the index thus goes together with a disproportionately large increase in the number of Crunchbase firms. To capture this nonlinearity in the relation between the quality of an entrepreneurial ecosystem and its entrepreneurial outputs, we performed a regression with quadratic effects; for the results, see Table A4 in the Appendix. The quadratic effects are significant ($p<0.001$) and show that the relation between the index and the entrepreneurial output is indeed nonlinear. However, the convex relationship between the index and output means that adding quadratic effects forces a quadratic curve on the observations that looks like a U-shape. This is an unintended side effect of using quadratic effects in linear regression.[10]

Therefore, to better capture the nonlinear relationship between the index and output, we instead perform a piecewise linear regression. This allows breakpoints in the regression line that is fitted to the data. The results are presented in Fig. 2.7 and Table 2.6[11]. The breakpoint that optimizes model fit for the additive index is located at an index score of 19.[12] At this point, the slope quite sharply increases from 0.08 to 0.39. For both the

10 We use the two lines test of Simonsohn (2018) to confirm that there is indeed no U-shape relationship between the index and output.

11 Our findings are robust when using Dealroom data. These results can be found in Table A2.

12 We get a very similar result when we allow for a structural break in the line. The primary method shown assumes a continuous relationship and uses the R package 'segmented' (Muggeo, 2008).

first and the second line, we find a positive and statistically significant relationship between the index and entrepreneurial output ($p<0.01$). The large increase in the slope of the regression line further shows there is a small group of regions with very high performance regarding entrepreneurial output at the high end of the index. This corresponds with our findings in the cluster analysis presented above. The results of the regression analyses with the unicorn output as a dependent variable are consistent with the findings reported in Table 2.6 and are presented in Table A5 in the Appendix[13].

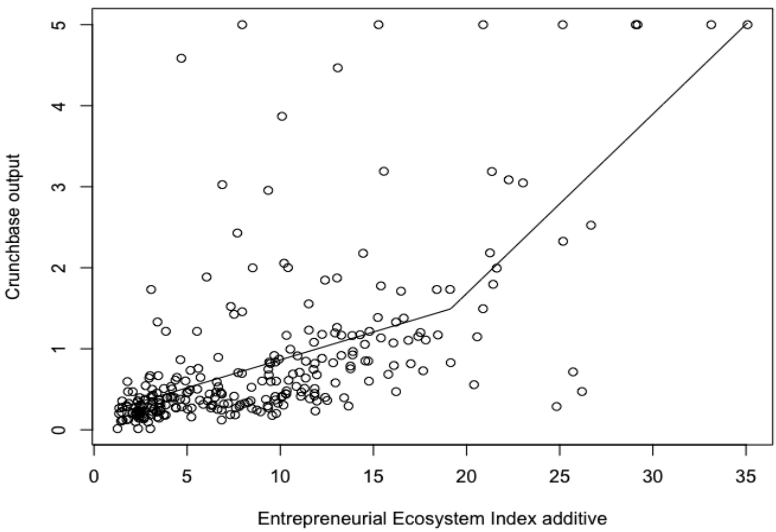


Fig. 2.7. Scatter plot with the line showing the fitted values of the piecewise linear regression

Table 2.6. Piecewise linear regression

	Crunchbase output	
	(1)	(2)
EE index additive	0.081^{***}	
	(0.014)	
Difference slope EE index additive	0.315^{**}	
	(0.146)	

13 We only report these findings in the appendix because of the limited number of regions with unicorn observations (20 out of 272).

EE index logarithmic		0.047***
		(0.009)
Difference slope EE index logarithmic		0.475***
		(0.088)
Constant	0.103	1.034***
	(0.120)	(0.129)
Observations	272	272
R^2	0.422	0.431
Adjusted R^2	0.415	0.425
F Statistic	65.213***(df=3;268)	67.697***(df=3;268)

Notes: Clustered standard errors at country level in parentheses. * p<0.05 ** p<0.01 *** p<0.001

The scatter plot (Fig. 2.7) shows that several regions do not seem to fit the plotted line, even with the piecewise linear regression. Particularly, we see some regions with very high entrepreneurial output and low index values. The regions in the upper left corner of the plot are, for example, Malta and Luxembourg, known for very favorable tax regulations, which previous studies have demonstrated to increase high growth entrepreneurship (Guzman and Stern, 2015). On the other hand, regions with high index values but relatively low entrepreneurial output are, for example, several outer London regions.[14] These are all regions with good conditions for entrepreneurship but located very close to even more 'vibrant' entrepreneurial areas, which attract a disproportionate share of innovative new firms (e.g., Inner London).

Since we compare regions in different countries, it is important to check whether the index not just captures differences between countries but also has explanatory power within countries. We therefore run a multilevel analysis with country-specific intercepts and our Entrepreneurial Ecosystem Index. The results of the multilevel analysis are presented in Table 2.7. The index variables still show a statistically significant and positive relationship with the entrepreneurial output ($p<0.001$). Adding country-specific intercepts improves the model, as evidenced by an increased R^2 as well as the likelihood ratio tests. The random effects at the bottom of the table show the regional variation (σ^2) and the variation between countries (τ_{00}). Our index's strong coefficient and statistical significance when we compare regions within countries shows the index's robustness. In addition, the high regional variation supports our choice to focus on the regional level when studying entrepreneurial ecosystems.

14 For some regions, this also has to do with the fact that the data for some indicators is measured at the NUTS 1 level, as described in Table A1.

Table 2.7. Multilevel analysis

	Crunchbase output	
	(1)	(2)
EE index additive	0.149 ***	
	(0.008)	
EE index logarithmic		0.168 ***
		(0.010)
Constant	-0.285 *	2.202 ***
	(0.144)	(0.203)
Random Effects		
σ^2	0.32	0.34
τ_{00}	0.32 $_{country}$	0.76 $_{country}$
ICC	0.50	0.69
N	23 $_{country}$	23 $_{country}$
Observations	267	267
Marginal R^2	0.594	0.570
Conditional R^2	0.798	0.868

Notes: This regression excludes countries that exist of only a single NUTS 2 region, which are Luxembourg, Malta, Estonia, Cyprus, and Latvia. Standard errors in parentheses. * p<0.05; ** p<0.01; *** p<0.001

Finally, to test the robustness of our index, we perform seven robustness checks to study its sensitivity to different calculation methods and extreme values. These robustness tests include the use of the principal components instead of the index as independent variables, as well as different ways of calculating the index. A description of the robustness checks and their results are presented in appendix A (Table A6-A12). The findings prove that our index is robust.

2.4.5 Comparison with existing indices

In the previous sections, we showed that the Entrepreneurial Ecosystem Index proved to be a good predictor of productive entrepreneurship. However, the question remains whether the Entrepreneurial Ecosystem Index also outperforms existing rankings on similar phenomena. Therefore, we compare the Entrepreneurial Ecosystem Index with two existing indices, first the Regional Competitiveness Index (RCI), which measures the competitiveness of a region, and second the Regional Innovation Scoreboard (RIS), which measures the innovative ability of a region. Furthermore, we also include the GRP per capita as an alternative measure of economic development. The results (Table 2.8) show that, as expected, there are strong correlations between our index and the RCI (0.92), the RIS (0.90) and GRP (0.77). However, our index clearly has a higher correlation with both entrepreneurial output measures than any of the alternatives. This shows that there is added value in developing theory-based metrics to measure the quality of regional entrepreneurial ecosystems and that our measure captures dimensions of the ecosystem which go beyond the level of economic development of a region. An example of this is Estonia (EE00), a low GDP region with very high entrepreneurial output due to a well-performing entrepreneurial ecosystem. The Entrepreneurial Ecosystem Index captures the quality of this entrepreneurial economy better than GRP measures or other indices do.

Table 2.8. Correlation table indices and outcomes

	EE index add	EE index log	RCI 2019	RIS 2019	GRP per capita	Crunchbase output
EE index log	0.985****					
RCI 2019	0.919****	0.941****				
RIS 2019	0.900****	0.903****	0.885****			
GRP per capita	0.771****	0.780****	0.820****	0.724****		
Crunchbase output	0.696****	0.695****	0.573****	0.588****	0.585****	
Unicorn output	0.351****	0.362****	0.300****	0.286****	0.281****	0.400****

Note: *p<0.05; **p<0.01; ***p<0.001; ****p<0.0001

2.5 Discussion and conclusions

The objective of this paper was to quantify and qualify regional economies with an entrepreneurial ecosystem approach. Quantification involved measuring the ten key elements of entrepreneurial ecosystems with a wide range of data sources. Qualification involved applying a network methodology to provide insight into the interdependencies between the elements and the construction of an Entrepreneurial Ecosystem Index to approximate the overall quality of entrepreneurial economies. Finally, we related the elements and the index to entrepreneurial outputs.

We answered three main research questions. First, how can we compose a harmonized dataset to measure the quality of key elements of entrepreneurial economies? We built on prior entrepreneurial ecosystem research and composed a harmonized dataset that measures each element of entrepreneurial ecosystems in the context of 273 regions in 28 European countries. To do so, we sourced a wide variety of data from existing datasets and online databases. However, not all elements could be measured in an entirely satisfactory way. Often, adequate data is available, but not at the same regional level or for all regions. An example is the data we used for the finance element: we prefer to have a composite indicator that includes objective data on the supply of different types of entrepreneurial finance. However, this is currently only available for venture capital in European regions. This could be improved by also including bank loans and crowdfunding. Another example is the data we used for the element networks. Even though the data provided on the engagement of SMEs in innovative collaborations is very informative, additional network data on collaborative networks and influencer networks, for example based on Twitter or LinkedIn data, could enrich the diagnosis of entrepreneurial ecosystems (Eveleens, 2019). This kind of network data would also allow for more refined measures of network diversity, density, and centrality. For other elements, there is no straightforward data available, and new variables had to be constructed. This was the case for leadership, for which others (Stam and van de Ven, 2021) have constructed country-specific regional indicators, and we have created a pan-European indicator. However, even though this indicator provides information on the prevalence of (public-private) leadership in the context of European projects, improvements can be made to measure leadership that is more relevant for the quality of entrepreneurial economies, for example, with the prevalence of public-private regional partnerships (see Olberding, 2002). Overall, there is a significant trade-off between getting richer context-specific data (often only available in a relatively small number of regions) and getting widely available, harmonized data, enabling comparisons between regions. We invite other researchers to take up the gauntlet and improve these metrics further by collecting new and richer data.

Second, to what extent and how are the elements of entrepreneurial economies interdependent? We performed correlation, principal component, cluster, and network analyses to visualize the interdependencies between elements. These analyses revealed that entrepreneurial economies are systems with highly interdependent elements. Our analyses showed that physical infrastructure, finance, formal institutions, and talent take a central position in the interdependence web, providing a first indication of these elements as fundamental conditions for entrepreneurial ecosystems.

Third, how can we determine the quality of entrepreneurial economies? We answered this question by composing our Entrepreneurial Ecosystem Index and analyzing its relation to entrepreneurial outputs. We used multiple data sources and methods, including web scraping and geocoding, to determine entrepreneurial outputs at the regional level. We have shown that it is possible to measure the quality of entrepreneurial economies in a way that has external validity: showing a ranking of European regions and range of variation that is credible. Our analyses reveal the wide-ranging quality of entrepreneurial ecosystems in Europe, showing a large group of substantially lagging regions and a smaller group of leading regions. We also tested the internal validity using the fact that high-quality entrepreneurial ecosystems are more likely to produce emergent properties, which we measured with indicators of productive entrepreneurship. The prevalence of innovative new firms is strongly positive and statistically significantly related to the quality of entrepreneurial ecosystems, as captured with differently constructed entrepreneurial ecosystem indices. Our empirical findings are thus in line with the upward causation found by Stam and van de Ven (2021) and Vedula and Kim (2019). The current index is formed under the assumption that each element is equally important for the quality of the ecosystem. While we find highly similar results when we challenge this assumption by employing principal component analysis, there is still a clear opportunity to improve the index in the future. We invite further research to study the respective importance of the ten elements for the quality of the entrepreneurial ecosystem and believe that the metrics developed in this study provide them with the opportunity to do so. In particular, future research should address if there are combinations of elements that are either necessary or sufficient for high outputs of productive entrepreneurship. Methods such as latent cluster analysis or qualitative comparative analysis (see Schrijvers et al., 2021) can play an important role in doing this and thus improve our understanding of the workings of entrepreneurial ecosystems.

There are several additional opportunities for improving the developed metrics that deserve substantial attention in follow-up research. First, the internal validity of the index should be tested more carefully, in particular with other (more direct) tests of causality, with longer time lags between changes in the quality of entrepreneurial ecosystems and the resulting entrepreneurial outputs, and with quasi-natural experiments in which a set of similar regions is confronted with substantially different changes in one or a few elements. In sum, we need to move from a comparative static analysis to a dynamic analysis, and therefore we need longitudinal datasets. This would make it possible to better trace processes within entrepreneurial ecosystems (Spigel and Harrison, 2018) and allow us to measure the distinct properties of complex evolving systems that arise from interdependencies, such as nonlinearity, emergence, tipping-points, spontaneous order, adaptation, and feedback loops.

Second, even though Europe provides a wide variety of regions to develop and test our entrepreneurial ecosystem metrics, these metrics also need to be developed and tested in other contexts, in large sets of regions in the US, Asia, Africa, and Latin America.

Third, our output measure of productive entrepreneurship is based on Crunchbase, and it is uncertain if the coverage of this database is equal among all regions. The same goes for the Dealroom data, which we used to test the robustness of this measure. There is a need to gain more insight into the coverage and quality of these private databases to assess their credibility. This is especially urgent given the increasing use of these databases in research on entrepreneurship and, in particular, on entrepreneurial ecosystems (Dalle et al., 2017).

Finally, statistical regions are not always overlapping with either the relevant jurisdictions or the spatial reach of the causal mechanisms involved (for example, related to culture and the provision of finance). Developing tailor-made spatial units and taking into account the nestedness of elements (cities, in regions, in countries), and neighborhood effects is also a challenge for future research. With the help of spatial econometrics, spill-over effects between regions could be analyzed. Our empirical research implicitly assumed an equal weight of all regional units. Future research can improve upon this by considering the differential (population, economic) size of regions, which might lead to more adequate regression analyses.

2.6 Policy implications

Despite the popularity of the entrepreneurial ecosystem approach in science and policy, there is a scarcity of credible, accurate and especially comparable metrics of entrepreneurial ecosystems. In this paper, we bridge this gap and measure the quality of entrepreneurial ecosystems by collecting and combining relevant data in a comprehensive set of metrics. These metrics are essential for data-and-dialogue-driven policy.

Measures of the elements of entrepreneurial ecosystems are an essential input for ex-ante policy diagnosis: to discover the weaknesses and strengths of entrepreneurial ecosystems. These weaknesses and strengths are always relative to other relevant regions: the benchmark. This is why the construction of large-scale datasets is a necessity for regional policy. Benchmarking the region could trigger policy by learning from regions that have comparable, entrepreneurial ecosystems. Tackling the weakest elements of entrepreneurial ecosystems is likely to provide the most efficient and effective way of improving the overall quality of the entrepreneurial ecosystem and stimulating productive entrepreneurship (Ács et al., 2014). However, a limitation in applying our metrics is that they provide insight into where to look for improvement, but not how this improvement should be achieved. It is thus important to combine these metrics with qualitative insights about particular entrepreneurial ecosystems.

The metrics are also an essential input for ex-post policy evaluation. They enable monitoring whether and to what degree the envisioned improvements of particular entrepreneurial ecosystem elements have been achieved and whether this has resulted in an increase in productive entrepreneurship and economic growth. For this monitoring, regular measurement of the quality of the entrepreneurial ecosystem elements is essential. For structural economic policy, annual data points would suffice, but in the context of rapidly evolving crises, including the COVID-19 crisis, more frequent monitoring with quarterly or even monthly data might be needed.

However, entrepreneurial ecosystem policy can never be entirely data-driven: comprehensive planning is computationally intractable (i.e., practically impossible) in large regional entrepreneurial ecosystems (cf. Bettencourt, 2014). Data on social phenomena are likely to remain insufficient, and interdependencies between elements and their emergent properties are unlikely to remain stable over time. Entrepreneurial ecosystem metrics facilitate a collective learning process to improve regional economies: this process combines data and dialogue. The diagnosis based on the metrics should, ex-ante, be used to facilitate dialogue between stakeholders of the entrepreneurial ecosystem about policy interventions, and facilitate, ex-post, a dialogue about the effectiveness of these interventions. Entrepreneurial ecosystem metrics are thus essential for data-and-dialogue-driven policy.

In sum, the entrepreneurial ecosystem approach, including the metrics we propose, provides the means to improve every regional economy in its own way. In particular, the approach and its metrics provide a lens for public policy to better diagnose, understand and improve entrepreneurial economies.

3.

The entrepreneurial ecosystem clock keeps on ticking – Regional persistence of high-growth firms

This chapter has been resubmitted to Research Policy after receiving revisions as van Dijk, J., Leendertse, J., Stam, E., van Rijnsoever, F.J., The entrepreneurial ecosystem clock keeps on ticking – A replication and extension of the Coad and Srhoj study. Both van Dijk and Leendertse contributed equally to the development of this chapter.

Abstract

The entrepreneurial ecosystem framework rests on the assumption that regional conditions enable productive entrepreneurship. However, existing studies lack longitudinal designs, and thereby provide limited evidence for causal mechanisms. In a first longitudinal step Coad and Srhoj (2023) argue that the relationship between entrepreneurial ecosystems and productive entrepreneurship only holds if the prevalence of high-growth firms, a proxy for productive entrepreneurship, in a region is persistent. They do not find consistent evidence of regional persistence of high-growth firms in Croatia and Slovenia. This leads them to conclude that the entrepreneurial ecosystem framework is not valuable for policymakers. We argue that their interpretation and generalization are incorrect. In fact, we argue that their findings are consistent with a further articulated entrepreneurial ecosystem framework. We provide a more articulated entrepreneurial ecosystem framework by formulating three hypotheses on causal mechanisms between entrepreneurial ecosystems and productive entrepreneurship. To test these hypotheses, we first replicate the study by Coad and Srhoj (2023) at two regional levels in the Netherlands with three measures of high-growth firms and in European regions with a measure of potential high-growth firms. We then extend the study by Coad and Srhoj (2023) and show that there is a positive relation between entrepreneurial ecosystem quality as well as entrepreneurial ecosystem size and regional persistence of high-growth firms. Our results challenge the dismissal of the entrepreneurial ecosystem framework. We propose a more nuanced understanding that considers regional differences in the effects of entrepreneurial ecosystem quality and size on the persistence of high-growth firms.

3.1 Introduction

High-growth firms (HGFs) and the conditions enabling them, captured in the so-called entrepreneurial ecosystem (EE) framework, have become a prominent topic in both academic and policy debates (Leendertse et al., 2022; Spigel, 2017; Stam, 2015; Stam and van de Ven, 2021; Wurth et al., 2022). An EE is defined as a set of interdependent actors and factors, that are governed in such a way that they enable productive entrepreneurship within a particular territory (Stam, 2015; Stam and Spigel, 2018). In the EE literature productive entrepreneurship is considered as the output of EEs and it is often proxied using HGFs (Fotopoulos, 2023; Henrekson and Johansson, 2010; Stam and Van de Ven, 2021). Even though substantial scientific progress has been made since Stam's (2015) sympathetic critique of the EE framework (see Wurth et al., 2023), there is still much to be done to improve our understanding of EEs and to increase the policy relevance of the framework.

The EE framework posits that productive entrepreneurship is consistently enabled by regional EE conditions (Leendertse et al., 2022; Spigel, 2017; Stam, 2015). This upward causation between the EE elements and its outputs is one of the key mechanisms argued for in the EE literature (Wurth et al., 2022). Several qualitative (Mack and Mayer, 2016; Spigel, 2017) and quantitative studies (Leendertse et al., 2022; Schrijvers et al., 2023; Stam and Van de Ven, 2021) have provided empirical validation for this hypothesis. However, Coad and Srhoj (2023) criticize the validity of this mechanism. They rightfully point out that these studies are not longitudinal in design and as a result these studies provide evidence for correlation and not yet for causation.

Longitudinal studies on entrepreneurship are not uncommon. There has been a multitude of studies showing the long-term regional persistence of self-employment and new firm formation in for example the UK (Fotopoulos, 2014; Fotopoulos and Storey, 2017), Germany (Fritsch and Wyrwich, 2014), and Sweden (Andersson and Koster, 2011). However, the regional persistence of HGFs has hardly been studied. An exception is a study by Friesenbichler and Hölzl (2020) who found moderate regional persistence of HGFs in Austria.

The study by Coad and Srhoj (2023) further investigates the persistence of HGFs. They argue that the elements of EEs are partly persistent and, based on a simulation model, show that this entails that the prevalence of HGFs should also be persistent over time. This means that the quality of EEs should not just affect the prevalence of HGFs, it should also affect persistence in the prevalence of HGFs. In their empirical analyses they do not find regional persistence of HGFs in Croatia (2004-2019) and Slovenia (2007-2019). Therefore, they state that the hypothesis 'High-quality EEs have a higher prevalence of HGFs than low-quality EEs' has to be rejected. They then formulate a novel 'broken clock' critique on EEs: "the relationship between inputs and outputs is so noisy that we conclude that the EE approach, according to its most recent formulations (Leendertse et al., 2022) is not a useful approach for policymakers with regards to generating the main outputs of ecosystems, i.e. HGFs." (Coad and Srhoj, 2023: p. 17). Coad and Srhoj (2023) highlight and address an important gap, but, we do not share their interpretation of their findings, for several reasons. First, the EE quality of the regions they analyze to test their hypotheses are below the European average (Leendertse et al., 2022), which provides a too limited context for rejecting entrepreneurial ecosystems. Second, the regions they study are very small in population size, which makes it less likely that HGFs emerge from the available human capital. In fact, we argue that their findings are consistent with a further articulated EE framework, for which the foundations were laid in Stam and van de Ven (2021) and Leendertse et al. (2022). The mechanism between EE elements and outputs has so far been specified as consisting of a positive relation between the quality of EEs and the prevalence of HGFs (Audretsch and Belitski, 2017; Leendertse et al., 2022; Stam and Van de Ven, 2021; Vedula and Kim, 2019). Our further articulated theory adds the persistence in HGFs to the EE framework. We therefore aim to answer the following research question in this paper:

What is the influence of the quality and size of entrepreneurial ecosystems on the persistence of high-growth firms?

To answer our research question, we formulate a series of hypotheses in which we argue that after reaching a critical mass in terms of quality or size of the EE, there is a positive relationship between EE quality or EE size and the persistence of HGFs. Empirically, we first replicate and extend the analyses of Coad and Srhoj (2023) in a larger country: The Netherlands, which has respectively 4 and 8 times the population size of Croatia and Slovenia) and has relatively high-quality regional EEs, at the NUTS-2 and NUTS-3 regional level (respectively 12 and 40 regions). Our results show persistence in HGFs. To explain these differences, we formally test our hypotheses on European NUTS-2 regions using data from Crunchbase (see Leendertse et al., 2022), which confirm our findings. We then discuss how different empirical studies on the persistence of HGFs are consistent with our further articulated EE framework. We conclude with a discussion of our findings, and suggestions for research and policy.

3.2 Theoretical background

The entrepreneurial ecosystem literature studies how the elements of entrepreneurial ecosystems, defined as the combination of interdependent actors and factors, influence the presence and performance of productive entrepreneurship in a region, which in turn influence economic growth (Stam, 2015; Stam and Spigel, 2018). Productive entrepreneurship is defined as any entrepreneurial activity "that contributes directly or indirectly to the net output of the economy or to the capacity to produce additional output" (Baumol, 1993, p.30). In the EE literature HGFs are considered a key proxy for productive entrepreneurship due to their contributions to economic development and growth (Fotopoulos, 2023; Henrekson and Johansson, 2010; Stam and van de Ven, 2021). The relation between HGFs and economic growth has been extensively studied (and mostly confirmed) in many other papers (e.g. Bisztray et al., 2023; Bos and Stam, 2014; Henrekson and Johansson, 2010).

Wurth et al. (2022) identify five mechanisms that play a role in the entrepreneurial ecosystem framework: (1) the interdependencies between the entrepreneurial ecosystem elements, (2) an upwards causation where the entrepreneurial ecosystem influences the output, the presence of productive entrepreneurship, and (3) a mechanism where productive entrepreneurship consequently affects the outcome, economic growth (4) downward causation, and where it (5) interacts across the boundaries of entrepreneurial ecosystems. Coad and Srhoj (2023) focus on the second mechanism (which is visualised in Fig. 3.1.), and so do we in this paper.

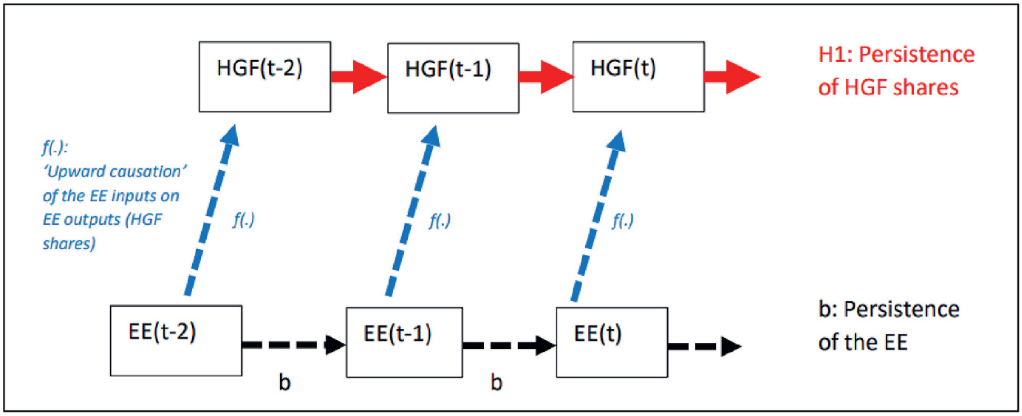


Fig. 3.1. Conceptual diagram of the relation between EE inputs and outputs, adapted from Coad and Srhoj (2023).

3.2.1 Prevalence and persistence of high-growth firms

The occurrence of HGFs in a region can be measured as either the presence or the prevalence of HGFs. We define the presence of HGFs as the absolute number of HGFs in a region. The prevalence is the number of HGFs in a region relative to the population of firms (e.g. Coad and Srhoj, 2023) or the human population (e.g. Leendertse et al., 2022). In line with these previous studies, we focus on the prevalence of HGFs as this measures how well an EE enables the emergence of HGFs accounting for the size of regions.

We define the persistence of HGFs as the consistent occurrence of HGFs in a region over time. Persistence was always implied in EE research (Leendertse et al., 2022; Spigel, 2017; Stam, 2015), in the sense that it assumed that well-developed EEs have a persistent high output of HGFs. However, no empirical attention was paid to the persistence of HGFs in relation to the quality of EEs. Coad and Srhoj (2023) empirically study persistence but did not relate this to EE quality. This paper follows-up on that agenda, by making that connection. In line with Coad and Srhoj (2023) we study persistence in the prevalence of HGFs.

3.2.2 The influence of entrepreneurial ecosystem quality on the prevalence of HGFs

The elements of EEs can be categorized in two layers (Leendertse et al., 2022; Stam and Van de Ven, 2021). First, the fundamental institutional arrangements including formal and informal institutions that subsequently influence the governance and allocation of resources in the second layer. This second layer includes actors and resources (such as talent, knowledge, and finance) that enable entrepreneurs to develop HGFs. The combination of these layers determines the quality of the EE. We define EE quality, along the lines of Leendertse et al. (2022), as the combined strength of its elements.

The mechanism between EE elements and outputs has been identified in previous research as consisting of a positive effect of EE quality on the probability that HGFs occur in a region and thus on the prevalence of HGFs within a region (Audretsch and Belitski, 2017; Leendertse et al., 2022; Stam and Van de Ven, 2021; Vedula and Kim, 2019). This relationship is non-linear: the effect increases when EE quality increases (Leendertse et al., 2022). This finding can be explained by regional agglomeration effects: the more firms collocate together, the more efficiently they can organize the provision of critical resources, which makes it in turn more attractive to found new businesses (Delgado et al., 2010; Van Oort and Bosma, 2013). In addition to resources, Tiba et al. (2020) argue that the successful entrepreneurs can serve as lighthouse or beacons for new talent to found similar firms in an EE, which makes high quality EEs even more successful. We formulate hypothesis 1 to test this non-linear relationship between EE-quality and the prevalence of HGFs:

Hypothesis 1: There is an increasing positive relationship between EE quality and the prevalence of HGFs.

3.2.3 The influence of entrepreneurial ecosystem quality on persistence of HGFs

As innovative and high growth entrepreneurship is surrounded by uncertainty (McMullen and Shepherd, 2006), one can view the founding and growth of HGFs as a probabilistic event. HGFs are a rare occurrence and individual HGFs are unlikely to consistently repeat high-growth over time (Coad et al., 2013; Mason et al., 2015; Raby et al., 2022). However, on a regional level the quality of an EE has a consistent positive effect on the probability that HGFs occur in a region (Leendertse et al., 2022; Stam and Van de Ven, 2021), which means that it becomes less of a rare event. As such, one can expect that the quality of an EE is related to regional persistence in HGFs over time (Spigel, 2017). In lower quality EEs HGFs will emerge, but less often and less persistent as in higher quality EEs. We expect that the relationship between EE quality and persistence is positive, but that the positive effect decreases as the quality of the EE increases. For this we first have a theoretical reason: HGFs rely strongly on a network of peers and benefactors for exchange of knowledge and resources that are critical for survival (Neck et al., 2004; van Weele et al., 2018). Hence, a network is a critical aspect of an EE, and a critical asset to its quality (Wurth et al., 2022). In line with critical mass theory (Marwell et al., 1988), simulations showed that EEs need a critical mass of networked HGFs to become stable over time (Van Rijnsoever, 2020). This is because firms go bankrupt (Hyytinen et al., 2015), or that ties decay over time (Burt, 2002). This critical network mass is dependent on the level of development of the EE (van Rijnsoever, 2022, 2020). After stabilizing, the effect of the network on the EE remains positive with a decreasing trend (van Rijnsoever, 2020). This is because each additional tie in the network has associated diminishing returns (Uzzi and Spiro, 2005). A second reason for the relationship is methodological. Persistence is a measure that is theoretically bound by a maximum, one cannot be more persistent than 100%. This means that the positive relationship will also decrease as the value of HGF persistence approaches its maximum.

Hypothesis 2: There is a decreasing positive relationship between EE quality and HGF persistence.

3.2.4 The influence of entrepreneurial ecosystem size on persistence

An ecosystem, be it biologic (Fahrig, 2001), or economic (Baldwin et al., 2024) should be large enough to sustain a species over time. Hence, we argue that persistence is also influenced by ecosystem size, which we define as the extent to which a region is able to facilitate the creation HGFs. In this case, ecosystem size is largely a function of the size of the population, since entrepreneurs and the employees from firms largely come from the same region (Dahl and Sorenson, 2012; Stam, 2007). We expect a decreasing positive relationship between EE size and HGF persistence. Ecological research suggests an extinction threshold, a minimum size of the ecosystem for species to show persistence (Fahrig, 2001, p.1998). In a similar vein, for HGFs to occur consistently over time, there needs to be a sufficient number of prospective entrepreneurs and employees in a region. This is again because of the critical mass that an ecosystem needs to maintain a network, for exchanging knowledge and resources (Van Rijnsoever, 2020). Beyond the critical mass, the network becomes stable enough to grow over time, but the marginal returns of each additional ties are diminishing (Uzzi and Spiro, 2005).

For the influence of ecosystem size we thus argue for a positive effect on persistence, but that positive effect decreases with the size of the population. This is because of the diminishing returns of a growing network, and because of the maximum value that persistency can take.

Hypothesis 3: There is a decreasing positive relationship between EE size and HGF persistence.

3.3 Methodology

To replicate the Coad & Srhoj (2023) study we use three databases, two with Dutch firms and one with European firms. Subsequently, we discuss our extension where we test our three hypotheses using the database with European firms.

3.3.1 Research design and data collection

To replicate the analyses by Coad and Srhoj (2023) we use three different datasets to collect data on three indicators of HGFs. The first dataset is from Statistics Netherlands (the Dutch Census Bureau), which allows us to study HGFs in 12 NUTS-2 regions in the Netherlands, the second dataset comes from a collaboration between the Dutch newspaper 'Het Financieele Dagblad' and the Dutch Chambers of Commerce (Het Financieele Dagblad, 2020), which has data for 40 NUTS-3 regions in the Netherlands.[1] For the third dataset we follow Leendertse et al. (2022) who use firms registered in Crunchbase (Crunchbase, 2019; Dalle et al., 2017). We downloaded the Crunchbase data on July 6th 2022 using academic access. We also use the Crunchbase dataset to replicate the analyses of Coad and Srhoj (2023) at the European level by analyzing 273 NUTS-2 regions from 28 countries.

To test our three hypotheses, the second part of our study, we use the Crunchbase dataset as it encompasses the most regions (273 NUTS-2 regions from 28 European countries). In addition, we use data on the quality of these EEs from Leendertse et al. (2022) and regional population data from Eurostat (2023).

3.3.2 Operationalization

3.3.2.1 Replication study

For the replication study we operationalize three different proxies of productive entrepreneurship, which are employment HGFs, sales HGFs, and innovative start-ups (potential HGFs).

We operationalize the employment HGF variable using data from Statistics Netherlands (the Dutch Census Bureau). This dataset includes firms that employed at least 10 Full

1 In line with existing studies (e.g. Leendertse et al., 2022; Stam & van de Ven, 2021; Coad and Srhoj (2023) we use the administrative boundaries as the borders of EEs. However, there is an ongoing debate on the potential limitations of this approach (e.g. Fischer et al., 2022; Schäfer, 2021). This is a potential limitation of our study.

Time Equivalents (FTEs) at the start of the three-year period and that have at least an average employment growth of 20 percent per year in the following three years. This definition is the same as the HGF definition of the OECD used by Coad and Srhoj (2023) and Friesenbichler and Hölzl (2020) and matches the HGF employment variable of Coad and Srhoj (2023). This measure is available at the NUTS-2 level for the Netherlands and the dataset covers the 2013-2020 period.[2]

We operationalize the sales HGF variable using the dataset from the Dutch newspaper Het Financieele Dagblad, constructed in collaboration with the Dutch Chambers of Commerce (Het Financieele Dagblad, 2020). This dataset includes firms with a minimum revenue of 250,000 EUR at the start of a three-year period, which have a turnover growth of at least 20 percent per year over three years. In addition, the firms had to be profitable for at least two of the last three years, and the dataset exclude branches that are part of a larger corporation such as franchises. This sales HGFs definition is very similar to the sales based HGF definition of Coad and Srhoj (2023). The main differences are that our definition includes profitability criteria and that the initial size is based on revenue not employment size. This measure is available at both the NUTS-2 and NUTS-3 level for the Netherlands and the dataset covers the period 2013–2020. A full overview of the average number of HGFs in each NUTS-2 region is provided in Table B1 in the Appendix.

For the third dataset we follow Leendertse et al. (2022) who use firms registered in Crunchbase (Crunchbase, 2019; Dalle et al., 2017) that are founded in the past five years, and regionalize the data to the NUTS-2 level. Crunchbase predominantly captures venture capital oriented innovative start-ups and largely ignores companies without a growth ambition and is thus a good source for data on potential HGFs (Dalle et al., 2017; El-Dardiry and Vogt, 2023; Leendertse et al., 2022). Crunchbase is increasingly used for academic research (Dalle et al., 2017; Nylund and Cohen, 2017). El-Dardiry and Vogt (2023) show that there is substantial overlap between the data from a commercial start-up registry (such as Crunchbase) and HGFs based on the business register, but that there are also distinct differences. The Crunchbase data largely comes from two sources, a community of contributors and an extensive investor network. These data are then validated with other data sources using AI and machine-learning algorithms (Leendertse et al., 2022). We find that 26% of the innovative start-ups in our Crunchbase data have attracted venture capital. To only include startups (and not long established firms) we selected firms founded between 2015-2020.[3] In our Netherlands replication

2 The absolute number of employment HGFs is rounded to the nearest 5. This would disproportionately influence the data when considering a smaller regional level than NUTS-2.

3 We also have data for 2021, however given the lag between firm founding and inclusion that is inherent in how Crunchbase collects data this data is not yet complete. Our findings remain robust when also including data from 2021.

study, we follow Coad and Srhoj (2023) by studying the HGFs shares in a region, the prevalence, by looking at the number of HGFs per 10,000 firms. In our replication at the European level, we operationalize the prevalence of HGFs through the number of firms per 10,000 inhabitants rather than per 10,000 firms due to uneven availability of the latter data across Europe (see Leendertse et al. 2022). For the Netherlands these two measures are very strongly correlations, with correlations between 0.929-0.997 for the different years.

3.3.2.2 Testing hypotheses

To test our hypotheses, we use the same Crunchbase data to operationalize the innovative start-ups (potential HGFs) variable. We operationalize the persistence of HGFs by constructing a measure for persistence at the regional level. For this we use the prevalence of HGFs for each of the years between 2015-2020. We calculate persistence as the inverse of the Coefficient of Variation. The Coefficient of Variation is calculated as the standard deviation divided by the mean of a series of variables. The standard deviation measures the variation in a variable over time. However, with standard deviation a higher value also leads to a higher standard deviation. We correct for this by dividing the standard deviation by the mean. A higher standard deviation indicates more variation and thus less persistence. Hence, we multiply the Coefficient of Variation with -1, so that a higher value means more persistence. The measure for persistence is thus calculated through the following formula.

$$Persistence_i = -\frac{\sigma_i}{\mu_i}$$

Where:

σ_i is the standard deviation of the values in row i

μ_i is the mean of the values in row i

We operationalize EE quality using the EE index from Leendertse et al. (2022). Leendertse et al. (2022) developed a set of metrics to measure the ten elements of EEs, as defined by Stam (2015), for European NUTS-2 regions. They combined these metrics to develop an EE index which measures the quality of EEs. To construct this index, they first standardized and normalized the quality of each element. They then set the maximum score for any single element to five, to prevent a disproportionate influence of strong performing ecosystem elements on the overall index. They then calculated the index in an additive way (E1 + E2 +...+E10). For the full operationalization of the EE index see Leendertse et al. (2022). Finally, to measure the size of an EE, we use the number of inhabitants (population) for each region (Eurostat 2023). We use the average population between 2010-2014 to ensure a time lag between our independent and dependent variable.

Table 3.1 presents the descriptives of the data at the European level. The 273 NUTS-

2 regions have an average of 1,865,398 inhabitants and on average 47.1 innovative start-ups are founded per year per region. At the NUTS-3 level this translates to 10.0 innovative start-ups per region per year. The NUTS-2 level therefore seems to be the more appropriate level to test persistence. Furthermore, it is notable that the correlation between the two persistence measures (based on prevalence and based on presence) is 1.000. There is thus no added value in using both measures and we only use the prevalence-based measure for persistence. In doing so we follow Coad & Srhoj (2023) who also look at prevalence-based persistence.

Table 3.1. Descriptives and Pearson correlations (based on 2015-2020 averages)

#		*n*	*Mean*	*S.D.*	*1*	*2*	*3*	*4*	*5*
1	Innovative start-ups (presence (absolute)	273	47.095	144.443					
2	Innovative start-ups prevalence (relative)	273	0.220	0.443	0.892				
3	Persistence of Innovative start-ups (absolute)	272	-0.592	0.361	0.189	0.223			
4	Persistence of Innovative start-ups (relative)	272	-0.595	0.360	0.185	0.218	1.000		
5	EE index	272	8.935	6.462	0.469	0.565	0.339	0.329	
6	Population (per 10,000 inhabitants)	273	186.540	152.552	0.357	0.094	0.313	0.314	0.101

3.3.3 Analyses

We replicate the analyses of Coad and Shroj (2023) with our datasets. This means we calculate the persistence for three different measures of HGFs in the Netherlands (at the NUTS-2 and NUTS-3 levels) and for one HGF measure in Europe (NUTS-2 level). Following Coad and Shroj (2023) we first visualize the correlations between two time periods by normalizing the data per year, such that each year has a mean of zero. We then pool the data. Then, similar to Coad and Shroj (2023), we compare the prevalences of HGFs in regions between different time periods through single variable regression analyses by taking the three-year averages of the share of HGFs as the independent and dependent variable. [4]

Next, we test our three hypotheses. For hypothesis 1 we perform regression analyses using the prevalence of innovative start-ups (potential HGFs) as the dependent variable and the EE index as the independent variable. To model the increasing positive effect, we added a quadratic term to the model. If the data fits the right side of the quadratic curve, and it has a positive slope, then this supports hypothesis 1. For hypothesis 2, we first illustrate the relation between EE quality and regional persistence of HGFs by combining our replication results with earlier results found in the literature. Second, we use regression analyses to test the relation between EE quality and regional persistence of HGFs. To account for a non-linear effect, we take the logarithm of the independent variable. To test hypothesis 3, we use the natural logarithm of population size as the independent variable.

3.4 Results

In section 4.1 we replicate the analyses of Coad and Srhoj (2023) for the Netherlands using three HGF measures. In section 4.2 we test our three hypotheses.

3.4.1 Replication of Coad and Srhoj (2023) for the Netherlands

The regions of our Netherlands replication study differ substantially in population size from the regions in Croatia and Slovenia included in the Coad and Srhoj (2023) study. The Netherlands replication study consists of 40 NUTS-3 regions with an average of 435,190 inhabitants, these NUTS-3 regions are embedded in 12 NUTS-2 regions with an average of 1,450,633 inhabitants. Croatia consists of 21 NUTS-3 regions with an average of 193,246 inhabitants, that are embedded in 2 NUTS-2 regions with an average of 2,029,082 inhabitants. Slovenia consists of 12 NUTS-3 regions with an average of 175,748 inhabitants, these regions are embedded in 2 NUTS-2 regions with 1,047,931

4 Coad and Srhoj (2023) also report the correlations between the time periods in their paper. However, because correlations and single variable regressions are the same type of analyses and thus provide nearly identical results, we only report the correlations in the Appendix.

inhabitants (all in 2020). The NUTS-3 regions in Croatia and Slovenia are thus much smaller than the NUTS-3 regions in the Netherlands.

Based on the EE index as calculated by Leendertse et al. (2022) the EE quality of the NUTS-2 regions in the Netherlands ranges between 10.9 and 25.2. The EE index for the regions in Slovenia ranges between 3.5 and 7.3 and for Croatia between 1.8 and 2.1. These EEs thus all score below the European average on the EE index. The Croatian regions even score in the bottom 10% of all European regions.

In the first step of our replication study, we visualize the correlations between time periods for the three prevalence of the HGF measures (Fig. 3.2a-c). For all three HGF variables regions with a high (or low) share of HGFs consistently also show a high (low) share in later years. In our replication of the single variable regressions by Coad and Srhoj (2023) we consistently find persistence (Table 3.2). We find a consistent highly significant positive relation between consecutive time periods for all three types of HGFs. For the employment HGFs variable we can correlate multiple time periods. The results show that persistence becomes weaker when the time period between the two variables increases. For the sales HGFs variable and the innovative start-ups variable our data covers a shorter time period (2013-2020); hence we could only compare two time periods.

The correlation tables (see Appendix B2-B4) confirm our findings and show that there is a lower persistence between time periods if the time between them is longer. This suggests that the regional share of HGFs, the prevalence, slowly changes over time. We perform a robustness test using presence (absolute numbers) instead of prevalence. We consistently find persistence for all time periods and all HGF measures (see Table B5 in the Appendix). Finally, we perform a further robustness test using the average of two instead of three years, this yields similar results (Appendix B6-B7). Our Netherlands replication study thus shows strong persistence in the regional prevalence and presence of HGFs over time. This finding contrasts the results by Coad and Srhoj (2023), but can be explained by our hypotheses that high quality EEs and larger EEs deliver more persistent HGFs than lower quality and smaller EEs. We provide further proof for these hypotheses in our extension.

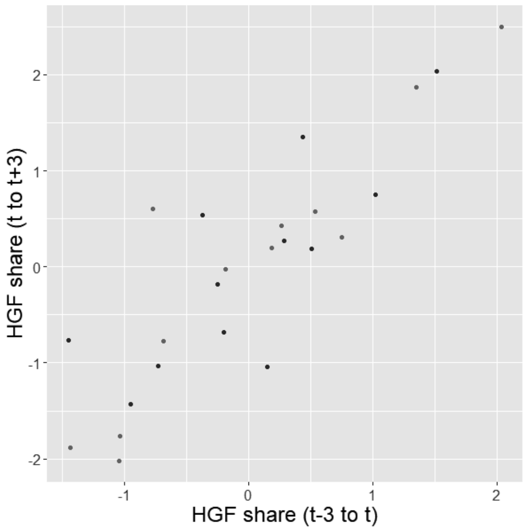


Fig. 3.2a. Standardized regional persistence of employment HGFs (NUTS-2 level, 12 regions). Note: Blue dots represent the correlation between 2010 - 2012 and 2013 - 2015; Red dots represent the correlation between 2013 - 2015 and 2016 - 2018.

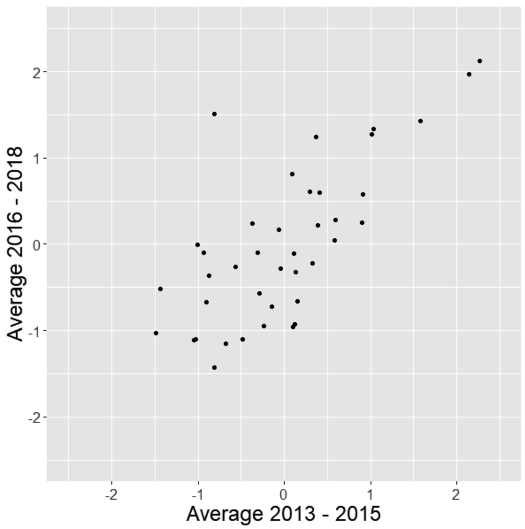


Fig. 3.2b. Standardized regional persistence of sales HGFs (NUTS-3 level, 40 regions)

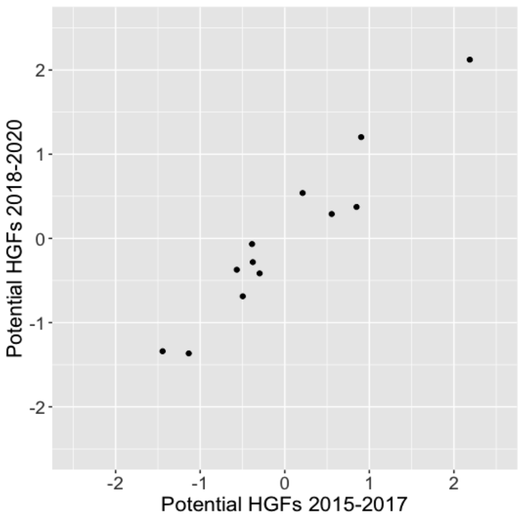


Fig. 3.2c. Standardized regional persistence of innovative start-ups (potential HGFs) (NUTS-2 level, 12 regions)

Table 3.2. Regression results for the regional persistence of three measures of HGFs in the Netherlands at NUTS-2 and NUTS-3 levels

	Dependent variable				
	Employment HGF (NUTS-2)			Sales HGF (NUTS-3)	Innovative start-ups (NUTS-2)
	2016 – 2018		2013 – 2015	2016 – 2018	2018 – 2020
	1	2	3	4	5
Employment HGF 2013 – 2015	1.234*** (0.175)				
Employment HGF 2010 – 2012		0.898 (0.457)	0.989* (0.246)		
Sales HGF 2013 –2015				1.298*** (0.192)	
Innovative start-ups 2015 – 2017					0.686*** (0.059)
Constant	50.201 (40.931)	108.186 (115.870)	- 18.716 (62.311)	18.223 (9.163)	-0.001 (0.002)
Observations	12	12	12	40	12
Adjusted R^2	0.815	0.207	0.580	0.534	0.925

. $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; standard errors reported in brackets

3.4.2 Replication for Europe

We also replicate the analyses of Coad and Srhoj (2023) using the persistence of innovative start-ups (potential HGFs) in 273 European NUTS-2 regions. As a first step we visualize the correlations[1] between time periods for the three prevalence of HGF measures (Fig. 3.3). We see a clear pattern of persistence.

In our replication of the single variable regressions by Coad and Srhoj (2023) for Europe we also find clear and highly significant persistence (Table 3.3). Our findings thus show that, in contrast to the findings of Coad and Srhoj (2023) for regions in two small European countries, a large-scale European replication reveals high persistence in the regional shares of innovative start-ups.

1 The correlation table (as provided in Coad and Srhoj (2023)) can be found in the Appendix as Table B8.

Fig. 3.3. Regional persistence of innovative start-ups (potential HGFs) in Europe (NUTS-2 level)2

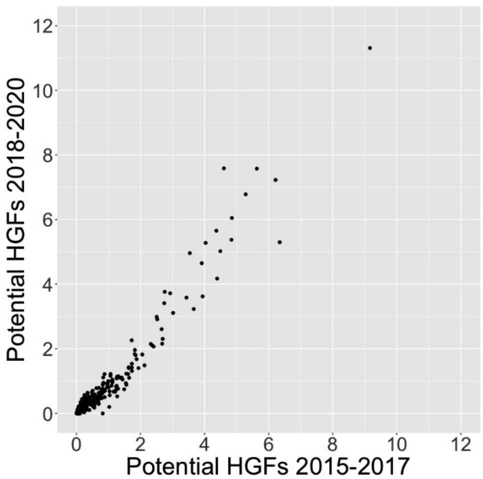


Table 3.3. Regional persistence of innovative start-ups in Europe (NUTS-2 level, 273 regions)

	Dependent variable
	HGF 2018 – 2020
HGF 2015 – 2017	1.161***
	(0.011)
Constant	-0.161***
	(0.025)
Observations	273
Adjusted R^2	0.974

. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets

3.4.3 Extension

To better understand the relationship between HGF prevalence and persistency and entrepreneurial ecosystems we extend our analysis. We test our three hypotheses .

3.4.3.1 Prevalence

With hypothesis 1 we expect an increasing positive relationship between EE quality and the prevalence of HGFs. Our tests show a consistent and positive relation between EE quality and subsequent prevalence of (potential) HGFs (Table 3.4).[3] These

2 The region UKI3&4 (Inner London) is not included in this scatterplot. The extreme values (25+ after normalization) reduced the readability of the scatterplot

3 We also run this analysis for the presence of firms. Our results do not change (Appendix Table B9)

regressions are similar to those in Leendertse et al. (2022), yet with more recent data of the dependent variable. As such we increased the time-lag between the dependent and independent variable and reduce the risk of reverse causality. Our findings are also consistent with those of Leendertse et al. (2022). We fitted both models with a linear term and with an added quadratic term. Both yield significant effects. Moreover, the quadratic term is positive, and gives a substantial increase in explained variance compared to the models with only a linear term. The turning point of the curve can be found at EE index values of 3.88 for the 2015-2017 time period and 4.42 for the 2018-2020 time period, which are at the very left hand side of the distribution, after which the curve increases quadratically. This supports hypothesis 1.

Table 3.4. The relation between EE quality and prevalence of innovative start-ups in Europe (NUTS-2 level, 273 regions)

	Dependent variable: Innovative start-ups prevalence			
	HGF 2015 – 2017	HGF 2018 – 2020	HGF 2015 – 2017	HGF 2018 – 2020
	1	2	3	4
EE index	0.048***	0.029***	-0.021.	-0.015.
	(0.004)	(0.003)	(0.011)	(0.008)
EE index squared			0.003***	0.002***
			(0.000)	(0.000)
Constant	-0.151***	-0.102***	0.140*	0.085*
	(0.045)	(0.031)	(0.061)	(0.043)
Observations	272	272	272	272
Adjusted R^2	0.338	0.280	0.428	0.363

. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets

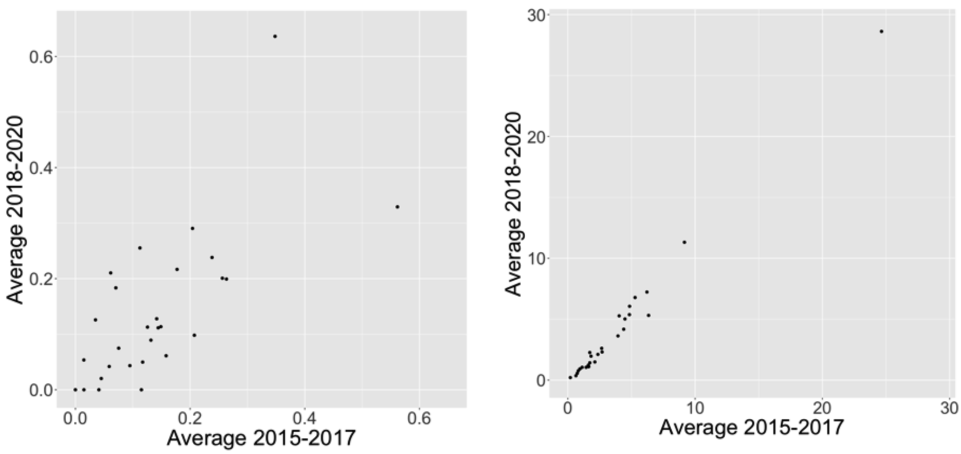
3.4.3.2 Persistence

As a first step in addressing hypothesis 2, which posits a decreasing positive relation between EE quality and HGF persistence, we visualize the correlation between the prevalence of innovative start-ups separately for the bottom 10 % of EEs in terms of EE quality (on the left) and the top 10% of EEs in terms of EE quality (on the right) between the 2015-2017 and 2018-2020 time periods (Fig. 3.4). We find some persistence[4] for

4 We also see this in a correlation table for the bottom 10% of regions (see Appendix, Table B12). We find much lower persistency levels for this group than for the full sample and when considering the individual years furthest apart (2015 and 2020) the persistency is not significant.

the bottom 10 % with a Pearson correlation of 0.684 and clear persistence for the top 10%, with a Pearson correlation of 0.994 (on the right).

Fig. 3.4. Regional persistence of innovative start-ups for the bottom 10% (left) and top 10% (right) in EE quality across 273 European regions.



Next, we formally test the relation between EE quality and persistence (Table 3.5, column 1.)[5] We find a significant positive relation. When we model the natural logarithm of the EE index (Table 3.5, column 2), we observe that the model fit dramatically improves, which supports hypothesis 2.

In a similar vein, we test hypothesis 3 on the influence of ecosystem size on the persistence of HGFs (Table 3.5, columns 3 and 4). The results also show that the natural log of the population fits the data much better than a linear relationship, providing support to hypothesis 3, that there is a decreasing positive relation between EE size and HGF persistence.

As robustness test, we construct two sets of dummies variables, where each variable either represents a 10% increment in the EE index, or a 10% increment in size. We run dummy regressions with the bottom 10% as the reference category (Appendix table B11). The results show that in both models all other groups have significantly more persistence than the bottom 10% in EE quality (hypothesis 2) and EE size (hypothesis 3), after which there is an overall gradually increasing trend. This is in line with the critical mass argument that lies at the basis of hypotheses 2 and 3. Some estimators are lower than the previous increment, but these differences are not significant. As a further robustness test we run a model with random effects for the countries. The

5 We also run this analysis for presence based persistence. Our results do not change (Appendix, Table B10).

results remain the same (Appendix Table B13).

Table 3.5 The influence of EE quality and population size on the prevalence of innovative start ups in European NUTS-2 regions6

Dependent variable: Persistence of innovative start-up prevalence				
	1	2	3	4
EE index	0.017***			
	(0.003)			
Log (EE index)		0.178***		
		(0.025)		
Population (per 10,000 inhabitants)			0.001*** (0.000)	
Log (Population (per 10,000 inhabitants))				0.227*** (0.025)
Constant	-0.744***	-0.929***	-0.732***	-1.719***
	(0.034)	(0.051)	(0.033)	(0.124)
Observations	271	271	272	272
Adjusted R^2	0.104	0.158	0.091	0.236

. $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; standard errors reported in brackets

3.5 Discussion

We can further illustrate the relation between EE quality and persistency by combining the operationalization of EE quality employed by Leendertse et al. (2022), our replication for the Netherlands (section 4.1), the results of Coad and Srhoj (2023) and those of Friesenbichler and Hölzl (2020). This dataset, which encompasses EE data for 273 European NUTS-2 regions, allows us to construct regional EEs, albeit at the NUTS-2 level, in Slovenia and Croatia (cf. Coad and Srhoj, 2023), Austria (cf. Friesenbichler and Hölzl, 2020), and the Netherlands (this paper). We provide an overview in Table 3.6, where we show that there is low persistency in low-quality EEs and high persistency in high-quality EEs. Hence, the findings of all three national studies, and our European study are fully in line with the argument that low-quality EEs show lower persistency.

6 One region is removed from the analyses as this region did not record any innovative start-ups in any year. Hence, the mean was 0 and it was impossible to calculate our measure for this region.

Table 3.6. Persistence of HGFs in countries with different EE development levels

	Number of NUTS-2 regions	Number of NUTS-3 regions	Startups per NUTS-2 region per year	Startups per NUTS-3 region per year	Range of EE-index	HGF persistency	Source
Croatia	2	21	17.25	1.64	1.82-2.08	Low	Coad and Srhoj (2023)
Slovenia	2	12	15.92	2.65	3.47-7.34	Some	Coad and Srhoj (2023)
Austria	9	35	14.67	3.77	7.85-22.26	Moderate	Friesenbichler and Hölzl (2020)
Netherlands	12	40	181.04	54.31	10.86-25.18	High	Our study

Combining the data sources also gives a coherent story for EE size and persistence. When we return to the regions studied by Coad and Srhoj (2023) using the Crunchbase data. We find that on average respectively 34.50 and 31.83 innovative start-ups (potential HGFs) are founded per year in Croatia and Slovenia. Given these numbers, the 21 NUTS-3 regions for Croatia, and to a lesser extent the 12 NUTS-3 regions for Slovenia, are too small to expect persistence in the prevalence of HGFs. The regions have an average of respectively 1.64 and 2.65 innovative start-ups per region per year for Croatia and Slovenia.[7]

In our analyses of European NUTS-2 regions there is still some persistence, even in the bottom 10% of regions. This could serve as an argument for the use of NUTS-2 regions rather than NUTS-3 regions if the latter have relatively low numbers of inhabitants (and a low prevalence of high-growth firms or innovative start-ups).

3.6 Conclusion and implications

In this paper we further articulated the EE-framework, by showing that the quality of an EE is positively related to the persistence of the emergence HGFs in a region, in addition to the prevalence of HGFs. However, whereas the slope of relationship between EE quality and prevalence is increasingly positive, the positive relationship between EE quality and persistence is decreasing. Moreover, the size of EEs is also decreasingly positive related to the persistence of HGFs.

7 Coad and Srhoj (2023) do not communicate any descriptives about the number of HGFs in their data and we can thus not confirm this for their HGF variables. However, for the Netherlands we find that the three HGF measures are similar in magnitude regarding their occurrence (see Table B1).

Thus, this study addressed the valid criticism of Coad and Srhoj (2023), who found that EEs do not lead to persistent emergence of HGFs. We showed that this indeed is true for EEs of a lower quality or of a smaller size. However, our Netherlands and European replication studies add nuance to their findings, by placing their results in a broader picture. Based on our hypotheses, we would indeed expect that regions in Croatia and Slovenia have a lower regional persistence of HGFs, as they score relatively low on the EE index. In contrast, regions with better developed EEs, like the regions in the Netherlands in our analyses and the Austrian regions studied by Friesenbichler and Hölzl (2020) indeed show higher regional persistence of HGFs. Moreover, the regions in Croatia and Slovenia have a low number inhabitants. Hypothesis 3 shows the importance of EE size for persistency, which indicates that the NUTS-3 level can be a too fine-grained spatial scale to identify persistence of HGFs, especially in the case of sparsely populated regions. Overall, we conclude that our findings, combined with those by Coad and Srhoj (2023), and Friesenbichler and Hölzl (2020) all fit with our further articulation of the EE framework. Our articulation is theoretically grounded in ideas about critical mass in social networks (Marwell et al., 1988), and decreasing marginal returns in social networks (Uzzi and Spiro, 2005), as well as on empirically grounded simulations on EEs (van Rijnsoever, 2020). Thereby, it has a solid theoretical base.

Our work combined with Coad and Srhoj (2023), and Friesenbichler and Hölzl (2020) contributes to the EE framework (Wurth et al., 2022), by pointing scholarly attention to the matter of the persistence of EE outputs over time. This is a research direction that received little quantitative empirical attention, but that is key for the argumentation behind the EE framework. We encourage future researchers to keep taking a longitudinal approach, and to account for EE quality and scale, to better understand entrepreneurial ecosystems, their effects and evolution. More research also is needed in additional mechanisms that can influence regional persistence of HGF. Possible candidates are the density of the population, or sectoral diversity. Further, until now, studies used the NUTS-2 or NUTS-3 level as unit of analysis of EEs. However, it is well possible that EEs do not adhere to these administrative boundaries (Fischer et al., 2022; Schäfer, 2021). More research is needed on the boundaries of EEs, and inter-ecosystem connections to see how regions can strengthen each other, or possibly compete.

Our paper also answers calls for more replication studies in economics (Hamermesh, 2007), management (Bettis et al., 2016), and entrepreneurship (Davidsson, 2016). Much more data-driven, and more longitudinal studies, taking into account longer time periods are needed to fully understand persistence, randomness, the appropriate territorial boundary of an EE, and the role of critical mass and cumulative causation in the evolution of EEs and their outputs (cf. Wurth et al., 2022). Until now studies considered persistence at the EE output level. This is the case because the required longitudinal data on the inputs of EEs is not yet systematically available (Leendertse et al., 2022), however the increased availability of data in this area makes such an approach increasingly viable.

Finally, Coad and Srhoj (2023) conclude their paper with a “broken clock” critique of the EE approach. A broken clock tells the correct time twice a day, but still is not useful to tell the time. The clock metaphor applies according to the authors to the EE approach: sometimes right but not useful for policy. Based on our results we conclude that the clock keeps on ticking, but perhaps less accurate in lower quality or smaller EEs. Ultimately the clock metaphor may be misleading in the context of EEs and especially EE policy, in two ways. First, improving the quality of EEs is a no-regret policy for EEs of sufficient critical mass. In doing so, policymakers can capitalize on the increasingly positive relationship between EE quality and the regional persistence of high-growth firms (HGFs). However, we also caution that policymakers should carefully examine which elements require strengthening. For EEs of insufficient quality or size, it is important to assess whether achieving critical mass is feasible. Scaling the administrative size might contribute to building a more coherent EE across regions, but this approach may pose challenges in sparsely populated areas where establishing interactions between EE elements is difficult. This bring us to the to the harder (and perhaps more interesting) question, which is how to improve each EE in a meaningful, effective and efficient way. Second, in a conceptual sense, entrepreneurial ecosystems are enabling the emergence of novelty and structural change, not the continuation of a ticking clock. To paraphrase Mark Twain, in well-developed entrepreneurial ecosystems history doesn’t repeat itself, but it often rhymes, in unexpected ways.

4.

Logics at play: How logics shape interactions across entrepreneurial ecosystems

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Abstract

Most entrepreneurial ecosystem research has focused on the actors and interactions within a focal (often regional) entrepreneurial ecosystem. This entails the often-implicit assumption that entrepreneurs mainly interact with actors located within their own entrepreneurial ecosystem. We argue that this assumption is a limitation for entrepreneurial ecosystem research and we address this limitation by studying the research question: What drives and hinders interactions across the boundaries of entrepreneurial ecosystems? We study how both individual motivations and the entrepreneurial ecosystem drive and hinder interactions across the boundaries of a focal entrepreneurial ecosystem. We find that actors primarily interact across entrepreneurial ecosystem boundaries to get access to resources and sometimes to more favorable institutions. The access to resources is a more frequent driver of interactions than the access to institutions. Furthermore, we find that the ability of actors to engage in cross-entrepreneurial ecosystem interactions is influenced by two logics. The start-up development logic, which does allow for interactions, and the regional development logic that often prevents interactions as it causes actors to transform administrative boundaries into entrepreneurial ecosystem boundaries. The identification and description of these logics is the primary contribution of this paper.

4.1 Introduction

The entrepreneurial ecosystem literature describes how entrepreneurs depend on other actors (incubators, provinces, entrepreneurs, investors etc.) for resources and how their behavior is shaped by the institutions and environments in which they are embedded (Alvedalen and Boschma, 2017; Audretsch and Belitski, 2017; Stam, 2015; van Rijnsoever, 2022). The entrepreneurial ecosystem framework has developed into an important tool for academics and practitioners to understand and influence productive entrepreneurship. This is important because productive entrepreneurship creates both social and economic value (Acs et al., 2013; Baumol, 1990).

To date, most scholarly attention has focused on the actors and interactions within a focal (often regional) entrepreneurial ecosystem (Fischer et al., 2022; Schäfer, 2021). There is only limited research that addresses interactions beyond a single entrepreneurial ecosystem. This entails the, often implicit, assumption that entrepreneurs mainly acquire resources from actors located within their own (regional) entrepreneurial ecosystem. This is surprising since entrepreneurial ecosystems do not exist in isolation but are in fact connected to each other (Wurth et al., 2022). The dominant approach of conceptualizing entrepreneurial ecosystems as isolated analytical units thus results in an incomplete understanding of entrepreneurial ecosystems. It ignores the influence of 'outside' interactions, for example with actors from other entrepreneurial ecosystems (Theodoraki and Catanzaro, 2022; Xu et al., 2023).

Recently, scholars have started to conceptually discuss the interactions across entrepreneurial ecosystem boundaries. Examples are Theodoraki and Catanzaro (2022) who look at entrepreneurial ecosystem boundaries through an international lens, and Brown and Mason (2017) who argue that the linkages between entrepreneurial ecosystems develop along with the maturity of the entrepreneurial ecosystem.

Brown and Mason (2017) hint that both 1) the motivations of individual entrepreneurs and 2) the characteristics of the entrepreneurial ecosystems may drive (or hinder) cross-entrepreneurial ecosystem interactions. However, these studies do not empirically address why stakeholders interact beyond the boundaries of their entrepreneurial ecosystems (Brown and Mason, 2017; Fischer et al., 2022; Schäfer, 2021; Theodoraki and Catanzaro, 2022; Wurth et al., 2022). As a result, it remains unclear when and how interactions across entrepreneurial ecosystem boundaries take place in practice.

The lack of research on interactions across entrepreneurial ecosystem boundaries means that the entrepreneurial ecosystem literature provides limited evidence on how such interactions affect the development and impact of productive entrepreneurship. This has implications for practitioners and policymakers seeking to stimulate productive entrepreneurship. They cannot build on evidence to determine whether cross-entrepreneurial ecosystem interactions are a relevant area for policy and what relevant policies would look like.

Understanding interactions beyond the boundaries of entrepreneurial ecosystems is thus a topic with both theoretical and practical relevance. We study this topic by asking the following research question:

What drives and hinders interactions across the boundaries of entrepreneurial ecosystems?

We draw on in-depth case studies of three entrepreneurial ecosystems, in the context of the Dutch EWUU alliance. The EWUU alliance is a Dutch university alliance which includes universities from the cities of Eindhoven, Utrecht, and Wageningen. It was established in 2019 by the Technical University Eindhoven, Wageningen University & Research, Utrecht University, and the Utrecht Medical Centre. The aim of the EWUU alliance is to enhance the societal impact (e.g. via entrepreneurship) of its partner organizations by exploring potential interactions between the organizations and their entrepreneurial ecosystems. This context provides an excellent opportunity to study the interactions across entrepreneurial ecosystems. We study how individual motivations of entrepreneurial ecosystem actors, and the entrepreneurial ecosystems in which they are embedded drive and hinder interactions across the boundaries of each region.

In doing so, we make several contributions to the literature. First, we outline the motivations of individual actors to interact across entrepreneurial ecosystem boundaries and we show how these motivations can be linked to the resources and institutions in an entrepreneurial ecosystem. We find that access to resources is the most frequent driver to cross entrepreneurial ecosystem boundaries.

Second, we identify two underlying logics that influence when and how actors do (not) cross ecosystem boundaries: regional development logics and start-up development logics. Thornton and Ocasio (2008) define an institutional logic as the socially constructed, historical patterns of cultural symbols and material practices, including assumptions, values, and beliefs by which individuals and organizations provide meaning to their daily activity organize time and space, and reproduce their lives and experiences. The concept of logics is well suited to study how actors are influenced by their situation in an institutional context (Thornton et al., 2012). We use the term logics as this theoretical construct matched well with the observed patterns in the data.

Regional development logics reflect support behaviors, rules and conditions that prioritize supporting start-ups in such way that they contribute to regional development or regional challenges instead of prioritizing support that best facilitates the start-up. *Start-up development logics*, on the other hand, reflect support behaviors, rules and conditions that prioritize developing and growing the start-up over the regional development goals. The logics can help researchers to understand emerging dynamics within and across entrepreneurial ecosystems. As such, we encourage entrepreneurial ecosystem scholars to further study these logics and their implications when shaping their future research.

While the identified logics are often complementary, our findings show how they can produce conflict, thereby hindering the development of start-ups: being part of one regional entrepreneurial ecosystem has, oftentimes limiting, consequences for the access to resources and support in other regional entrepreneurial ecosystems. We encourage entrepreneurial ecosystem support actors to critically reflect on their own logics and be mindful of behaviour that may have a counterproductive influence on the development of start-ups and productive entrepreneurship overall due to a clash of interests.

4.2 Theory

4.2.1 Entrepreneurial ecosystems

An entrepreneurial ecosystem comprises a set of interdependent actors and factors that are governed in such a way that they enable productive entrepreneurship within a particular territory (Stam, 2015; Stam and Spigel, 2018). Productive entrepreneurship consists of entrepreneurial activities that create both social and economic value (Acs et al., 2013; Baumol, 1990) and is often proxied through innovative start-ups (Leendertse et al., 2022; Schrijvers et al., 2023).

We define start-ups as small and young entrepreneurial ventures which are in the process of exploring a technology to develop a fast-growing business (Bjornali and Ellingsen, 2014; Fontes and Coombs, 2001; Klotz et al., 2013). Start-ups suffer from a lack of resources (Kuratko et al., 2017; Leendertse et al., 2021; Truong and Nagy, 2020), which causes them to depend on other actors for access to resources (Alvedalen and Boschma, 2017; Audretsch and Belitski, 2017; Stam, 2015; van Rijnsoever, 2022). In addition, entrepreneurship has been found to be most productive in contexts with inclusive and growth-enhancing institutions (Bosma et al., 2018; Sobel, 2008).

The available resource endowments and institutional arrangements are the two functions through which an entrepreneurial ecosystem influences productive entrepreneurship. We, along the lines of Stam and van de Ven (2021) and Leendertse et al. (2022), conceptualize the resource endowments and institutional arrangements as the two layers of the entrepreneurial ecosystem framework. Stam (2015) further details how the entrepreneurial ecosystem contains ten elements, seven in the resource endowments layer, and three in the institutional arrangements layer (see Fig. 4.1). The resource endowments category covers physical infrastructure, demand, intermediaries, talent, knowledge, leadership, and finance. The *institutional arrangements* cover formal institutions, culture, and networks. Empirical research has shown a positive relation between the quality of the entrepreneurial ecosystem and productive entrepreneurship, as an output of the entrepreneurial ecosystem (Leendertse et al., 2022; Schrijvers et al., 2023; Stam and van de Ven, 2021).

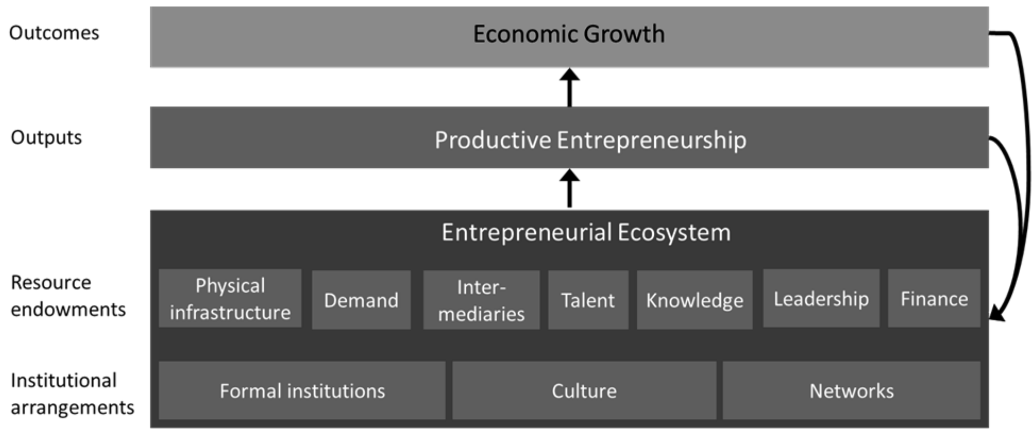

Fig. 4.1. Elements and outputs of the entrepreneurial ecosystem (adapted from Stam and van de Ven, 2021).

Wurth et al. (2022) identify five sets of key mechanisms in the development of entrepreneurial ecosystems, namely (1) the interdependencies between the entrepreneurial ecosystem elements, (2) an upward causation through which the elements influence the outputs, productive entrepreneurship, and (3) a subsequent upwards causation between the outputs and the outcomes, economic growth, (4) downward causation, and (5) interactions across the boundaries of entrepreneurial ecosystems. In our study we focus on the fifth mechanism, the interactions across entrepreneurial ecosystem boundaries. We discuss these boundaries in the next section.

4.2.2 Entrepreneurial ecosystem boundaries

The boundaries of economic systems are a topic of frequent debate in the ecosystems literature (Carlsson et al., 2002; Cho et al., 2022; Cobben et al., 2022). The scholarly discussion around the (characteristics of the) boundaries of entrepreneurial ecosystems can be considered as building on the biological understanding of how ecosystems function. This means that clarifying the spatial boundary of ecosystems is crucial to unpacking the dynamics in entrepreneurial ecosystems (Gulati et al., 2012; Post et al., 2007). The spatial boundaries are, currently, often chosen to coincide with administrative borders (Cobben et al., 2022; Schäfer, 2021; Wurth et al., 2022). However, several authors (e.g. Cho et al., 2022; Fischer et al., 2022; Schäfer, 2021) argue that this approach of defining boundaries of entrepreneurial ecosystems is too simplistic. Inspired by recent research by Fischer et al. (2022), we categorize our understanding of what characterizes entrepreneurial ecosystem boundaries along two main schools of thought: economic geography theories and neo-insitutional theory.

Economic geography theories (Davis and Weinstein, 1999) conceptualize ecosystem boundaries as territorial phenomena. Within this category, spatial boundaries of ecosystems are clearly defined and can span from communal or city-levels (e.g. Mack and Mayer, 2016; Motoyama and Knowlton, 2017; Qian et al., 2013; Radziwon and Bogers, 2019; Spigel, 2017) to regional or provincial levels (e.g. Guzman and Stern, 2020; Leendertse et al., 2022; Stam and van de Ven, 2021; Sternberg et al., 2019; Xu et al., 2023) to national levels (e.g. Ács et al., 2014; Radosevic and Yoruk, 2013). However, when researchers choose to define the spatial boundaries of an entrepreneurial ecosystem in territorial terms, they encounter several difficulties in incorporating sector-specific expertise, socio-economic factors, and diverse forms of formal and informal institutional support (Fischer et al., 2022; Perugini, 2023). As a result, the ambiguity in identifying the spatial boundaries around entrepreneurial ecosystems prevents researchers from investigating the inter-linkages and interactions among entrepreneurial ecosystems (Wurth et al., 2022).

This can be addressed using the second school of thought. Based on neo-institutional theory, the conceptualization of boundaries can be defined by the actors, activities, and artifacts that are part of the entrepreneurial ecosystem. This conceptualization thus goes beyond the strict territorial identification of boundaries. Instead, one looks at the locations of actors and defines the boundaries of an ecosystem based on the range in which actors perform activities that connect them with other actors or artifacts. Placing entrepreneurial actors at the core of entrepreneurial ecosystems and defining entrepreneurial ecosystem boundaries based on the extent of entrepreneurial activities, has been a fundamental step in the current scholarly understanding of entrepreneurial ecosystem boundaries (Brown and Mason, 2014; Hernández-Chea et al., 2021; Roundy, 2016).

In line with Fischer et al. (2022), we combine the economic geography and neo-institutional schools of thought to conceptualize ecosystem boundaries as a combination of territorial boundaries and the range in which actors, activities, and artifacts operate. This enables us to understand 1) how a focal entrepreneurial ecosystem is connected to other entrepreneurial ecosystems through actors and activities and 2) what characterizes these relations.

4.2.3 Interactions across entrepreneurial ecosystem boundaries

Typically, the interactions of entrepreneurs focus on a local context (Brown and Mason, 2017). However, sometimes they engage in cross-entrepreneurial ecosystem interactions (Harima et al., 2021; Wang et al., 2023). These non-local interactions can be driven (or hindered) by both 1) the motivations of individual entrepreneurs and 2) the institutional context that is the entrepreneurial ecosystem.

The individual motivations are addressed in the transnational entrepreneurship literature (Abd Hamid et al., 2023; Fuller-Love and Akiode, 2020; Harima et al., 2021), where a lack of resources in the local context is considered the main motivation for non-local interactions. An example could be the availability of investments. Although the majority of venture capital investments are national or even regional, there is still a substantial amount of venture capital investments that crosses international borders (Bertoni et al., 2015; Wright et al., 2005). The access to resources as a motivation to interact across entrepreneurial ecosystems aligns theoretically with the resource endowment layer of the entrepreneurial ecosystem framework (see Fig. 4.1).

Brown and Mason (2017) state that the entrepreneurial ecosystem itself also has an influence on cross-entrepreneurial ecosystem interactions. They do so by arguing that the linkages between entrepreneurial ecosystems develop along with the maturity of entrepreneurial ecosystems. Not just by attracting more entrepreneurs (March-Chordà et al., 2021) but also through stronger outward connections. To study the influence of the embedding entrepreneurial ecosystem on interactions across the boundaries of a focal entrepreneurial ecosystem, we conceptualize the entrepreneurial ecosystem as an institutional context. Institutional contexts shape the behaviors of the actors embedded in them (Battilana et al., 2009) and some institutional contexts have been found to facilitate or limit the crossing of boundaries (Sternlieb et al., 2013).

The concept of institutional logics is well suited to study how actors are influenced by their institutional context (Thornton et al., 2012). According to Thornton and Ocasio (2008) institutional logics are the socially constructed, historical patterns of cultural symbols and material practices, including assumptions, values, and beliefs by which individuals and organizations provide meaning to their daily activity organize time and space, and reproduce their lives and experiences.

The institutional logics present in an institutional context impact the interactions by the actors embedded in that institutional context (Nederhand et al., 2019; Witte et al., 2008) and whether multiple institutional logics are complementary or conflicting (Currie and Spyridonidis, 2016). Following the conceptualization of Alterskye et al. (2023) we study how different institutional logics come together at the entrepreneurial ecosystem (the institutional context) level and how this influences cross-entrepreneurial ecosystem interactions.

4.3 Method

4.3.1 Research Design and case selection

To explore the interactions across entrepreneurial ecosystem boundaries, we performed an in-depth case study of three Dutch regional entrepreneurial ecosystems. We selected three entrepreneurial ecosystems based on the location of the partner organizations that form the EWUU (Eindhoven University of Technology, Wageningen University and Research, Utrecht University, University Medical Centre Utrecht) alliance, which is the context of our research. We started our study from the three focal cities in which the four EWUU alliance university partners are located. These three entrepreneurial ecosystems all matched the following five criteria: 1) presence of a high-quality entrepreneurial ecosystem (top 10% in Europe) as operationalized by Leendertse et al. (2022)[1] 2) part of the same national context 3) identifiable regional boundaries, 4) some degree of geographical connectedness between entrepreneurial ecosystems and 5) presence of a university.

Besides the common characteristics we also identified a distinguishing feature of each entrepreneurial ecosystem based on the degree of industrial specialization. Wageningen is highly specialized in agrifood, which leads to a clear prominence of start-ups in this sector. Eindhoven is specialized in high-tech, but this specialization is less prominent than the specialization in Wageningen. Utrecht is a more diverse entrepreneurial ecosystem in which healthcare is the dominant theme, but it is only slightly larger than several other focal areas.

The selected entrepreneurial ecosystems form good cases to study high-quality entrepreneurial ecosystem. All entrepreneurial ecosystems meet the five selection criteria. At the same time, each ecosystem has a clear distinguishing feature and has slightly different characteristics (see Table 4.1). This makes it interesting to compare the cases and study ecosystem interactions based on the degree of sectoral specialization. It is assumed that – because of the differences and similarities – the entrepreneurial ecosystems offer different resources to entrepreneurs, challenging them to consciously choose in which of the ecosystems they prefer to build their venture, but also to interact with other regions. Table 4.1 provides an overview of the three cases. We use CBS (2023) for the population statistics, Leendertse et al. (2022) for the EE quality score, and Crunchbase (2023) for the start-up data.

1 Leendertse et al. (2022) operationalize the 10 elements as outlined by Stam (2015) and combine the measurements of the elements in an entrepreneurial ecosystem index that shows the quality of 273 regional entrepreneurial ecosystems.

Table 4.1. Characteristics of the three entrepreneurial ecosystems.

Focal city	Eindhoven	Utrecht	Wageningen
Population in city	243,730	367,974	40,960
Population in NUTS-2 region	2,626,210	1,387,643	2,133,708
EE quality index score	18.46	25.18	17.67
Total start-ups in NUTS-2 region	922	669	748
Total start-ups in city	173	260	26
% of start-ups active in most prolific sector	23%	12%	58%
Focal university	Eindhoven University of Technology	Utrecht University	Wageningen University & Research
Main industrial focus	High-tech	Health	Agrifood
# actors interviewed	16	19	17

4.3.2 Data collection

We start our research by identifying and sampling key informants (entrepreneurial ecosystem actors) in each regional entrepreneurial ecosystem starting from our network at the university, governmental organizations and entrepreneurs. Our team includes authors from all three universities which allowed us to start with an equal representation in each entrepreneurial ecosystem. Within the three entrepreneurial ecosystems we then performed snowball sampling, by asking interviewees to refer us to other relevant actors in their EE, served to arrive at a balanced and representative sample of informants for each EE. We define the entrepreneurial ecosystems based on the boundaries as described by entrepreneurial ecosystem actors. The entrepreneurial ecosystem actors include municipalities, provinces, universities, other education institutes, regional development agencies, investors, entrepreneurs, start-up team members, corporates, mentors, and entrepreneurial support actors (Brown and Mason, 2017; Wurth et al., 2022). Entrepreneurial support organizations are incubators, accelerators, science parks, maker spaces, and co-working spaces (see Bergman & McMullen, 2023). We interviewed 52 actors using a semi-structured interview guide, a full overview of the organizations represented by the informants, per entrepreneurial ecosystem, is provided in Appendix C. We ensured to interview actors from each actor group and stopped performing interviews when we found to have reached theoretical saturation (Hennink et al., 2017; Van Rijnsoever, 2017).

To identify when interactions crossed entrepreneurial ecosystem boundaries we, using the two schools of thought as the underlying framework, asked the informants to characterize the boundaries of their entrepreneurial ecosystem. For triangulation, we also asked who the informants see as the most important actors in their entrepreneurial ecosystem based on the importance of interactions. Before conducting our analyses, we used these answers to check what the informants perceive to be the boundaries of their entrepreneurial ecosystem. The interviews show that the three focal cities, from which we started, are considered part of three distinct entrepreneurial ecosystems. We find that different types of actors within the same entrepreneurial ecosystem are mostly consistent in what they outline as the boundaries of their entrepreneurial ecosystem. We do find differences in the type of boundaries across the three entrepreneurial ecosystems. We describe the respective boundaries in Appendix C.

For our research objective we asked informants to name concrete examples of cross-entrepreneurial ecosystem interactions and to describe these examples. We asked them to provide examples of interactions they perceived as successful and as unsuccessful and about their motivation to (not) interact with other ecosystems. We used our theoretical background to distinguish between individual motivations and the influence of the institutional context, the underlying entrepreneurial ecosystem. All interviewees gave permission to record and transcribe their interview. The interview guide can be found in Appendix C.

4.3.3 Data analyses

For our data analyses we used the method of Gioia et al. (2013). The first step of this method is to create first-order concepts, each statement is coded based on its essence (ibid). Little attempt is made to categorize these concepts. The categorization is done in the creation of second-order concepts. These translate the terms of the interviewees to the theoretical level (ibid). These second-order concepts are related to the overall aggregate dimension, in our case, cross-entrepreneurial ecosystem interactions. An overview of the data structure is provided in Table 4.2.

We first analyzed the cross-entrepreneurial ecosystem interactions as described by the informants. Here, after inductively deriving the theory from the data, using Gioia et al. (2013), we found that the individual motivations of actors to cross entrepreneurial ecosystem boundaries could, abductively, be linked to the two layers and the ten elements of entrepreneurial ecosystems (Stam, 2015; Stam and van de Ven, 2021). We thus link our findings to the entrepreneurial ecosystem framework of Stam (2015) and use the theoretical framework to abductively explain the phenomenon (Goldkuhl and Cronholm, 2010).

Second, we analyzed how the entrepreneurial ecosystems, as institutional contexts, enable or prevent these interactions from occurring. We systematically identify two logics that influence cross-entrepreneurial ecosystem interactions. We describe these logics and how they influence cross-entrepreneurial ecosystem interactions. Third, we use the two logics to characterize the three entrepreneurial ecosystems and how the logics shape cross-entrepreneurial ecosystem interactions in each entrepreneurial ecosystem.

Table 4.2. Data structure.

First order concepts	Second order concepts	Aggregate dimension
Access to different institutions	Individual motivations	Cross-entrepreneurial ecosystem interactions
Access to resources		
Only support start-ups within the region	Regional development logics	
Require start-ups to move for support		
Prevent start-ups from moving		
Stimulate other actors to think regionally		
Self-reinforcing networks		
Share knowledge with similar actors	Start-up development logics	
Facilitate interactors across entrepreneurial ecosystem		
Provide support to entrepreneurs outside of the entrepreneurial ecosystem		
Get access to resources and institutions		
Territorial boundary descriptions	Geographical boundaries	
Actor boundary descriptions		
Activity boundary descriptions		
Actor boundary descriptions	Sectoral boundaries	
Activity boundary descriptions		

4.4 Findings

In the next sections we present the findings of our research as follows. In section 4.4.1 we characterize the individual motivations of actors to engage in interactions across entrepreneurial ecosystems and abductively link these motivations to the entrepreneurial ecosystem elements by Stam (2015). In section 4.4.2 we discuss the two logics that emerged inductively from patterns in the data across the three entrepreneurial ecosystems. We first discuss the regional development logics and then discuss the start-up development logics. For both logics we also describe how they influence cross-entrepreneurial ecosystem interactions. In section 4.4.3 we use the logics to characterize the three entrepreneurial ecosystems in our study. We describe the different logic combinations and discuss how that influences the interactions across entrepreneurial ecosystems.

4.4.1 Characterizing entrepreneurial ecosystem interactions

In this section we explore the motivations of actors to engage in cross-entrepreneurial ecosystem interactions and link them to the entrepreneurial ecosystem layers and elements as defined by Stam (2015). We find motivations for each of the ten elements. The majority of cross-entrepreneurial ecosystem interactions are driven by a desire to obtain access to resources. Access to finance is especially frequently discussed as a resource. This aligns with previous research on transnational entrepreneurship (e.g. Abd Hamid et al., 2023; Fuller-Love and Akiode, 2020). More surprisingly, we also identify interactions that are initiated to get access to institutional arrangements. We provide an overview of the identified motivations for individual organizations to interact across the boundaries of entrepreneurial ecosystems, using a set of example quotes, in Table 4.3.

Table 4.3. Overview of example quotes for the cross-ecosystem interactions per entrepreneurial ecosystem element.

	EE element	Example quotes for cross-ecosystem interactions motivation
Resource endowments	Physical Infrastructure	*'Utrecht was in the middle of where the two founders lived, so they moved the start-up to Utrecht.' (U03)* *'Wageningen is closer to where we live than Noordwijk.' (W06)* *'Location is a core reason for start-ups who move here.' (U06)* *'The lack of available connections on the electricity grid means some companies have to (re)locate to other regions.' (E09)* *'Some start-ups come to Wageningen for access to laboratories.' (W11)*
	Demand	*'We can connect start-ups to large corporates in the agrifood and if they can contribute to their business, they have a big impact.' (W01)* *'For our market it is important to have connections in different countries.' (E08)* *'[Start-up] wanted to move their business to our region because the people in the region where more likely to be customers.' (U13)*
	Intermediaries	*'Start-ups moved here to join our incubation programme.' (E01)* *'If there is a greenhouse start-up somewhere else, they [another incubator] will call us. Then we make a connection.'' (W01)* *'The start-up moved here because the AI theme of the incubator matched their business.' (U03)* *'Start-ups come here because of the thematic focus on the game industry at our incubator.' (U16)*
	Talent	*'Start-ups move here for access to talent.' (U02)* *'They [start-up] wanted to move to Utrecht because they felt it was easier get access to talented employees.' (U06)* *'The lack of available talent is a reason for start-ups to move to other regions.' (E09)* *'Some start-ups come to Wageningen campus because they want to be as close to the students as possible.' (W11)* *'We are partly located here due to the strong connections with universities in the region. This allows us to find relevant talent and exchange knowledge.' (U15)*

	Knowledge	*'LeatherCo[2] moved to Leiden because of the knowledge available there.' (U03)* *'Start-ups come here from other universities because they have an agriculture or food solution.' (W07)* *'We are in different ecosystems to get access to the domain knowledge in that ecosystem.' (W06)* *'For the technology we need to collaborate with different partners from different regions.' (E08)* *'Specialized knowledge is a key reason for interactions between regions.' (E11)*
	Finance	*'If a regional development agency doesn't provide finance and another does but says, well then you have to move [to our region] they do.' (U02)* *'If you get an investment from a particular regional development agency then you must move to that region.' (W07)* *'In the past investments for companies in Utrecht came from other ROMs, but that required moving to that region.' (U04)* *'If we can't get finance here we have to consider moving.' (E08)* *'I can move the business to Limburg if there is funding from that regional development agency.' (Start-up at event)* *'Start-up often move to this region to get easier access to finance.' (E03)* *'Start-ups that leave the region go to Amsterdam to be closer to an investor.' (U13)* *'We also made an investment with two different regional development agencies.' (U04)*
	Leadership	*'We are starting up collaborations across the regions, to start using the same language.' (U03)*

2 All company names are anonymized

Table 4.4. Overview of the logics, their elements and example quotes.

Logics	Logic elements	Example quotes
Regional development logics	Only support start-ups within the region	*'We are focused on the 21 municipalities that are partners of Brainport. Our activities really focus on this region. (E03)* *'A part of our funding comes from the province and that needs to be directed to companies that have an impact in the Wageningen region.' (W01)* *'some used to have a very clear strategy to not share much because the more they felt that the more they helped others along the weaker there leading position became.' And 'I feel that some smaller ecosystems in the Netherlands perceive connecting ecosystems as a threat. It can expose that there is not a lot happening in these ecosystems.' (U03)* *'They might have a different reason for being on the campus than we did.' (W04)* *'There is sometimes a conflict between the university who wants to earn money from the IP and the success of start-ups'. (U11)* *'If it is a marketing start-up that is great but we won't put extra energy in that because it doesn't really fit our economic agenda, which focusses on societal challenges.' (U01)* *'Contact with [start-ups, incubators, investors] in other regions is less direct. If a start-up from another region reaches out and they want to come to this region then we can help with location, finding a spot.' (U01)*

Require start-ups to move for support	*'if moving regions is a requirement to get investments then we will have to consider that'. (E08)* *'If a regional development agency doesn't provide finance and another does but says, well then you have to move [to our region] they do.' (U03)* *'If you get an investment from a particular regional development agency then you must move to that region.' (W07)* *'The regional development agency said you are not located in our region, even though they were working there four days a week.' (E10)* *'If a start-up can't find investments in their region but we, or another investor, are willing to invest it can be that they are required to move to our region.' (E15)* *'I know founders who move to a specific region, because then they get investments from the regional development agencies of that region.' (W17)*
Prevent start-ups from moving	*'It happens that start-ups are told: You can't relocate to another region because we are one of your funders.' (U03)* *'The regional development agencies might state in the financial terms that start-ups have to remain in the region.' (W09)* *'The regional development agency are upset when start-ups move, they are competing with each other instead of looking at the big picture. (W07)* *'The key issue is you get in these procedures and they take so long that it harms the innovative potential of the country.' (E10)*
Stimulate other actors to think regionally	*'There is friction between the goals of the municipality and the goals of start-ups. Look, for us the regional economic agenda is crucial. When we talk with start-up incubators they have a broader perspective. And we try to focus them more on the regional economic agenda.' (U01)* *'The goal is to have the incubator really in the region, embedded in the region.' (E01)* *'The municipality frequently asks did we lose start-ups to other regions.' (U02)* *'There is a financial incentive from Gelderland, so some parts of our programme are only for firms in this province.' (W07)*
Self-reinforcing networks	*'We don't have as strong of a network outside as inside the region.' (E03)* *'The collaboration here in the region is very intensive.' (E01)* *'In [the province] everyone knows everyone.' (E06)* *'Everyone knows everyone, the network is not independent.' (E04)* *'There are very strong connections in the region, we all help each other.' (E13)*

Share knowledge with similar actors	*'We collaborate a lot within the 4TU alliance.' (E01)* *'I participate in a knowledge network for cities in the Netherlands, in which all cities with a university participate and the start-up officers network organized by the RVO, in which all people with a similar role as I at public organizations are present.' (U01)* *'We are one of the initiators of Incubators United, which is a collaboration between all university incubators in the Netherlands.' Followed by 'internationally there is the University Business Incubators, UBI, network' and the 'EuroIncNet, which is a European incubator network with several German, Scandinavian, and English incubators.' (U03)* *'I regularly meet with other campus developers to try to learn from each other.' Followed by 'We lobby together to get more shared facilities so that start-ups have access to not just office space but also laboratories etc.' (W11)* *'We [municipalities] connect to lobby together for changes at the national level.' (E05)* *'We have a regular meeting, every 6 weeks, with technology transfer offices of the 4TU and TNO where we discuss cases.' (W09)* *'I try to collaborate with other regional development agencies as much as possible.' (U04)* *'We started a collaboration with others in the same position at different universities.' (U10)* *'We have good personal connections with the other ROMs and exchange knowledge.' (E09)*

Facilitate interactions across entrepreneurial ecosystem	*'I think it is a shame that [regions] do not invite each other to events outside of the region. I would like to invite our community for other events. And if someone then moves regions, well than that's the way it is.' (U02)* *'An example is a start-up from Delft that makes bioreceptive concrete, which enables concrete facades with moss. In Delft they are knowledgeable about concrete but less so about moss so we connected them with knowledge from the WUR.' (W09)* *'We had a life-sciences start-up that we, on purpose, forwarded to Utrecht and they were very satisfied with the result.' (E01)* *'I prioritize start-ups and if I am forced to choose between the interests of the municipality and a start-up I lean towards the start-ups.' (E05)* *'If a start-up moves that can be ok, the company should be where it can grow the fastest.' (E09)* *'We now launch in the USA and we do that with a lot of support from this ecosystem.' (E12)*
Provide support to entrepreneurs outside of the entrepreneurial ecosystem	*'If there is a greenhouse start-up somewhere else, they [another incubator] will call us. Then we make a connection.' (W01)* *'They are located in Delft but we have great connections in the industry so they joined our programme but are still located in Delft, but connecting them to our network is relevant. (W01)* *We are organizing Meet-Your-Cofounder-XL, an event where several incubators all bring start-ups and potential co-founders to connect them.' (U03)* *'We now have a start-up from Utrecht, who wasn't happy with the support there, but the colleague in Utrecht said. We can't get him on board so if you can that's better.' (E01)*
Get access to resources and institutions	*'We are in different ecosystems to get access to domain knowledge and networks.' (W06)* *'I can move the business to Limburg if there is funding from that regional development agency.' (Start-up at event).* *'For the technology we need to collaborate with different partners from different regions.' (E08)* *'If I need knowledge about greenhouses I get in my car and drive to 'Het Westland' [a region with many greenhouses]. My advice is to stop thinking along regional boundaries. The Netherlands are too small for that.' (W17)* *'Before an investment we always want to talk to key global experts in the specific domain and he/she is frequently not in our region.' (E09)*

Institutional arrangements	Culture	*'We see that the vibe in Utrecht is less about the lifestyle and we are more down to earth, and some science start-ups really appreciate that.' (U03)* *'I am located here because I like the culture, the mindset.' (E08)*
	Formal institutions	*'We [municipalities] connect to lobby together for changes at the national level.' (E05)* *'We are in a working group with provinces and discuss the plans of the ministry regarding plans for 'start-ups.' (U08)*
	Networks	*'They are located in Delft but we have great connections in the industry so they joined our programme but are still located in Delft, but connecting them to our network is relevant.' (W01)* *'We are active in two ecosystems to get access to the respective networks.' (W06)* *'We are organizing Meet-Your-Cofounder-XL, an event where several incubators all bring start-ups and potential co-founders to connect them.' (U03)* *'[They] a start-up moved to the region for better connection to actors.' (U06)* *'We get asked to co-invest outside of our region due to our network in the production supply chains in the Eindhoven region.' (E13)*

4.4.2 Entrepreneurial ecosystem support logics: Regional development logic vs start-up development logic

In the interviews we find that not all actors engage in cross-entrepreneurial ecosystem interactions. This can be considered somewhat surprising given the potential advantages of increasing the access to resources or institutions. Based on the interviews we find that this is the result of the institutional context, the entrepreneurial ecosystem, surrounding those actors. We identify two sets of underlying logics that influence whether organizations engage in cross-entrepreneurial ecosystem interactions or not. These logics arrived inductively from the data. We named these logics the regional development logics and start-up development logics. Here regional development logics reflect support behaviors, rules and conditions that prioritize developing and growing the region (irrespective of start-up development), whereas start-up development logics reflect support behaviors, rules and conditions that prioritize developing and growing the start-up (irrespective of regional development). One logic does not exclude the other. We find both logics in all three ecosystems and although actors can be guided by both logics, we often observe that actors predominantly follow one of the two logics. In the following sections we ground these two logics in our empirical data. For each logic we first describe the logic, then we outline which actors adhere most closely to each set of logics and finally we describe how the logics influence cross-entrepreneurial ecosystem interactions. The two logics, their elements, and exemplary quotes can be found in Table 4.4.

4.4.2.1 Regional development logics: The enactment of boundaries

Regional development logics reflect entrepreneurial support behaviors, rules and conditions that lead them to prioritize developing and growing the region. This can relate to regional economic growth but also to addressing regional societal challenges. The regional development logics are, for some actors, the driver to be active in the entrepreneurial ecosystem. This is illustrated by U08 who state that the primary reason that the province is involved in the entrepreneurial ecosystem is that they believe start-ups and scale-ups can help address societal challenges. In their perspective entrepreneurship is a mean to a broader regional goal.

We find that the regional development logics are most clearly adhered to by the provinces, municipalities, and regional development agencies. These actors have an explicit regional focus in their mission and this focus shapes their entrepreneurial support behavior. An example is given by E03 who states that 'We are focused on the 21 municipalities that are partners of Brainport. Our activities really focus on this region.' We also find the regional development logics with universities, other education institutes, and some entrepreneurial support organizations. For instance, universities prioritize campus development or capturing value from entrepreneurial endeavors.

We find that actors who adhere to regional development logics enact the boundaries of administrative regions to become the boundaries of entrepreneurial ecosystems. Actors who adhere to the regional development logics shape the behavior of other actors in the ecosystems in several ways.

First, we find that actors who follow the regional development logics only provide support to start-ups if they are considered to contribute to regional development goals. This can manifest in explicitly designing support structures in such a way that they are only applicable for start-ups that they consider to be aligned with the regional development logics, W01: 'A part of our funding comes from the province and that needs to be directed to companies that have an impact in the Wageningen region.' Another way in which this shapes behavior is that adhering to the regional development logics can result in actors deciding to provide no support to start-ups from other regions, U01: 'Contact with [start-ups, incubators, investors] in other regions is less direct. If a start-up from another region reaches out and they want to come to this region then we can help with location, finding a spot.' Finally, the regional development logics also influence start-ups within an ecosystem that are considered to be not aligned with the regional development goals, U01: 'If it is a marketing start-up that is great but we won't put extra energy in that because it doesn't really fit our economic agenda, which focusses on societal challenges.'

Second, actors adhering to the regional development logics sometimes require start-ups to move to their region as a condition for providing support. This behavior is considered to be widespread and is illustrated by W07: 'If you get an investment from a particular regional development agency then you must move to that region.' An extreme example was provided by E03 about a start-up with an office in three different regions to get access to support in each region. We find that this manifestation of the regional development logics also influences start-ups. W07 also states that start-ups struggle with these dynamics. This is further illustrated by start-up E08 who observes that even though they did not want to relocate: 'if moving regions is a requirement to get investments then we will have to consider that'. Or start-up W17 who states that 'The regional development agencies set up boundaries, the start-ups and the money have to stay in the province. That is a poisonous combination. You shouldn't do that with a start-up'.

W17 also indicates that they are becoming more flexible with these boundaries. This sentiment is shared by several actors who indicate that the competition between regions is becoming less prominent due to increased collaboration between the regional development agencies. Interestingly enough, several actors also observe that some start-ups try to profit from these regional development logics by trying to get more investments in another region. We also noticed an example of this while present at a session in Eindhoven where the start-up stated 'I am also talking to the LIOF [regional development agency of another providence Limburg] and they are very interested'. Some entrepreneurs seem to understand how entrepreneurial ecosystem actors are driven by regional stakes and try to use that to create a strategic advantage.

Third, actors prevent start-ups from relocating to other regions due to past support they provided. U03 describes 'It happens that start-ups are told: You can't relocate to another region because we are one of your funders.' And W07 gives an example of a regional development agency that became upset when a start-up did move regions. This is an extreme illustration of how the regional development logics influence cross-entrepreneurial ecosystem interactions.

Fourth, we find that actors stimulate other actors to think and act along the lines of the regional development logics. This is illustrated by U01: 'For us the regional economic agenda is crucial. When we talk with start-up incubators they have a broader perspective. And we try to focus them more on the regional economic agenda.' They also do this by designing the KPIs of entrepreneurial support actors in such a way that support must go to regional start-ups. As a result, we find that these actors start adhering to the regional development logics and start enacting the regional boundaries set by other actors. This is illustrated by incubator U03 who, when talking about other incubators, states that: 'some used to have a very clear strategy to not share much because they felt that the more they helped others along the weaker there leading position became.' And 'I feel that some smaller ecosystems in the Netherlands perceive connecting ecosystems as a threat.'

Finally, we find that the regional development logics and the resulting enactment of entrepreneurial ecosystem boundaries has a self-reinforcing effect through networks. We find that the actors in entrepreneurial ecosystems consistently spend time and effort to connect entrepreneurs to their networks. The regional development logics cause these networks to have a strong regional component. E03 illustrates this by saying 'We don't have as strong of a network outside as inside the region'. As a result, start-ups are often not connected to potentially relevant partners from outside of the region because these are not part of the existing networks of entrepreneurial ecosystem actors. This is summarized by U02 who states that 'I think that the regional boundaries are still somewhat limiting, and they shouldn't be.'

We thus find that actors who adhere to regional development logics often hinder cross-entrepreneurial ecosystem interactions. They do so by enacting the boundaries of administrative regions which causes these boundaries to also become the boundaries of entrepreneurial ecosystems. The regional development logics are most clearly adhered to by the provinces, municipalities, and regional development agencies. To a lesser extend universities, other education institutes, and some entrepreneurial support organizations also adhere to these logics.

4.4.2.2 Start-up development logics: Facilitating cross-entrepreneurial ecosystem interactions.

Start-up development logics reflect entrepreneurial support behaviors, rules and conditions that prioritize developing and growing the start-up. The start-up development logic means that start-up support is prioritized independent of regional development goals.

The support to start-ups often manifests in the form of providing resources, advise, or network connections. Actors who adhere to the start-up development logics often believe that the eventual goal, economic growth or addressing societal challenges, will follow from start-up success. A good example of this is provided by U02 who states: 'I think it is a shame that we [other regions] do not invite each other to events outside of the region. I would like to invite our community for other events. And if someone then moves regions, well than that's the way it is.'

We, obviously, see that the start-up development logics are closely adhered to by entrepreneurs themselves. In addition, we find that entrepreneurial support organizations, start-up support platforms, and investors strongly adhere to these logics. To a lesser extent universities, regional development agencies, provinces, and municipalities adhere to these logics. We find that the start-up development logics allow for or enable cross-entrepreneurial ecosystem interaction. The start-up development logics shape the behavior of actors in the entrepreneurial ecosystem in several ways.

First, we see that entrepreneurs who act in their own interest and/or are enabled by the start-up development logic engage in cross-entrepreneurial ecosystem to get access to resources or to find more favourable institutions. They follow the start-up development logic, irrespective of the degree to which their actions affect regional development. This matches the motivations for cross-entrepreneurial ecosystem interactions that we outlined in section 4.4.1.

Second, we find that entrepreneurial ecosystem actors facilitate start-ups to engage in interactions with actors from outside the entrepreneurial ecosystem. An example of this is provided by incubator U03 who states: 'Eventually, you draw the conclusion we can't offer you this in Utrecht, but they can in Leiden. So we connected them to the incubator in Leiden for them to move there.'

Third, entrepreneurial ecosystem actors engaging in the start-up development logic provide support to start-ups that are not from their own region. This is illustrated by incubator W01 who states that: 'If there is a greenhouse start-up somewhere else, they will call us, we know a lot about the robotics but not about greenhouses. Then we make a connection'. An example is AdvocadCo, a company that uses microwaves to test if the inside of an avocado or mango is still good. 'They are located in Delft but we have great connections in the industry so they joined our programme but are still located in Delft, they don't have to come to Wageningen but connecting them to our network is relevant.' Start-ups consider this type of behaviour as beneficial for their development. This is illustrated by start-up W06: 'We are embedded in two ecosystems. Noordwijk where there is a lot on aerospace, and Wageningen with agrifood and that combination is really beneficial for us.'

Fourth, we see that actors interact with actors who have the same function in other ecosystems to improve the quality of the start-up support that is provided by both actors. An example is given by W03 from the regional development agency who states that 'There is the establishment of ROM Nederland, in which we as regional development agencies discuss and align our actions'. These interactions are mainly aimed at sharing knowledge, improving the quality of intermediate service, and to change institutions by organizing a shared lobby at the national level. They are perceived to help improve the support offered to start-ups: U03: 'The collaboration with other incubators works nicely, we can create a soft-landing for start-ups in other ecosystems.'

We thus find that the start-up development logics enable and allow cross-entrepreneurial ecosystem interactions. The start-up development logics are most clearly adhered to by entrepreneurs, entrepreneurial support organizations, start-up support platforms, and investors. To a lesser extent universities, and even regional development agencies, provinces, and municipalities sometimes adhere to these logics. Several informants, who adhere to the start-up development logics, express frustration with how the regional development logics create boundaries that they argue reduces the opportunities for productive entrepreneurs. This sentiment is expressed by E10 who summarizes it as: 'In the Netherlands, regional barriers don't make sense, but they are there because of the behavior of certain actors.'

4.4.2.2 Towards characterizing entrepreneurial ecosystems through the regional development and start-up development logics

In this section we reflect on the influence of the two logics on the three entrepreneurial ecosystems in our study. We explore how the logics can be used to characterize entrepreneurial ecosystems and how different logic strength' influences cross-entrepreneurial ecosystem interactions in particular entrepreneurial ecosystems. We discuss how the historical patterns in the entrepreneurial ecosystem, as described by our informants, influence the combination of logics. This use of logics in line with how Thornton and Ocasio (2008) define institutional logics. Finally, for each entrepreneurial ecosystem we describe how the logics influence the interactions across the boundaries.

In Eindhoven, we find moderate regional development logics and the strongest start-up development logics. In this entrepreneurial ecosystem the two logics are very much intertwined. The interviewees describe how the historical development of the Eindhoven region has been strongly influenced by the role of several dominant large firms, such as Philips and ASML. These firms have strong regional ties and emphasise the importance of these ties. Historically, the performance of these firms has gone hand-in-hand with the performance of the region. This cumulated in a strong perception that what is good for the firm is good for the region and what is good for the region is good for the firm. The entrepreneurial ecosystem resembles this perspective.

In Eindhoven the moderate regional development logics and the strong start-up development logics are often in balance with each other. The result is an entrepreneurial ecosystem in which actors embrace both logics. Regional actors (regional development agencies, province, municipalities) also act upon the start-up development logics and entrepreneurial support organizations also act upon the regional development logic. A good illustration of this is provided by E05 who, as the dedicated start-up officer of the municipality, states: 'I prioritize start-ups and if I am forced to choose between the interests of the municipality and a start-up I lean towards the start-ups'. While E01 from the university entrepreneurial support agency states that '[We] find the region so important that we sometimes place the interest of the region above the interest of the university.' These dynamics create a favorable entrepreneurial ecosystem.

A downside that we observe is related to the networks. The Eindhoven entrepreneurial ecosystem has a strong focus on regional networks, which means that networks across the boundaries of the entrepreneurial ecosystem are weaker or not even present. As a result, start-ups who require resources that are not present in the entrepreneurial ecosystem have a harder time connecting to outside the region or are even stopped by regional actors from doing so. This closed network also has an influence on non-Eindhoven start-ups as W16 indicated that he tried to connect into the Eindhoven entrepreneurial ecosystem and found it difficult to do so. We clearly observe that this manifestation of the regional development logics influences the behavior of actors in the Eindhoven entrepreneurial ecosystem.

In Wageningen, we see the weakest regional development logics and moderate start-up development logics. The interviewees describe how, historically, the positioning of Wageningen University as a world leading agricultural university plays an important role. This has led to a strong focus on the agrifood sector and a multitude of companies from this sector locating on the Wageningen campus. As a result, actors are very much driven by the focus on the agrifood sector and contributing to that sector. The prowess of the region in this sector has created a widespread believe that they are experts in the sector. This trumps the importance of regional boundaries. W03 from the regional development agency stated: 'The regional boundaries are to a certain degree important for provinces but they are also not the sole factor'. As a result, the regional development logics are weaker. Nevertheless, the regional development logics still play a role as illustrated by W01: 'A part of our funding comes from the province and that needs to be directed to companies that have an impact in the Wageningen region.'

We find a relatively moderate strength for the start-up development logics in Wageningen. Several actors have a clear focus on providing the best support possible to start-ups. However, the focus on the agrifood sector means that entrepreneurship, by other actors, is often considered a means to an end: 'I believe strongly that start-ups play a crucial role in achieving societal transitions'. (W09) and 'Sustainable entrepreneurs play a crucial role in addressing societal challenges' (W13). The sectoral focus means that the development of start-ups is not always prioritized as some actors also look to incumbent firms for the intended solutions. This combination results in moderately strong start-up development logics.

The combination of weaker regional development logics and moderate start-up development logics results in a repeated willingness by actors to support start-ups across the geographical boundaries of the entrepreneurial ecosystem. This is illustrated by incubator W01 who states that: 'They are located in Delft but we have great connections in the industry so they joined our programme but are still located in Delft, but connecting them to our network is relevant.'

In Utrecht, we see the strongest regional development logics and the weakest start-up development logics. Historically, there were relatively fewer large companies in the region and these companies do not consider being from Utrecht as part of their identity. This is widely perceived, by interviewees, as a weakness of the region and has resulted in an entrepreneurial ecosystem in which actors feel the need to compensate for this absence. As a result, we see that several governmental actors play an active role in the entrepreneurial ecosystem. These actors have an explicit regional focus in their mission and bring this focus to their activities in the entrepreneurial ecosystem. These actors see entrepreneurship as a means to the goal, addressing societal challenges. This strengthens the regional development logics and establishes them as a clear priority.

Also in Utrecht, the regional development and start-up development logics often align. A strong performance of a start-up within a region yields positive results that are in line with both the regional development and the start-up development logics. This is illustrated by U03 who states that as a result of their support to start-ups: The municipality is happy that we function as a driver in job creation and the province is happy because we help improve the attractiveness of our region. However, in cases where the logics do not align the regional development logics dominates, as the start-up development logic is less widespread. The potential negative effects of this are outlined by U16: 'An exclusive focus on game start-ups for societal missions by the province means that I cannot provide the support to the other game start-ups who form the foundation of an ecosystem that those start-ups who focus on societal missions rely on.'

We find that several entrepreneurial support organizations really embrace the start-up development logics. However, these actors are simultaneously being influenced by the regional development logics of other actors. Governmental actors are key funders of entrepreneurial support organizations and influence them through the regional development logics. This is illustrated by U01 who states 'There is friction between the goals of the municipality and the goals of start-ups. Look, for us the regional economic agenda is crucial.' The result in Utrecht is that several actors are interested in and actively working on stimulating cross-entrepreneurial ecosystems interactions, because they believe this will benefit start-ups. However, these actors are still constrained in doing so.

4.5 Discussion

4.5.1 Conclusion

Recently, several authors (e.g. Fischer et al., 2022; Schäfer, 2021; Wurth et al., 2022) critique existing entrepreneurial ecosystem research that ignores the influence of 'outside' interactions, for example with actors from other entrepreneurial ecosystems (Theodoraki and Catanzaro, 2022; Xu et al., 2023). We addressed this by answering the following research question: What drives and hinders interactions across the boundaries of entrepreneurial ecosystems? We do so using interviews with 52 actors that cover in-depth case studies of three entrepreneurial ecosystems, in the context of the EWUU alliance (Eindhoven, Utrecht, and Wageningen).

First, we explored what individual motivations drive (or hinder) actors to interact across the boundaries of their regional entrepreneurial ecosystem. We find that entrepreneurs interact across the boundaries of their entrepreneurial ecosystem to get access to resources and more favorable institutions. We find interactions related to all ten entrepreneurial ecosystem elements (Stam, 2015). The access to resources is a more frequent driver of interactions than the institutional arrangements.

Second, we explored how the institutional context, the entrepreneurial ecosystem, influences the ability of actors to engage in cross-entrepreneurial ecosystem interactions. We find that this ability is influenced by two logics. The start-up development logic, which does allow for interactions, and the regional development logic that often prevents interactions as it causes actors to transform administrative boundaries into entrepreneurial ecosystem boundaries.

4.5.2 Theoretical implications

Our paper has several theoretical implications that relate to a specific mechanism in the entrepreneurial ecosystem framework, the interaction across entrepreneurial ecosystems (see Wurth et al., 2022).

First and foremost, we identify two underlying logics that influence when and how actors choose (not) to cross entrepreneurial ecosystem boundaries: regional development logics and start-up development logics. Regional development logics reflect support behaviors, rules and conditions that prioritize developing and growing the region (irrespective of start-up development), whereas start-up development logics reflect support behaviors, rules and conditions that prioritize developing and growing the start-up (irrespective of regional development). One logic does not exclude the other.

Our findings show how decision-making following regional development logics results in actors more strongly enacting the boundaries of their entrepreneurial ecosystem, thereby limiting cross-entrepreneurial ecosystem interactions. Whereas start-up development logics are more facilitative towards interactions across these boundaries. In other words, support behaviours, conditions and rules that are shaped from regional development logics serve goals beyond the entrepreneur – the priority is to serve economic growth or social and environmental impact in the region. Support behaviours, conditions and rules driven from the start-up logic prioritize the entrepreneur. Here, the entrepreneurial ecosystem serves start-up creation, whereas in the regional development logic, engaging in the entrepreneurial ecosystem is a means to realize regional development – and the entrepreneur is just one of the players via whom regional development goals can be achieved.

We find that actors adhering to the regional development logics enact the boundaries of entrepreneurial ecosystems; they transform administrative boundaries into entrepreneurial ecosystem boundaries. This provides an argument in favour of using the administrative boundaries as entrepreneurial ecosystem boundaries (e.g. Leendertse et al., 2022; Schrijvers et al., 2023; Stam and van de Ven, 2021) an approach that has, recently, been questioned by several authors (Cho et al., 2022; Fischer et al., 2022; Schäfer, 2021). We find this result of the regional development logics in all three ecosystems. However, the strength of the entrepreneurial ecosystem boundaries depends on the strength of the logics in an entrepreneurial ecosystem. The use of these logics can help researchers understand both the strength of entrepreneurial ecosystem boundaries and the dynamics within and across entrepreneurial ecosystems. We thus encourage entrepreneurial ecosystem scholars to use these logics to shape their future studies.

Second, we find that individual actors, both entrepreneurs and other actors, are motivated to interact across entrepreneurial ecosystem boundaries to obtain access to resources and sometimes institutions. This means that future research should consider cross-entrepreneurial ecosystem interactions when studying the access to resources and institutions. We thus join recent calls to consider interactions across entrepreneurial ecosystem boundaries more consistently (Fischer et al., 2022; Schäfer, 2021; Wurth et al., 2022).

Third, we operationalize the conceptualization of entrepreneurial ecosystem boundaries as outlined by Fischer et al. (2022) and show that this is a feasible way to operationalize entrepreneurial ecosystem boundaries. Different types of actors within the same entrepreneurial ecosystem are consistent in how they describe and conceptualize the boundaries of their entrepreneurial ecosystem, independent of the approach they took to conceptualize the boundaries. This serves as validation for this approach of defining boundaries. The strength and type of entrepreneurial ecosystem boundaries differ between the three cases and are either purely geographical or a combination between geographical and sectoral. The implication is that every study on entrepreneurial ecosystems should be explicit in how and where they define boundaries. Based on our findings, we encourage future research on entrepreneurial ecosystem to explore the nestedness between the general entrepreneurial ecosystem and specific sectoral components.

4.5.3 Practical implications

The two identified logics often go hand-in-hand: what is good for the region is often good for the entrepreneur and vice-versa. However, the two logics are not always complementary, they sometimes conflict. When this is the case regional development logics, although they make sense from a policy maker perspective, can hurt entrepreneurs. This is particularly the case if multiple regions engage, separately, in regional development logics. The resulting competition between regions creates a suboptimal environment which hurts entrepreneurs and in turn also the regional development outcomes.

We find that interacting across the boundaries of entrepreneurial ecosystems may require entrepreneurs to choose between regional ecosystems: being part of one regional entrepreneurial ecosystem has, oftentimes limiting, consequences for the access to resources and support in other regional entrepreneurial ecosystems. We encourage entrepreneurial ecosystem actors to critically reflect on their own logics and to change behaviour that has a counterproductive influence on the entrepreneurial ecosystem. We recommend actors in entrepreneurial ecosystems to do two things 1) discuss logics 2) connect across entrepreneurial ecosystems. We recommend to discuss the logics as we find that the negative results of conflicting logics are often a blind spot, policy makers are not directly aware of the negative consequences. Discussing logics allows for addressing these blind spots. Connecting across entrepreneurial ecosystems then allows for (partial) mitigation of the conflicting logics. These connections can create shared goals and this alignment might reduce the artificial competition between regions that we currently see. We find some early evidence that initiatives as 'Incubator United' and the collaborations between different regional development agencies 'ROM Nederland' are having this effect.

Furthermore, we recommend actors that do not have an explicit regional mandate embedded in their mission, such as universities, entrepreneurial support organizations, or national organizations to engage in changing these institutional logics. We encourage these actors to play an active role in facilitating cross-entrepreneurial ecosystem interactions. Relatedly, we advise to take the potential negative effects of regional development logics into account in the interplay between national and regional policies. Our study shows how incentives for provinces or municipalities to focus on the region, can create rigid entrepreneurial ecosystem boundaries that hinder start-up development at the national level. In other words, the boundaries become borders. While there are clear benefits of having regional governments active in entrepreneurial ecosystems, we recommend to create national coordination to reduce conflicting interests among regions, and thus reduce behavior that may limit economic growth and societal impact.

Finally, based on our findings regarding differences in the strength of the logics in the ecosystems and the resulting strength of entrepreneurial ecosystem boundaries we argue that specific policy recommendations require in-depth analyses of a region that considers the boundaries of that specific entrepreneurial ecosystem. It is crucial to not base strategic decisions solely on quantitative analyses across multiple regions (e.g. Leendertse et al., 2022) but to complement it with in-depth insights obtained through qualitative analyses.

4.5.4 Limitations and future research

The most important limitation of our research is in the case selection. We select three high-quality entrepreneurial ecosystems with a university presence in the Netherlands as the starting point of our studies. The cases are a good representation for well-developed entrepreneurial ecosystems. However, future research is needed to show whether these findings are generalizable to other countries and to less well-developed entrepreneurial ecosystems. In particular, the balance of the logics and the resulting outcomes are unique for different entrepreneurial ecosystems and might show strong differences between countries and between high- and low-quality entrepreneurial ecosystems. It could for example be the case that the regional development logics play a much smaller role in more centralized countries or countries without regional development agencies. Furthermore, we find that in Wageningen sectoral considerations play a relevant role. Future research of entrepreneurial ecosystems with a strong sectoral focus is needed to determine whether 'sectoral development logics' are a third set of logics of relevance.

Furthermore, we recommend to explore the possibility of quantifying the two logics to enable studying how the strength of the two logics influences the outcomes of entrepreneurial ecosystems. Such research could also take address how an increase in interactions influences the perceived start-up and regional outcomes. In addition, we encourage entrepreneurial ecosystem scholars to use spatial econometrics to study the interactions across entrepreneurial ecosystems more formally, for example by studying the influence of the quality of entrepreneurial ecosystems in neighbor regions on a focal region.

Finally, we currently do not study if the logics differ in their influence on cross-entrepreneurial ecosystem interactions depending on the specific resource or institution that is a driver. We do find some indications that the regional development logics are especially stringent if access to finance is at play. Future research could explore the interactions between the entrepreneurial ecosystem elements and the logics. This would improve our understanding of the regional development and start-up development logics.

5.

Public and private investigations: Exploring differences between strategies from private and public incubators to ignite institutional change in entrepreneurial ecosystems

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Abstract

Entrepreneurs are dependent on the regional context in which they operate. This context is called the entrepreneurial ecosystem (EE). Institutions -the rules of the game that guide behavior- are an important part of the EE. Theoretically, we can distinguish between normative, regulative and cultural-cognitive institutions. Entrepeneurial support organizations are key actors in an EE and are well-positioned to act as institutional entrepreneurs. This means that they try to change or create institutions in the EE. However, it is unknown how incubators with public or private backgrounds do so in different types of EEs. Hence, we answer the following research question: *How do public and private incubators differ in the strategies that they use to change or create normative, regulative and cultural-cognitive institutions in different institutional contexts?*

Based on a study of 17 incubators in seven Dutch cities, we find that incubators indeed shape EEs by trying to change institutions. We make two theoretical contributions First, current IE literature makes little distinction between different types of institutions. Our findings show that the strategies employed to create institutional change vary per type of institution. Institutional entrepreneurs often use a larger number of change strategies to address cultural-cognitive institutions compared to normative and regulative institutions. Second, our work is the first to systematically compare public to private institutional entrepreneurs. We show that public actors are more active institutional entrepreneurs than their private counterparts, particularly in transparent ecosystems. Public incubators are therefore an influential actor in creating supportive institutions for entrepreneurship and should be enabled by universities and governments.

5.1 Introduction

Entrepreneurship has long been recognized as an important source of innovation and economic growth (Schumpeter, 1934). However, entrepreneurs cannot innovate in isolation; they are influenced by, and dependent on, the ecosystem in which they operate (Stam, 2015; Stam and van de Ven, 2021). Institutions are an essential building block in such ecosystems, and the influence of institutions on entrepreneurs is a well-studied topic (Acs et al., 2018; Audretsch and Belitski, 2017; Bosma et al., 2018; Stam and van de Ven, 2021; Urbano et al., 2019). The influence of actors on the institutions in entrepreneurial ecosystems (EEs) has received less attention, even though new innovations from entrepreneurs often require institutional change (Boon et al., 2019; Kuratko et al., 2017; Moodysson and Sack, 2016) In their review of the EE literature, Alvedalen and Boschma (2017) therefore argue that the framework would benefit from a better understanding of how actors change institutions.

This process of institutional change has been discussed in institutional theory, which distinguishes regulative, normative and cultural-cognitive institutions (Scott, 2008). Regulative institutions are formal rules and laws. Normative institutions include social obligations and expectations, such as norms and values. Cultural-cognitive institutions have largely historical roots; they are based on common beliefs, "taken-for-grantedness" and a shared understanding of how things are done. Together, these institutions form a regime that shapes the behavior of actors, and is continuously reproduced by these actors (DiMaggio and Powell, 1983; van Mossel et al., 2018). When actors deviate from the existing institutional demands they ignite a process of institutional change (DiMaggio, 1988; Garud et al., 2007; Moodysson and Sack, 2016). These actors are called institutional entrepreneurs, which are individuals or organizations who create new or transform existing institutions by mobilizing resources, allies, and narratives (Battilana et al., 2009; DiMaggio, 1988; Dorado, 2005; Gurses and Ozcan, 2015).

Entrepreneurs with innovative ideas are often not ideally suited to act as institutional entrepreneurs. They suffer from a lack of resources and a liability of newness, which reduces their legitimacy (Hyytinen et al., 2015; Kuratko et al., 2017; Leendertse et al., 2021; Truong and Nagy, 2020). Start-ups would therefore benefit from another actor that plays an active role in improving the institutions of the EE. One actor that could fulfil this role is the incubator (Dutt et al., 2016; Goswami et al., 2018; van Weele et al., 2018). Incubators are organizations that support start-ups by offering a combination of office space, resources, coaching and network access (Bergek and Norrman, 2008; Bergman and McMullen, 2022; Cohen et al., 2019a; Leendertse et al., 2022; Theodoraki et al., 2018). They are well-positioned to become institutional entrepreneurs since they occupy a central position in social networks (Theodoraki et al., 2018; van Rijnsoever, 2020) and possess the status and resources needed to act as institutional entrepreneurs

(Aernoudt, 2004; Hansen et al., 2000).

The institutional entrepreneurship (IE) literature provides important insights into how and when actors change institutions. However, two important research areas remain underexplored which we address in our study. First, most existing institutional change studies focus on the organizational field or sector, instead of the actual institutions (Pacheco et al., 2010; Weisenfeld and Hauerwaas, 2018). In doing so, existing studies on IE implicitly assume that all institutions are changed in the same way. This is unlikely, as change in regulative institutions is formal by nature and implemented by agents with the appropriate powers, such as policy makers (Oliver, 1991), while change in informal institutions, such as normative or cultural-cognitive institutions, is essentially a diffusion process of attitudes or practices throughout society (DiMaggio and Powell, 1983; Oliver, 1991). The IE literature does not yet systematically describe how institutional change differs between these different types of institutions. To address this we look at the relation between the institutional entrepreneur, the incubator, and an institution as our unit of analysis. Second, most empirical evidence for IE comes from public actors (Maguire et al., 2004; Perkmann and Spicer, 2007) or from large private actors (Garud et al., 2002; Greenwood and Suddaby, 2006; Munir and Phillips, 2005). These types of actors differ in their strategy to change institutions. Large private actors are focused on mobilizing resources for institutional change (Greenwood and Suddaby, 2006; Kukk et al., 2016). They often focus on changing institutions surrounding new products, which means they create awareness for the product and change consumer behavior within markets (Garud et al., 2002; Kukk et al., 2016; Moodysson and Sack, 2016; Munir and Phillips, 2005; York et al., 2018). Public actors have a broader perspective on institutional change, often working on changing regulative and cultural institutions (Perkmann and Spicer, 2007). For publicly sponsored actors, personal legitimacy is found to be an important driver of institutional change (Maguire et al., 2004). Both public and private actors thus engage in IE in different ways (Boyne, 2002). However, existing studies focus on either public or private actors.

Public and private institutional entrepreneurs also have not yet been studied in similar institutional contexts, even though institutional context is known to be an important factor that influences institutional change processes (Boon et al., 2019; DiVito, 2012; Moodysson and Sack, 2016). In particular, institutional contexts can be transparent, which provides room for IE, or intransparent, which hinders IE (Dorado 2005). There is thus a need for a systematic comparison between public and private institutional entrepreneurs that accounts for the influence of the institutional context. This requires studying an actor that can be public or private in similar contexts with similar resources and abilities. The incubator meets this criteria as there are both private and public incubators and they are found in many different cities (Dutt et al., 2016; Mrkajic, 2017; Theodoraki et al., 2018; van Weele et al., 2018). This leads to the following research question:

How do public and private incubators differ in the strategies that they use to change or create normative, regulative and cultural-cognitive institutions in different institutional contexts?

We study the strategy of public and private incubators to change different types of institutions in multiple institutional contexts using an abductive research approach. To this end, we conducted a qualitative multiple case study in which we conduct 29 interviews with personnel from 17 public and private incubators in seven Dutch cities. We study multiple institutional contexts with embedded units of analysis, this is the appropriate method for our research question as it allows for the intended in-depth rigorous comparison (DiVito, 2012). This systematic comparison highlights our core contributions. First, by studying incubators as institutional entrepreneurs in an entrepreneurial context, this paper builds much needed bridges between the EE and IE literature (Battilana et al., 2009; Sine and David, 2003). Our study shows how incubators are able to act as institutional entrepreneurs to support entrepreneurs, which helps bring innovations to the market. In doing so, we open the black box of EE and provide insight on how institutions can be changed. Second, our findings demonstrate that the strategies employed to attempt to create institutional change vary per institutional pillar, institutional entrepreneurs use a larger number of change strategies to address cultural-cognitive institutions. Third, we show that public incubators are more active institutional entrepreneurs than their private counterparts, particularly in transparent ecosystems.

The outcomes of this study are particularly relevant to incubators and policy makers in the field of entrepreneurship. This study shows how incubators can change institutions, and which strategy they should use to change a particular type of institution. In line with earlier findings (Dutt et al., 2016; Goswami et al., 2018) we confirm that the influence of incubators on EEs extends beyond supporting start-ups to shaping EEs by changing institutions. However, as also shown by van Weele et al. (2018) incubators still struggle to create institutional change and policy makers can use the insights to enable incubators in their role as institutional entrepreneurs.

5.2 Theoretical Framework

Starting with DiMaggio (1988), various scholars have studied the politics, agency and legitimacy of institutional entrepreneurs (Battilana, 2006; Clemens and Cook, 1999; Garud et al., 2007; Rao et al., 2003). Institutional entrepreneurs can be individuals, organizations, groups of organizations, or departments within organizations (Aldrich, 2012; Wijen and Ansari, 2006). An actor is considered an institutional entrepreneur when it consciously or unconsciously initiates divergent institutional change and/or when it actively helps with the implementation of such changes (Battilana et al., 2009). Institutional change is by no means an easy endeavor, partly because institutional entrepreneurs are embedded in the institutions they are trying to change (Battilana et al., 2009).

In the remaining parts of this chapter we first review how the role of incubators in EEs becomes increasingly that of an institutional entrepreneur. We then outline the theoretical background for the key concepts of our study: the different types of institutions, the institutional change strategies, the distinction between public and private institutional entrepreneurs, and the institutional contexts.

5.2.1 The role of incubators in entrepreneurship

Incubators are commonly seen as organizations that support start-ups by offering a combination of resources, such as office space, coaching and network access (Bergek and Norrman, 2008; Bergman and McMullen, 2022; Cohen et al., 2019a; Leendertse et al., 2022; Theodoraki et al., 2018). The role of incubators has changed considerably since they first came into existence in the Batavia Industrial Centre in New York in 1959 (Leblebici and Shah, 2004). These changes can be conceptualized along several generations, with each new generation adding to the existing roles (van Weele et al., 2018). The first generation of incubators became popular in the 1980's and provided firms with tangible resources such as office space and other facilities (Barrow, 2001; Bruneel et al., 2012; van Weele et al., 2018). The second generation began in the early 1990's when incubators started supporting start-ups (Barrow, 2001; Bruneel et al., 2012). Start-up founders often lacked entrepreneurial skills which caused the incubators to also provide intangible resources, such as training and coaching (Ahmad and Ingle, 2013; Bruneel et al., 2012; Leblebici and Shah, 2004). The third generation, starting in the late 1990's, moved to a more systemic view on entrepreneurship and added a focus on networking, aiming to connect start-ups with each other and with external actors and resources (Bøllingtoft and Ulhøi, 2005; Eveleens et al., 2017; Hansen et al., 2000).

More recently, a potential fourth generation of 'systemic' or 'institutional' incubators was proposed by van Weele et al. (2018). Their call is based on the increasing awareness that incubators are embedded in EEs, the quality of which is an important determinant for the presence and performance of start-ups (Leendertse et al., 2022; van Rijnsoever, 2020). EEs are the set of interdependent actors and factors that enable entrepreneurship within a particular region (Ács et al., 2014; Audretsch and Belitski, 2017; Leendertse et al., 2022; Stam, 2015; Wurth et al., 2022). The institutional incubators would expand the role of the incubator by engaging in the process of changing institutions to strengthen EEs. In the next section, we outline the institutional pillars which these incubators could attempt to change.

5.2.2 Institutional Pillars

Institutions embody the norms, values, rules and regulations that govern the actions and ideas of individuals and organizations (DiMaggio, 1988; DiMaggio and Powell, 1983). Scott (2008) distinguishes between regulative, normative and cultural-cognitive institutions. We define each type of institution. We start with the most fundamental type: cultural-cognitive institutions. Cultural-cognitive institutions can be defined as 'the shared conceptions that constitute the nature of social reality and the frames through which meaning is made' (Scott 2001, p. 57). They embody symbols, signs and cultural rules that describe the nature of the society and culture in which actors operate (Hoffman, 1999) and create a shared understanding of "how things are done" (Sine and David, 2010). Actors often abide by cultural-cognitive institutions without conscious thought or consideration (Hoffman, 1999). Cultural-cognitive institutions are rooted in deep societal and personal beliefs, which often take a long time to change (Roland, 2004). Cultural-cognitive institutions thereby provide a solid foundation on which other institutions build (Scott, 2008).

Normative institutions can be defined as normative systems that define goals or objectives 'but also designate appropriate ways to pursue them.' (Scott, 2001, p. 55). They prescribe and evaluate how actors should behave according to others (Roland, 2004; Scott, 2008) utilizing rules-of-thumb, social beliefs and informal standards (Hoffman, 1999). Actors comply with these normative institutions out of moral obligation or because they feel it is expected of them (Hoffman, 1999), which creates stability (Alexander, 2012). Both cultural-cognitive institutions and normative institutions are informal institutions (Scott, 2008).

Finally, regulative institutions can be identified with the most ease; they take the form of rules, laws and policies, and are usually established through some legitimized process. They are often formalized expressions of cultural-cognitive and normative institutions. Actors abide by regulative institutions because they fear sanctions, or simply because they are coerced into submission (Hoffman, 1999). Regulative institutions have received the most attention from academics (Pacheco et al., 2010; Scott, 2008).

The three institutional pillars are expected to differ in their change processes. Regulative institutions are often considered to be the easiest to manipulate, because they can be changed using formal decrees by actors with authority (Geels, 2004; Scott, 2008). Changing normative institutions is harder, since it requires social interaction between different actors. Finally, the process of changing cultural-cognitive institutions is considered the most time-intense and difficult, because these institutions are deeply rooted in societal values and personal beliefs. Furthermore, since regulative and normative institutions build upon cultural-cognitive institutions (Scott, 2008), it is likely that changes in cultural-cognitive institutions also lead to changes in regulative and normative institutions.

5.2.3 Institutional change strategies

Institutional entrepreneurs need to overcome inertia and resistance from other actors to change institutions. Several works from IE literature identify the strategies that institutional entrepreneurs can use to overcome this resistance (Battilana et al., 2009; Greenwood and Suddaby, 2006; Rao et al., 2003). We now present an overview of the strategies that are described in the literature. In line with an abductive research approach, we use them to interpret our findings.

The first strategy is *creating legitimacy*. A legitimate actor is endorsed by legal authorities and/or considered desirable and appropriate according to current standards, norms and values or beliefs (Aldrich and Fiol, 1994). Legitimacy can give the entrepreneur credibility and status which is considered crucial when suggesting institutional change (Battilana et al., 2009; Dorado, 2005; Greenwood and Suddaby, 2006; Pacheco et al., 2010; Rao et al., 2003). Therefore, increasing legitimacy increases the chances that institutional entrepreneurs are able to create change (Fligstein, 1997; Garud et al., 2002; Greenwood et al., 2002).

The second strategy is *sharing the narrative*. Once institutional entrepreneurs identify an opportunity to develop new institutions and create their vision, an important strategy is to share this vision with the actors who have the ability to create institutional change (Battilana et al., 2009; Rao, 1998; Rao et al., 2003). This strategy is limited to interpersonal communication between the institutional entrepreneur and other actors.

The third strategy, *delegitimizing institution*s is the process of explicitly noting the failure of existing institutions to reduce their value (Clemens and Cook, 1999; Rao, 1998; Rao et al., 2003). Whereas creating legitimacy and sharing the narrative are focused on the positive side of institutional change, this strategy is focused on the failures of the existing institutions (Battilana et al., 2009).

The fourth strategy, *mobilizing allies* entails the process of building a coalition behind the vision of the institutional entrepreneur (Battilana et al., 2009; Fligstein, 1997; Leca and Naccache, 2006; Rao et al., 2003). Mobilizing allies is considered an important strategy because affiliation with other legitimate actors increases the legitimacy of the institutional entrepreneur and the proposed institutional change (David et al., 2013). This strategy can be used to leverage the higher legitimacy of the group.

The fifth strategy, *mobilizing resources* entails either the use of resources the institutional entrepreneur already possesses or the acquisition of new resources. Two types of resources are deemed particularly important. First, financial assets. Institutional entrepreneurs can use these to overcome sanctions or transitional costs associated with the institutional process or to persuade other actors to enter an alliance (Battilana et al., 2009; Garud et al., 2002). Second human resources. These can function as providers of legitimacy (Sherer and Lee, 2002), and determine the amount of time institutional entrepreneurs can dedicate to institutional change.

In the next section we describe public and private institutional entrepreneurs and provide a theoretical foundation for why we expect them to differ in how and when they change institutions.

5.2.4 Differences between Public and Private Institutional Entrepreneurs

The difference between public and private actors is defined in terms of ownership and the source of funding. Private organizations are typically owned by entrepreneurs or shareholders and derive their income from fees on customers. Public organizations are owned collectively or by political communities and acquire funding through taxation (Boyne, 2002). However, there is a large grey area of organizations which fit into either definition (ibid). This means that public and private actors exist on a scale that requires careful navigation. On this scale, we distinguish internal and external differences between public and private actors that influence their strategies as institutional entrepreneurs.

Externally, public and private actors are exposed to different institutional environments (Rainey et al., 1976) and have different perspectives on their environment (Krøtel and Villadsen, 2016). Public actors are less exposed to market factors and are more constrained by political influences and multiple stakeholders. As a result, they have a higher level of accountability and are under more intense scrutiny, which makes them more risk-averse (Hall et al., 2016; Rainey and Bozeman, 2000). Public organizations can also have a broader impact and are more coercive because of their sanctioning and governing power. This does not mean every public organization has sanctioning power, but they at least have higher legitimacy and closer ties to actors with sanctioning power.

Public and private actors also have different internal processes, they are managed differently (Rosenberg Hansen and Ferlie, 2016). An example is that they have different objectives and evaluation criteria, with private actors being more profit driven. Literature also finds that employees of public organizations are more intrinsically motivated and are driven by societally beneficial motives (Bullock et al., 2015; Rainey et al., 1976). Employees of private organizations are more motivated by financial rewards (Bullock et al., 2015). This might make public organizations employees more inclined to change institutions whereas private organization employees focus more on their own organization.

Indeed, several studies into IE have highlighted that public and private actors focus on different institutional change strategies (Greenwood and Suddaby, 2006; Kukk et al., 2016; Maguire et al., 2004). Private actors have a focus on resource mobilization, whereas public actors focus on increasing legitimacy. As a result, we expect public and private actors to differ in what types of institutions they change. Public actors are more likely to lobby for changes in regulative institutions due to their connections to policy makers. Private organizations may lack these connections, which is why we expect them to be less capable of changing regulative institutions. We expect smaller differences between public and private organizations in changing normative and cultural-cognitive institutions.

5.2.5 Institutional contexts

The choice and success of the institutional entrepreneur's strategy is influenced by the transparency of the institutional context, which in turn depends on the degree of multiplicity and institutionalization of the institutional context (Dorado, 2005). We first discuss the concepts of multiplicity and institutionalization before explaining how these influence the transparency of the institutional context.

5.2.5.1 Multiplicity

Institutional contexts are governed by a multitude of institutional logics (Zilber, 2011), which are social prescriptions that guide the behavior of actors in a context (Battilana, 2006; Thornton et al., 2005). The multiplicity of an institutional context consists of the amount of (conflicting) institutional logics that are present in that context. This occurs when there is a variety of actors with different viewpoints on what the institutions should be present in the ecosystem (Dorado, 2005; Seo and Creed, 2002; Zilber, 2011).

In a context with low multiplicity there is little exposure to new ideas and these environments are thus less likely to facilitate the type of creative action necessary for IE (Dorado, 2005). In a context with moderate multiplicity, conflicting institutional logics provide opportunities for IE because actors are less likely to take one institutional logic for granted when there are several alternatives present (Battilana et al. 2009; Clemens and Cook 1999; Dorado 2005). However, extreme multiplicity increases complexity and uncertainty to the extent that it reduces the opportunities for IE (Dorado, 2005). An institutional context is best suited for IE when it has a moderate level of multiplicity (Dorado, 2005).

5.2.5.2 Institutionalization

The degree of institutionalization is the extent to which the actions of actors are adjusted to fit into existing institutional structures, it shows the degree to which actors are forced to conform to the existing institutions (Zucker, 1977). Following the work of Beckert (1999) and Dorado (2005) there needs to be some institutionalization to enable IE. Without any institutions to build on, or be opposed to, it becomes more difficult to create new institutions. The uncertainty that comes with a low degree of institutionalization causes actors to refer back to old behavior patterns that feel safe, which prevents IE (Beckert, 1999; Dorado, 2005) . However, in contexts with an extreme degree of institutionalization, the institutions are taken for granted and nobody is likely to question the existing institutions (DiMaggio, 1988; Dorado, 2005; Zucker, 1977). An institutional context is thus best suited for IE when it has a moderate degree of institutionalization (Dorado, 2005).

5.2.5.3 Transparency

Based on its multiplicity and institutionalization, a context can be transparent or intransparent (Dorado 2005). A context is intransparent when it has high multiplicity and low institutionalization, because this creates uncertainty and reduces the actors' ability to envision new or better institutions. Intransparency can also be caused by low multiplicity and high institutionalization because this creates extreme certainty. There is no possibility for actors to deviate from the current institutional context. Transparent contexts have moderate multiplicity and institutionalization and are considered most beneficial for IE. We thus expect that transparent contexts will contain a larger number of institutional change processes than intransparent contexts.

5.3 Methodology

This study was designed as a qualitative multi-case study and follows an abductive research approach. This enables us to use the theory to interpret the findings of our interviews. This chapter starts with a description of the sampling strategy employed to select the seven Dutch cities in which we performed interviews. We also operationalize the institutional contexts discussed in our theoretical chapter: multiplicity, institutionalization, and transparency. We then use this operationalization to complete our sampling strategy at the institutional context level. Next, we describe the methods used to collect and analyze the qualitative data we obtained from interviews held in these seven Dutch cities.

5.3.1 Operationalization and selection of institutional contexts

The institutional context differs between regions (Moodysson and Sack, 2016) and this is particularly the case for entrepreneurship because this is very much a regional phenomenon (Feldman, 2001; Stam and van de Ven, 2021). The institutional context in which incubators are active is the regional EE, the set of interdependent actors and factors that enable entrepreneurship within a particular region (Ács et al., 2014; Audretsch and Belitski, 2017; Leendertse et al., 2022; Stam, 2015; Wurth et al., 2022). We therefore select different regions to allow us to compare between institutional contexts. In doing so we study multiple institutional contexts (cities) with embedded units of analysis (incubator-institution relations).

We selected our cases using theoretical sampling. To do so we used a dataset of Dutch start-ups, access to which was provided by Techleap (2020). This dataset provides the most comprehensive overview available of Dutch start-ups and contains information on the location of each start-up. As a first step in our sampling strategy we selected the five Dutch cities with the most start-ups in the Netherlands: Amsterdam, Utrecht, Rotterdam, Eindhoven and Delft (Table 5.1).

To allow us to study the influence of institutional contexts we, as a second step in the sampling strategy, ensured that we had regions in our sample with different degrees of multiplicity and institutionalization. We operationalized multiplicity by looking at the variety and dominance of certain technological sectors in the EEs. We distinguish based on technological sectors because institutions and institutional views have been found to differ between technological sectors (Moodysson and Sack, 2016; Moodysson and Zukauskaite, 2014). Therefore, the amount of start-ups active in different technological sectors within one cities represents the multiplicity of that EE. A high dominance of certain technological sectors indicates an ecosystem with low multiplicity as there are a limited number of different views present in that EE. The Techleap dataset also contains information on the technological sector in which the start-up is active. We used this to determine how many of the start-ups in each city were active in the first, second and third most prolific technological sectors. If more than 50% of start-ups are from the most prolific sector, we consider this city to have a low multiplicity, as the majority of start-ups is active in the same sector, which increases the risk of institutional tunnel-vision[1]. We argue that the other EEs have moderate multiplicity because there

1 We performed two robustness checks. First, we applied the 50% limit to the combined share of start-ups in the three most prolific industries. Second, we used the Shannon-Weaver (1948) entropy index as an alternative way of determining the level of multiplicity in each city. Both alternatives resulted in the same categorization.

are no EEs with extreme multiplicity, all start-ups are to some extent guided by the same cultural ideals around entrepreneurship (Brattström, 2022). We find that the five Dutch cities with the highest number of start-ups had moderate multiplicity (Table 5.1), which is why we added the two largest cities that met our operationalization for low multiplicity, Nijmegen and Wageningen, to our sample.

Table 5.1. Startup count and multiplicity operationalization

City	# of start-ups	% of start-ups active in most prolific industry	% of start-ups in 2nd most prolific industry	% of start-ups in 3rd most prolific industry	Multiplicity
Amsterdam	1309	13%	9%	8%	Moderate
Rotterdam	215	20%	8%	8%	Moderate
Utrecht	290	12%	11%	9%	Moderate
Eindhoven	141	23%	11%	7%	Moderate
Delft	117	19%	14%	12%	Moderate
Nijmegen	50	61%	5%	5%	Low
Wageningen	26	58%	8%	8%	Low

We operationalized *the degree of institutionalization* by looking at the number of incubators and the presence of a local start-up support platform dedicated to start-up support. We define a start-up support platform as an organization established by a combination of actors (city government, incubators, investors, banks, universities, etc.) with the aim of supporting and growing the EE in a city (Iamsterdam, 2020; Utrecht Region, 2020). These start-up support platform are the result of different actors coming together and establishing a shared vision on the institutions in that ecosystem. The presence of such a platform thus provides concrete evidence that there is at least some institutionalization in the ecosystem. These platforms were found in Utrecht and Amsterdam. All of our regions are emerging start-up cities with a high growth rate, they are thus still constantly changing. There is thus inherently no case with an extreme level of institutionalization yet, which is why none of the cities are labeled as 'highly institutionalized'. An overview of the transparency of the institutional context in each of the seven cities is provided in Table 5.2.

Table 5.2. Transparency of studied ecosystems

Ecosystem	Institutionalized?	Multiplicity?	Transparency
Amsterdam	Moderate, presence of StartupAmsterdam and multiple incubators	Moderate, no sector accounts for more than 50% of start-ups	Transparent
Utrecht	Moderate, presence of StartupUtrecht and multiple incubators	Moderate, no sector accounts for more than 50% of start-ups	Transparent
Rotterdam	Low	Moderate, no sector accounts for more than 50% of start-ups	Intransparent
Eindhoven	Low	Moderate, no sector accounts for more than 50% of start-ups	Intransparent
Delft	Low	Moderate, no sector accounts for more than 50% of start-ups	Intransparent
Nijmegen	Low	No, one sector accounts for more than 50% of start-ups	Intransparent
	Low	No, one sector accounts for more than 50% of start-ups	Intransparent

5.3.2 Unit of analyses

We selected our cases using theoretical sampling and studied 17 incubators in the aforementioned seven regions in the Netherlands to ensure similarity in national institutions. Incubators are central actors in social networks that consist of a diverse number of actors, such as start-ups, policy makers, incumbent[2] firms, and investors (van Rijnsoever, 2020). Therefore, we expect incubators to have both the incentive and the legitimacy required to engage in IE. These reasons make incubators particularly well suited as a case to study IE. Note that, besides incubators, some of the organizations studied in our sample call themselves an accelerator or a venture builder. However, all these organizations help entrepreneurs to develop a successful start-up with a combination of workspace, workshops, advice, and network access. These entities can thus be thought of as manifestations of the pluriform incubation phenomenon (Bosma and Stam, 2012; van Rijnsoever, 2020)[3]. For clarity, we refer to all such initiatives as 'incubators'.

2 An incumbent firm is a firm that has already established itself in the market and is therefore embedded in the current institutions (van Mossel et al. 2018).

3 In a recent study Bergman & McMullen (2022) use the term Entrepreneurial Support Organizations for a similar definition.

We distinguish between public and private incubators by looking at their ownership and source of funding. Private incubators are owned by entrepreneurs, shareholders or incumbent firms and take equity in their start-ups as a source of income (Barbero et al., 2012). Public incubators are owned collectively and are funded by public organizations such as universities and governments. Public incubators are often established to stimulate economic development in regions, for which they depend on public funds (Barbero et al., 2012; Thierstein and Willhelm, 2001). Due to the uneven distribution of public and private incubators in the Netherlands, not all ecosystems in our study contain both a public and a private incubator. However, we have public and private incubators in each type of ecosystem, which allows us to make a systematic comparison. The units of analysis are the relation between each incubator and a set of institutions, we use the change strategies to conceptualize this relation.

5.3.3 Data Collection

We study public and private incubators in both transparent and intransparent ecosystems. We selected individuals at incubators best suited to give insights about the institutional activities, mostly managing directors. These people were approached by e-mail, by meetings at events or by visiting the incubator. To reach people inside incubators, a snowball strategy was also used, with interviewees being asked for contact details and introductions to other incubator staff. Based on the snowball strategy we also identified and interviewed several actors who could provide insight into the effects of incubator activities within the ecosystem, such as technology transfer office liaisons, staff of the start-up platforms and governmental actors. Finally, we interviewed a senior representative of the national start-up organization, Techleap (formerly known as Startup Delta), to acquire a broader view of the EE in the Netherlands, and the activities of incubators in various ecosystems. The non-incubator respondents were included to triangulate the findings of the incubator interviews. We do not include incubated start-ups in our research design as we focus on the degree to which incubators act as institutional entrepreneurs in the ecosystem rather than at their effectiveness in supporting incubator tenants. Data was collected from 29 respondents, 26 of whom participated in a semi-structured interview lasting between 24 and 75 minutes. Eight interviews were held over the telephone and 18 were held face-to-face. Three respondents did not have time for an interview, so they filled out the list of questions by mail. An anonymized list of interviewees and their affiliated organizations can be found in Table D1 in the Appendix.

5.3.4 Interview Strategy

The interviews follow a semi-structured interview guide. Semi-structured interviews start from a basic structure, which should ensure all relevant concepts and topics are covered. However, the interview guide also leaves room for improvised follow-up questions, to allow for novel insights. This gives respondents the ability to give detailed and original answers, which helps to provide an in-depth picture of the concepts. The questions were updated throughout the study, as novel insights from interviews are taken into consideration for the remainder of the study. All interviewees gave permission to record and transcribe their interview. The initial interview guide is found in Appendix D. In practice, we used the closed questions to address new topics that had not been mentioned to avoid implying that respondents had to discuss the topic. The interviews and analyses mainly revolved around the open questions.

5.3.5 Data Analysis

The interviews were fully recorded and transcribed. The transcripts were analyzed using the method developed by Gioia et al. (2013), which increases the rigor and transparency of qualitative research using a coding scheme. The first step of this analysis involves creating first-order concepts. This means that each sentence or statement is coded in such a way that the code represents the essence of the statement (ibid). The first-order concepts stay connected to the terms of the interviewee and little attempt is made to categorize these concepts. The number of first-order concepts therefore becomes quite large. Between these concepts, similarities and differences are sought, and the concepts are aggregated into second-order themes. These themes are related to the theory and aim to translate the terms of the interviewee to the theoretical concepts studied (ibid). It is possible for one first-order concept to be connected to multiple second-order themes. In our case, the second order themes are the strategies used by incubators to change institutions. This is in line with the abductive research approach that we follow. These strategies were outlined in section 2.3. We did not identify any new strategies that were not yet described in the theory. At multiple times during the analysis, previous transcripts were re-evaluated to check if any concepts had been missed to increase the validity of the research. Furthermore, concepts and themes found in initial interviews were discussed with other interviewees, to increase the reliability of the research. Table 5.3 presents an overview of the concepts and themes found and examples of quotes on which they are based. We present this Gioia table to provide insight into our data analysis (Gioia et al., 2013). The quotes depicted in Table 5.3 are exemplary quotes to make our data analysis transparent and thus do not provide a complete overview of respondent quotes.

Table 5.3. Overview of themes and concepts with example quotes

Second order themes	First order concepts	Example quotes
Creating legitimacy	Displaying achievements of the incubator	Most job growth comes from high-growth start-ups, this makes it easier to convince an alderperson than four years ago. (A8) Governments start realizing that start-ups are an alternative to boost the local economy. (U2) Our track record of nine years, the successes we achieved, both of those are good arguments to at least assume that whatever we give them is either true or important. (U1) The problem is that a lot of beautiful things are happening here but we do a very bad job of communicating that. (N1) We made a progress report to display that entrepreneurs grow quicker here than if they stay at home. (N2) It is the track record that we have created by organizing events like the StartupDelta summit. (R1) People see the success of our start-ups and the media attention they receive. (D1) We present the amount of new companies and lots of other numbers to the university. (W1) The nice thing is that we have many examples, there are some interesting [incubated] companies that are doing very well. (U7)
Sharing the narrative	Communicating expectations to start-ups	We have discussions with start-ups to make them aware of what all needs to happen. (U4) We try to explain and show how they can use and develop the required competences. (W1)

	Sharing the opinion of the incubator with the government	We have some advice on the best way to approach this. So far we give advice on some policy issues. (R1) On starting policy discussions: We [incubators] all have our feet on the ground. We see where it goes wrong and what we need. (U3) We really had to insist. They [municipality] were blind to the importance of start-ups, only focusing on scaleups. This doesn't work but the civil servants did not understand this in the beginning. (N1) We have our expertise, and if the municipality wants to cooperate we give advice. (R1)
Delegitimization	Sharing that current organizational structures are not adequate	It will take time, but also when you talk about valorization, it also takes time. It's a cultural change in the DNA of a university, which is completely different than the DNA of a commercial organization. In the end we'll get there (U2). Through our efforts we can show what works and what doesn't work in order to develop a new strategy. (A1)
	Convincing actors of better alternatives	The first step would be to offer them the opportunity to become aware that there are different approaches to value chains and entrepreneurship. And convince them those alternatives are better suited than what they are currently doing. (U1)
Mobilizing allies	Incubators collaborate with other incubators.	When you translate that back to the past, we would individually approach the government. Right now, we've said: "let's do it together" (U2) Government appreciate the fact that incubators have united themselves because they prefer a complete policy over ideas from fragmented parties. (U7)
	Incubators work together with government	We and the local government discuss opportunities for collaboration. (U2) Right now we are talking to X [municipality employee] and he takes us on a journey who do we need to influence. And what is at stake? (U2)

Mobilizing resources	Not spending resources on uncooperative start-ups as an informal sanction	If we see that a startup is not contributing at all they will start noticing that we do not contribute to them as well. Why put a lot of effort into start-ups that don't contribute anything to the ecosystem (U1). I am not going to push and pull on entrepreneurs, that is completely against the entire idea of entrepreneurship. (U5). If they do not make sufficient progress we withdraw our support. (N1) If we, during the program, find out that 'it' doesn't work we can throw you out (R1).
	Spending resources on selecting which start-ups are admitted to the incubator	So in the selection process we choose really committed people, they are in it for some kind of mission. (A2) We want them to have existing customer relations and we want the founders-team to be right. (A2) We want entrepreneurs that are able to really work and have the vision and passion to make impact. (U1) We want real entrepreneurs, students who say they are busy with their normal studies don't belong here. (N1) Due to the high number of applications we can focus on teams that are highly committed and relatively mature. (R2) We have a selection to keep the quality high and for our accountability to stakeholders. (D1)

5.4 Results

This chapter outlines how and to what extent incubators engage in strategies to change the cultural-cognitive, normative, and regulative institutions in the EE. We do so using typical cases of institutional change. We break down the quotes by type of actor and ecosystem and summarize our results in Table 5.4. In the first section of the results we discuss institutional change processes that we find in both types of ecosystems and by both types of incubators. They are listed at the top of Table 5.4. Next, we discuss the strategies that we find for public and private incubators in transparent ecosystems. Finally, we describe the strategies employed by public and private incubators in intransparent ecosystems. These are listed at the bottom of Table 5.4. Where appropriate, we illuminate our findings with exemplary quotes from our respondents. We refer to our respondents with anonymized codes (see Appendix D).

Table 5.4. Institutional change strategies

		Strategies used by all types of incubators in all ecosystems	
Cultural Cognitive		- Creating legitimacy - Sharing the narrative	
Normative		- Creating legitimacy - Sharing the narrative - Mobilizing resources	
Regulative		- Creating legitimacy - Sharing the narrative	
		Public	Private
Transparent	Cultural Cognitive	- Mobilizing resources - Mobilizing allies - Delegitimizing	- No additional strategies
	Normative	- No additional strategies	- Creating legitimacy[4]
	Regulative	- Mobilizing allies - Delegitimizing	- No additional strategies
Intransparent	Cultural Cognitive	- No additional strategies	- No additional strategies
	Normative	- Mobilizing resources - Creating legitimacy[2]	- Mobilizing resources Creating legitimacy[2]
	Regulative	- No additional strategies	- No additional strategies

5.4.1 Institutional Entrepreneurship Found in All Types of Ecosystems

All incubators attempt to create legitimacy in the eyes of other stakeholders to change all three types of institutions (Table 5.4). This legitimacy mainly originates from the incubator's track record. Incubators actively display the achievements of their (former) incubatees. Incubators use this strategy in two ways. First, they try to increase their legitimacy as part of a particular institutional change strategy. Second, they also continuously try to ensure that other actors see them as legitimate so they can use this legitimacy in future (as of yet defined) change processes. For all three pillars, incubators often combine *creating legitimacy* with other strategies, such as *sharing the narrative*. An example of this combination is that incubators showcase the successes of incubated

4 They use this strategy to change a particular normative institution that is not addressed in all cases. Hence we mention this particularly in the table.

start-ups to policy makers to convince them that incubators boost the local economy and create jobs. Interviewee N2 provides an example of this as he states: "We made a progress report to display that entrepreneurs grow quicker here than if they stay at home.".

We find one change process specifically for **cultural-cognitive** institutions that occurs in all ecosystems with both types of incubators. This concerns (unsuccessful) attempts to overcome a focus on regional interests. According to incubators, important regional stakeholders, such as the university or local government, maintain a culture wherein collaboration between incubators across different regions is discouraged or even prohibited. The incubators indicate that they believe this is the case because regional stakeholders are afraid that such collaborations will have a negative influence on the innovative image and competitive advantage of the stakeholder. Examples of this are given by interviewee U3 "Some stakeholders focus on their own city. They want to help if it is local but don't care for what happens nationally" and by interviewee N2: "Civil servants are afraid of losing talent to Amsterdam". Interviewees SU1 and D1 give the extreme example that a specific incubator wasn't allowed to start a satellite location in a different city because the municipality wanted the name of the incubator to reflect that of its own city. To change this institution, all incubators use the tandem strategies of *creating legitimacy and sharing the narrative*. However, at the time of data collection, no incubator had yet been able to change this institution using these strategies, because, as they state it, they still lack the required legitimacy in the eyes of the regional stakeholders.

All incubators use a similar approach to change certain **normative** institutions. A typical example is the expected behavior of start-ups in the ecosystem. Incubators describe a start-up hype that has emerged, in which so-called "wantrepreneurs" spend a lot of their time at events or trying to get temporary funding instead of focusing on building their business. These wantrepreneurs represent an institutional mindset, which incubators see as conflicting with how entrepreneurs ought to behave. To make their beliefs the norm incubators first employ the strategy of *sharing the narrative*. Incubators consistently communicate their expectations of the behavior of start-ups ought to display to their incubatees and, where possible, other start-ups in the ecosystem. Incubators combine this with a second strategy, which is mobilizing resources. These resources take the form of human resources and time spent on coaching start-ups. Interviewee D1: "*We provide weekly masterclasses, peer to peer feedback sessions but also individual coaching"*.

When attempting to change **regulative** institutions, we find that, in all cases, incubators also use the dual strategies of *using legitimacy and sharing the narrative.* One typical example of a regulative institution are regulations that govern the subsidies given to incubators by local government. Interviewee U1 gives examples of using legitimacy: “Our track record of nine years, the success rate that we achieved, both are good arguments [for the municipality] to at least assume that whatever we give them is either true or important.” And on sharing the narrative to create a change regarding subsidies: “So I gave this back to the municipality and now they will change the rules for this subsidy in 2021.” Incubators state that periods of political change, elections, provide opportunities for these regulative and cultural-cognitive change processes.

However, we also find that there are two types of regulative institutions that incubators do not attempt to change. First, incubators do not actively engage in IE when it concerns laws at the national level. Interviewee D1: “We do not do enough at the national level”, interviewee A1: ”It’s not very high on the agenda”. Second, incubators do not attempt to change regional regulative institutions that hinder the business models of their incubated start-ups. For example: both interviewee D1 and A1 mentioned flying regulations that prevented a start-up from testing its drones. While incubators would like to see some of these regulative institutions changes, they do not view removing the regulatory barriers for start-ups as a task of the incubator.

5.4.2. Transparent ecosystems

We find that **public incubators in transparent ecosystems** are the most active institutional entrepreneurs. They use a variety of institutional change strategies, in addition to those discussed in Section 4.1, aimed at changing cultural-cognitive and regulative institutions. They do not use additional strategies to change normative institutions.

First, one public incubator used a unique strategy to change the **cultural-cognitive** institution of focusing on regional interests. This incubator was prevented from collaborating with incubators from other regions in the “offline” environment. U3 described that, when the incubator started a free online incubation program for early stage entrepreneurs, the incubator saw this as an opportunity to collaborate with incubators from other regions. The incubator *mobilized resources* in the form of its own time and money. By inviting other incubators, they *mobilized allies*, first through personal contacts and then through more formal contacts. By showcasing the value of these collaborations, the incubator hopes to increase its legitimacy to change the cultural-cognitive institutions that currently inhibits collaborations between incubators from different ecosystems.

Furthermore, we find that public incubators in transparent ecosystems attempt to change several other **cultural-cognitive** institutions, which regard the culture around entrepreneurship, for example within local governments. A central strategy that they employ for all cultural-cognitive institutions is *mobilizing allies*. They mobilize other incubators in the region to form an informal coalition. Interviewee U6: “There was an initiative from some incubators, where you passed each other the ball. We discussed things”. Or A8: “the most important step is to know who the players in your ecosystem are, and engage them”. U3 describes that personal, informal connections are the key driver behind this process of *mobilizing allie*s. Incubators use these coalitions to develop a joint perspective on intended cultural changes and share narratives from this joined perspective because they believe that this will be more impactful than individual efforts. These incubators also frequently discuss opportunities for change with the local government to get them to support their vision of new institutions.

Public incubators also use the strategy of *mobilizing allies* when attempting to change **regulative** institutions around the local start-up policy. An example of this is a “start-up in residency” program, which concerns changing public procurement regulations so local governments can function as a customer for start-ups. Incubators work in coalitions because they argue that regional policy makers are more receptive to policy suggestions that come from a broad coalition of incubators than from individual incubators. Interviewee U2 illustrates this: “Right now, we’ve said, let’s do it together. Let’s make our wishes clear.”

Here, we find an important relationship between the cultural-cognitive and regulative institutions. The regulative institutions (start-up policy) are, in this case, a result of the dominant cultural-cognitive institutions about entrepreneurship. Incubators use the same strategies to change the cultural-cognitive institutions and the regulative institutions that build on them. Public incubators also use the strategy of *delegitimizing existing institutions* to change both cultural-cognitive and regulative institutions. They do this by forming and sharing narratives about why the current institutions are suboptimal and trying to get other actors in their ecosystem to support this narrative. One example is given by Interviewee U5, who explains how he pointed out the problems with a new regional finance fund and tried to convince other participants of Startup Utrecht to join his opposition.

We find that **private incubators** in transparent ecosystems are part of the same sort of *alliances* for cultural-cognitive and regulative institutions. They participate with the goal of changing the beliefs about the importance of entrepreneurship. However, many of our respondents explicitly noted that public incubators are more highly involved in these alliances and are therefore more active institutional entrepreneurs than private incubators. Interviewee A8 says about private incubators: “there are definitely parties that are more involved”. Interviewee A5 explicitly states that they leave alliance formation up to the public incubators. The private incubators are less active because their connections to governments and universities are weaker and because they are more focused on their own organization than on the entrepreneurial culture in the ecosystem. This was explicitly stated by interviewee A3: “we are focused on our own program”. Interviewee U5 says: “my first priority is to make [my incubator] as big as possible”. We find no other change processes for cultural-cognitive or regulative institutions.

Private incubators in transparent ecosystems do try to change one **normative** institution: the perception of entrepreneurship in incumbent firms. Private incubators create *legitimacy* in the eyes of incumbent firms by providing showcasing opportunities for incumbent firms. The incumbent firms are allowed to list the incubator as a partner, to help develop an innovative image for the firm. Interviewee A4 states that: “for them [incumbent partners] it is exposure, it is branding.” Furthermore, incubators have skills in developing early-stage start-ups, which incumbent firms often lack. This gives incubators legitimacy in the eyes of incumbent firms. Incubators then use their legitimacy to introduce new tools, such as the lean methodology and the business model canvas in these firms. An example from interviewee A5: “We work on methodologies for incumbent firms, in a similar way as for start-ups.” For some, but not all, private incubators this strategy has the positive side effect that they receive some funding from these incumbent firms.

5.4.3 Intransparent ecosystems

Public incubators in intransparent ecosystems are less active institutional entrepreneurs than their counterparts in transparent ecosystems. These incubators do not attempt to change either **cultural-cognitive** or **regulative** institutions, beyond those described in Section 4.1. This is partly because they indicate that they are unable to find potential allies that they can *mobilize*. Interviewee E1: “There are not that many other accelerators here. There are some initiatives, but they are all very young.”

The one institutional change process led by both public and private incubators in intransparent ecosystems, that we do not describe in section 4.1 is focused on changing the perception of entrepreneurial activities in incumbent firms, a **normative** institution. These incubators attempt to create institutional change by organizing workshops and by hosting teams from incumbent firms in the incubator, which both require the incubator to *mobilize* resources in the form of time. This is illustrated by interviewee E2 from a public incubator: “We are looking for expertise and they [incumbent firms] like to offer it, so we search for a common ground.” and by interviewee E1 from a private incubator: “We support entrepreneurs as well as teams from larger organizations.” followed by: “A reason to work with us is that we have supported over 200 start-ups and innovative teams already.” In doing so, they hope to use the performance of these teams *to create the legitimacy* to change the norms regarding innovative ideas in these firms and to get these incumbent firms more involved in the EE. Also, in this case there is sometimes the side effect that incumbents pay for these services.

5.5 Discussion

5.5.1 Conclusion

In this section we provide a synthesis of our findings and answer our research question: *How do public and private incubators differ in the strategies that they use to change or create normative, regulative and cultural-cognitive institutions in different institutional contexts?*

We find that incubators, as institutional entrepreneurs, use a larger number of change strategies to address cultural-cognitive institutions compared to normative and regulative institutions. We find that incubators describe legitimacy as key to all change processes and is seen as the core barrier when incubators feel they are unable to change institutions. The *creation of legitimacy and sharing of the narrative* are overarching strategies that occur for all three pillars. If incubators deem these strategies insufficient to achieve the desired institutional change they combine these with additional strategies. We observe this mainly for **cultural-cognitive** institutions and the **regulative** institutions that build on them, here the additional strategies are *delegitimization and mobilizing allies*. For **normative institutions** they employ *mobilizing resources* as an additional strategy.

We mainly observe a difference between public and private incubators in transparent ecosystems. Public incubators in these ecosystems are more active as institutional entrepreneurs particularly regarding cultural-cognitive and regulative institutions. Public incubators *mobilize allies*, especially with other incubators in their region, as these alliances are better able to change institutions. Private incubators also participate in these alliances but play a much less active role. Public incubators also delegitimize existing institutions and work with governments to change start-up policies. We did not find any private incubators who did this. We do not find strong differences for private incubators between the two types of ecosystems. We thus find that there is an interaction between the type of context and the type of incubator. The difference between public and private incubators in how they engage in institutional entrepreneurship is mainly notable in transparent ecosystems.

We find an interesting exception in the case of changing one particular normative institution, the perception of entrepreneurship in incumbent firms. This institutional change process is performed by all types of incubators except by public incubators in transparent ecosystems. These actively decide not to engage with them because they already have connections to a multitude of other actors and the incumbent firms here are not (yet) very involved in the ecosystem. This exception thus fits the conclusion that that the combination of public or private and the transparency of the institutional context influence whether incubators act as institutional entrepreneurs.

5.5.2 Theoretical Contributions

As our first theoretical contribution, we show that incubators fulfil the role of institutional entrepreneur. This shows that the role of incubators in EEs is extending beyond the start-up support and network function which are given primary consideration in the existing literature. We thus argue that the role of the incubator is currently expanding to a fourth generation, the 'institutional' incubator. We find that this function is primarily undertaken by public incubators and in transparent EEs. This is an important factor to consider in the comparison of the performance between public and private incubators. However, in line with the findings of van Weele et al. (2018) this does not automatically mean that incubators initiate successful institutional change.

Second, we show that institutional change processes differ between institutional pillars. This shows that it is important to consider the type of institution more closely in future research on institutional change. We observe that institutional entrepreneurs often use a larger number of change strategies to address cultural-cognitive institutions compared to normative and regulative institutions, this aligns with the notion that cultural-cognitive institutions are more complex and harder to change. Institutions are also interdependent. We find that, to change regulative institutions, institutional entrepreneurs often also address the underlying cultural-cognitive institutions. This supports the idea that cultural-cognitive institutions form a foundation on which the other institutional pillars build.

Third, our work is the first systematic comparison between public and private institutional entrepreneurs. Our findings indicate that public incubators are more active as institutional entrepreneurs than their private counterparts. The difference between public and private actors is most clearly noticeable in cultural-cognitive and regulative institutions. This supports the notion that public actors have closer ties to lawmakers and are more concerned with the welfare of the region. Public actors are also well-positioned to optimize institutions to foster innovation and nurture EEs. We find an interaction with the type of institutional context as the difference between public and private incubators is much stronger in transparent ecosystem. In line with the findings of Dorado (2005) we thus show the higher visibility and legitimacy of the institutional entrepreneur in transparent ecosystems causes them to be more active as institutional entrepreneurs.

5.5.3 Limitations and Future Research

Our study uses incubators as an exemplary case to systematically study the differences between public and private institutional entrepreneurs. Future research could study whether these differences remain consistent for other actors that have a public or private variant, such as medical clinics and educational facilities. This could show if our findings on public and private incubators are generalizable to other contexts.

In our sample we do not have a public and private incubator in each studied ecosystem. Future research could address this limitation through different research designs. This would require a sample with an even distribution of public and private incubators and would also provide additional insight into the effect of the ecosystem on the activities of the incubator.

As we used a static research design, another promising avenue for further research is to look at the degree to which incubators act as institutional entrepreneurs as the EE evolves. It would be particularly useful to study, through a longitudinal design, if incubators change the institutional change strategies that they employ over time and whether they become more active institutional entrepreneurs. Our results suggest that this may be the case, but our cross-sectional research design does not allow us to answer this question. The lack of a longitudinal research design also means that we are not able to reflect on the interdependencies and path-dependencies between incubator and ecosystem, we thus do not shed insight in whether and how the incubators helped shape the ecosystem they are currently trying to change or in how the incubators where themselves shaped by this ecosystem. This is an important avenue to explore in future research.

Finally, our study focuses on the degree to which incubators act as institutional entrepreneurs. Our research design thus does not allow us to draw conclusions about when incubators where successful in changing institutions. We looked at the incubator's activities as institutional entrepreneurs rather than their performance. In line with this we want to emphasize that there are also many institutions that incubators do not engage with, this was particularly evident for national level institutions. This is a limitation of our research that could be addressed in future research.

5.5.4 Practical Contributions

We show that incubators can act as institutional entrepreneurs and frequently do so to support entrepreneurship in the region. This aligns with earlier findings that incubators provide value to ecosystems beyond supporting specific start-ups (Dutt et al., 2016; Goswami et al., 2018) and with calls for the institutional incubator as the next step in the role of incubators in EEs (van Weele et al., 2018). We also show, in line with van Weele et al. (2018) how incubators are still constrained to do so. This is an important point as here the EE theory and the practicalities of regional policy are at odds. We encourage municipalities, provinces, regional development agencies, and universities to enable incubators in their role of institutional entrepreneurs. We call upon these actors to allow them the freedom to spend resources as institutional entrepreneurs working on developing the ecosystem. Furthermore, in their role as funders they can provide resources for this specific function as incubators are sometimes reluctant to spend their scarce resources on developing the ecosystem. We advise the incubators to further embrace the role as institutional entrepreneur, improving the conditions in the EE can reduce barriers for start-ups.

The crossing of regional boundaries is another point where the EE theory and the practicalities of regional policies are at odds. Because regional constraints sometimes hinder the ability of incubators to optimize support for their start-ups, they should ideally not be constrained in their attempts to formally collaborate with others. So perhaps the most important way that local governments and universities can help incubators is to give them the freedom to operate on both national and international levels. Based on EE literature we suspect that more interaction across regions will strengthen all regional ecosystems.

These findings also have two implications for entrepreneurs. First, we recommend them to communicate the institutional boundaries that their start-up encounters to the incubators as these can play an important role in changing institutions. Second, when incubators start alliances to facilitate institutional change entrepreneurs can join these alliances to add their voice in institutional change processes.

Beyond the incubator context, our findings show that an important part of any institutional change strategy is to continuously work on increasing the legitimacy of the institutional entrepreneur in the eyes of other actors in the ecosystem. Creating legitimacy is often part of a particular institutional change strategy, for example, having a clear goal. However, legitimacy of the institutional entrepreneur accumulates slowly over time. Therefore, institutional entrepreneurs can also increase legitimacy as an enabler of future institutional change processes. Furthermore, we recommend that institutional entrepreneurs let the strategies that they use for institutional change depend on the difficulty of the desired institutional change. Harder institutional change, such as in cultural-cognitive or particular regulative institutions, often require a higher number of institutional change strategies. Our interviews show that *mobilizing allies* is a useful strategy because incubators considered themselves to be more effective as institutional entrepreneurs when they formed alliances and collaborated with other incubators. Finally, new laws or elections, often increase the opportunities for IE. We therefore recommend that institutional entrepreneurs use these external shocks.

5 Public and private investigations

6.

The sustainable start-up paradox: Predicting the business and climate performance of start-ups

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Abstract

Sustainable start-ups introduce new sustainable technologies and business models that facilitate the transition to a carbon neutral economy. To understand how to create viable sustainable start-ups, we study what factors predict their business performance and climate performance (i.e. the ability of the start-up to reduce CO2e emissions), and if these contradict. A critical factor we consider is technology, which is commonly at the root of climate performance, and important for business performance because it influences a start-up's competitive advantage. Using a sample of 197 sustainable start-ups, we find a paradox between business and potential climate performance. Start-ups that exploit hardware technologies have a lower business performance, but a higher potential climate performance. Through the use of mediating effects we show that the sustainable start-up paradox is context specific. Start-ups can partly escape this paradox by focusing on novel and hardware technologies. We discuss implications for theory and practice.

6.1 Introduction

New sustainable technologies and business models are necessary for the transition to a carbon neutral economy (Gibbs, 2006; Niemann et al., 2020; Schaltegger et al., 2016). These are likely to be introduced by sustainable entrepreneurs (Cohen and Winn, 2007; Shane and Venkataraman, 2000), which makes entrepreneurship a critical component for the development of a carbon neutral economy (Dean and McMullen, 2007; Gibbs, 2006; Loorbach and Wijsman, 2013). Hence, governments and universities strongly support environmentally sustainable entrepreneurship (Gast et al., 2017; Kanda et al., 2014). To effectively support these start-ups it is crucial to understand when sustainable start-ups contribute to the transition to a carbon neutral economy (Gast et al., 2017; Loorbach and Wijsman, 2013). A first condition is that the start-up's business model must have the potential to reduce greenhouse gas emissions, this is the start-up's climate performance. Second, to be able to significantly contribute to climate mitigation, sustainable start-ups need to grow, they need to maintain a healthy business performance (Bjornali and Ellingsen, 2014; Calel and Dechezlepretre, 2013; Meyskens and Carsrud, 2013). Climate mitigation and business performance are thus both crucial performance indicators for environmentally sustainable start-ups (Gast et al., 2017; Schaltegger and Wagner, 2011; Stubbs, 2017). Based on Bjornali and Ellingsen (2014), we define an environmentally sustainable start-up as: *an entrepreneurial venture which significantly reduces greenhouse gas emissions by exploiting technological knowledge*.

The business performance of start-ups is a widely studied topic in entrepreneurship (Shane and Venkataraman, 2000; Song et al., 2008). In contrast, no research has yet studied what factors determine the climate performance of start-ups (Bjornali and Ellingsen, 2014; Meyskens and Carsrud, 2013). Studies on corporate firms show that climate performance easily goes at the expense of business performance (Dean and McMullen, 2007; Pinkse and Kolk, 2010). At the same time business performance is required, the start-up's product or service needs to be sold, for the start-up to contribute to climate mitigation (Bjornali and Ellingsen, 2014). There thus appears to be a paradox between the two performance dimensions. A possible explanation for this paradox is that large corporates rely strongly on existing routines, and that they lack the capabilities to align both performance dimensions (Van Mossel et al., 2018). Yet, as startups are relatively unburdened by an organizational history, it is unknown if this problem also applies to start-up firms. In particular, some authors have argued that the relation between climate and business performance is context specific (Flammer, 2015; Hang et al., 2018; McMullen, 2018; Russo Spena and Di Paola, 2020). We aim to find out whether and when environmentally sustainable start-ups encounter the aforementioned paradox between climate and business performance.

A critical factor to consider in this context is technology, which is commonly at the root of climate performance (Bjornali and Ellingsen, 2014; Gerlach, 2003; Stirling, 2010; Zhang et al., 2013), and also considered a key source of a start-up's competitive advantage (Aharonson and Schilling, 2016; Debackere et al., 1999; Deeds, 2001; Zahra, 1996). However, technology has so far received little attention as an independent variable in the start-up performance literature. There are a few exceptions that do study technological novelty in start-ups, however, these studies do so in the form of entrepreneur self-assessment (Hyytinen et al., 2015; Soetanto and Jack, 2013), which leaves room for a content driven method to measure technological novelty. We aim to fill this research gap by considering the effects of two technology dimensions, technology type (hardware or software) and the novelty of the technology, on both types of performance.

This leads to the following research question: *What is the influence of the technology characteristics of sustainable start-ups on their business and climate performance?* We quantitatively test the influence of these variables on performance using a sample of 197 Western-European start-ups. Because start-ups are small in the first years of their business, their emission reductions will inherently also be small during these years (Hyytinen et al., 2015). We therefore consider the potential climate performance rather than the achieved climate performance (Bjornali and Ellingsen, 2014; Rasmussen et al., 2012).

This study has two main contributions. First and foremost, by including the climate dimension of performance, this study takes a new step towards a more holistic evaluation of start-up performance, which includes their societal contributions as well as their business performance (Horne et al., 2020; Tiba et al., 2019; Zahra et al., 2009). Second, by focusing on the important but complex role of technology in start-ups we contribute to the technological trajectory literature (Fleming and Sorenson, 2001).

From a practical perspective, this study helps entrepreneurs, business coaches investors, and policy makers understand the influence of sustainable start-ups' technologies on their business and potential climate performance. Using our results, they can make more informed decisions when investing in and advising to sustainable start-ups.

6.2 Theory

Start-ups are small and young entrepreneurial ventures which are in the process of exploring a technology to develop their business (Bjornali and Ellingsen, 2014; Fontes and Coombs, 2001; Klotz et al., 2013). This study focuses on sustainable start-ups, which are hybrid organizations who besides developing a business also contribute to solving social and environmental problems (McMullen and Warnick, 2016; Munoz and Cohen, 2018; Stubbs, 2017). While sustainable start-ups all face similar challenges in balancing their business ambitions with a societal purpose, they differ empirically (de Lange, 2017). In particular, the literature on sustainable entrepreneurship identifies social and environmental entrepreneurship as two distinct categories (Belz and Binder, 2017; Bocken, 2015; de Lange, 2017). In this study we focus on environmental entrepreneurship (Dean and McMullen, 2007; Gast et al., 2017), which has been defined as "the process of discovering, evaluating, and exploiting economic opportunities that are present in environmentally relevant market failures" (Dean and McMullen, 2007, p. 58). More specifically, we look at start-ups that help reduce CO_2 equivalent (CO_2e) emissions (Bjornali and Ellingsen, 2014; Meyskens and Carsrud, 2013). Based on Bjornali and Ellingsen (2014), we define an environmentally sustainable start-up as: an entrepreneurial venture which significantly reduces greenhouse gas emissions by exploiting technological knowledge. In the rest of this study we refer to these as sustainable start-ups.

6.2.1 Start-up performance

The performance of a start-up is defined as whether the start-up achieves its desired purpose (Wright and Stigliani, 2012). Sustainable start-ups desire to both exploit a market opportunity and to reduce the impact of climate change (Bjornali and Ellingsen, 2014; Parrish, 2010). Therefore, business and climate performance constitute two different dimensions of performance (Bennett, 1991). In the next sections we explain how two technology characteristics, the type of technology and the technological novelty, are expected to influence business and climate performance. Fig. 6.1 displays our hypothesized relationships.

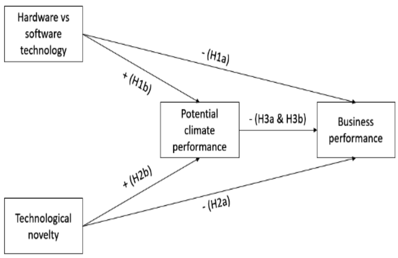

Fig. 6.1. Conceptual model

6.2.2 Type of technology

Digital, software, technologies have unique characteristics that make them fundamentally different from physical, hardware, technologies (Nambisan, 2017). In entrepreneurial practice start-ups are therefore often judged based on whether their product is based on a digital or physical technology (Alasdair, 2015; Block and Sandner, 2009; Lindtner et al., 2014). We therefore study the difference in performance between these technology types. We expect start-ups with a software technology to have a higher business performance for three reasons. First, they are considered to be more easy to scale because their digital nature doesn't require the production of physical products

(Nambisan, 2017; Zhang et al., 2015). This makes it easier for software technology start-ups to reach a larger market segment. Second, digital technologies have fast learning curves which enables them to grow quicker than other firms (Zhang et al., 2015). Finally, the physical nature of hardware technologies often results in a need for larger upfront investments to produce and purchase the product (Eveleens, 2019). This results in barriers to the adoption of the product. These arguments are in line with Chatterjee and Hambrick (2007) who find that start-ups in the computer software industry perform better than those in the computer hardware industry. As such, we arrive at the following hypothesis:

Hypothesis 1a: Start-ups with a hardware technology have a lower business performance than start-ups with a software technology

As mentioned above, there is no previous literature on the influence of technology type on the potential climate performance of start-ups. However, we can deduce arguments by looking at findings from other empirical fields. For example in a study of the electricity value chain, Moore and Wüstenhagen (2004) show that most of the opportunities for sustainable innovation concern hardware technologies, indicating that hardware technologies have a larger potential climate performance.

Furthermore, hardware technologies are often replacements of the existing process or product, while software technologies often make existing processes and products more efficient (Hellström, 2007). We argue that, although efficiency increase is important, the replacement of existing processes and products by hardware technologies will lead to larger reductions in CO_2e emissions because CO_2e emissions are very much driven by physical processes such as fossil fuel burning and industry (Raupach et al., 2007). Furthermore, hardware technologies are more likely to be radical and thus to have a larger impact.

Hypothesis 1b: Start-ups with a hardware technology have a higher potential climate performance than start-ups with a software technology

6.2.3 Technological novelty

Start-ups with a more novel technology have a high technological potential and as a result novel technologies have the potential to gain a competitive advantage (Debackere et al., 1999; Deeds, 2001; Harrigan and DiGuardo, 2014; Zahra, 1996). However, novel technologies are at the beginning of technological trajectories, which increases the time needed to develop the technology and the risks associated with developing the technology (Fleming, 2001; Hyytinen et al., 2015; Weissbrod and Bocken, 2017). Customers are often reluctant to adopt these high risk technologies, which reduces the firms' business performance (Fleming, 2001; Marra et al., 2003; Verhoeven et al., 2016). Start-ups with less novel technologies, on the other hand, build closely on technologies in existing technological trajectories. As such, they can be expected to benefit from economies of scale and learning effects obtained through experience with these other technologies (Yu et al., 2011; Zhong and Verspagen, 2016). This makes these technologies more competitive on the market (Anandarajah and McDowall, 2015; Rogner, 1998). Furthermore, a higher similarity to other technologies is likely to increase societal confidence in the product (Amezcua et al., 2013). This is supported by Hyytinen et al. (2015), who find that more innovative start-ups are likely to encounter a greater liability of novelty, which makes them less likely to achieve high business performance. Also, Soetanto and Jack (2016) find that start-ups with a strategy of discovering new knowledge, have a lower business performance than start-ups that optimize existing technologies. This leads to the following hypothesis:

Hypothesis 2a: Start-ups with a more novel technology have a lower business performance

For novel technologies which are at the start of technological trajectories learning effects have not yet occurred (Nemet, 2006; Rogner, 1998; Yu et al., 2011). Novel technologies thus often combine their high risks with a large technological potential. Because the risks associated with exploring novel technological options are so high, we expect that a start-up will only explore a novel technology if it has a large technological potential. The larger technological potential of these start-ups also means that they have a larger potential to mitigate climate change. We thus hypothesize that start-ups with a more novel technology have a larger potential to reduce CO_2e emissions (Aghion et al., 2014, 2012; Bjornali and Ellingsen, 2014; Nemet, 2009).

Hypothesis 2b: Start-ups with a more novel technology have a higher potential climate performance

6.2.4. Mediation of climate on business performance

To develop this section we combine the existing sustainable entrepreneurship literature, which is still limited on this topic, with the more developed CSR literature. A similar approach in theory development was successfully implemented by de Lange (2017). Research on corporates shows that the climate performance of firms influences their business performance (Hoang et al., 2020; Ong et al., 2015; Pinkse and Kolk, 2010; Qiu et al., 2016). (Linder et al., 2014) find that environmental oriented firms have lower economic performance than their counterparts. While, (Flammer, 2015) shows that, under certain conditions, adopting CSR policies can have a positive effect on the business performance. This indicates that the two performance dimensions are not independent and that the relation between them is context specific (Hang et al., 2018; McMullen, 2018; Niemann et al., 2020). Therefore we, in this section, discuss the influence of potential climate performance as a mediating variable on the relation between technology characteristics and business performance.

The product of a sustainable start-up is considered more difficult and costly to implement than that of a regular start-up (Giudici et al., 2017), which forms a barrier to a scalable business model. As a result, sustainable start-ups add more risk compared to other start-ups which causes investors to avoid climate sustainability start-ups (de Lange, 2017; Martin and Moser, 2016). Several scholars argue that this is the case because sustainable start-ups have to balance their economic and sustainability objectives and experience tensions in doing so (Jolink and Niesten, 2015; Smith et al., 2013; Stubbs, 2017). We therefore hypothesize that the potential climate performance has a negative influence on the business performance of sustainable start-ups.

We have argued that technology influences the business and climate dimensions of the performance of sustainable start-ups, and in addition that the potential climate performance has a negative influence on the business performance. However, in the literature on larger firms we also find a strong context specific component to the relation between climate and business performance (Flammer, 2015). We therefore include the potential climate performance as a partial mediator in the relation between technology and business performance:

Hypothesis 3a: Part of the relation between a start-up's type of technology and its business performance is mediated by the start-up's potential climate performance, such that hardware relates positively to potential climate performance, which subsequently relates negatively to business performance.

Hypothesis 3b: Part of the negative influence of a more novel start-up technology on the start-up's business performance is mediated by the start-up's potential climate performance, such that a more novel technology leads to a higher climate performance which subsequently relates negatively to business performance.

6.3 Methodology

6.3.1 Research design and data collection

To test our hypotheses, we collected data from 197 start-ups that participated in three regions of the Climate-KIC accelerator program 1) the Netherlands, 2) the DACH (Germany, Austria, Switzerland), and 3) the Nordics (Denmark, Norway, Sweden, Finland) between 2012-2016. The start-ups in this program are especially suited for this research because the program only selects young entrepreneurial ventures with a positive climate impact. Using the Climate-KIC accelerator as a sampling frame thus helps us select only start-ups that meet our definition of sustainable start-ups (Climate-KIC, 2017). Furthermore, this allows us to gain access to detailed information on a large sample of sustainable start-ups, which is hard to achieve due to their (relatively) limited number.

We collected data from three sources: (1) The Climate-KIC evaluation surveys, which were conducted about each start-up's performance in 2014-2016, are used as the data source for the business performance variables. (2) We use archival data from the Climate-KIC accelerator in the form of the application forms from the time the start-up applied to the accelerator. These forms are text-mined to collect the information for the independent and control variables as well as for the climate dependent variable. Due to the use of archival data the measurement of the independent and control variables takes place prior to the business performance variables. (3) A combination of public sources, such as the Chamber of Commerce and LinkedIn, are used to fill in missing information. We impute remaining missing variable using multivariate imputation by chained equations (Buuren and Groothuis-Oudshoorn, 2011; Rubin, 1987, pp. 76–77).

6.3.2 Variables

6.3.2.1 Dependent variable: Business performance

Business performance is a multidimensional concept because start-ups take different paths in growing their business, they prioritize different dimensions of business performance at different points in time (Davidsson et al., 2009). Hence, no single dimension can sufficiently capture business performance (Daily and Dalton, 1992; Murphy et al., 1996; Wiklund and Shepherd, 2003). Therefore, we use *firm size, revenues, and investments* as three dimensions of business performance. In doing so we follow the advice of (Eveleens et al., 2017; Wiklund and Shepherd, 2003) to include multiple measures of business performance in studies on start-up performance.

We use firm size and revenues as dimensions of business performance to illustrate the achieved growth of the firm. Similar to existing studies, we operationalize firm size through a count of the number of employees who are employed by the start-up in the year of the performance survey (Eveleens et al., 2017; Groenewegen and De Langen, 2012; Peña, 2004). The revenues are measured as the absolute amount of turnover created by the company in the year of the performance survey (Groenewegen and De Langen, 2012; Rothaermel and Thursby, 2005; Sullivan and Marvel, 2011). The revenue variable is measured on a four-level ordinal scale (0 = no revenues, 1 = €0-10,000, 2=€10,000-100,000 , 3 = €> 100,000).

Because the climate sector is very capital intensive, start-ups need external funding to achieve future growth (Bjornali and Ellingsen, 2014; Bocken, 2015; Rothaermel and Thursby, 2005). The investments thus represent the potential growth of a start-up. We operationalize the investments as the cumulative amount of external investments made into the company between the start-ups foundation and the moment of the performance survey. This variable is also measured on a four-level ordinal scale (1 = €0-250,000, 2 = €250,000-500,000, 3=€500,000-1 million, 4 = €> 1 million).

6.3.2.2 Dependent variable: Climate performance

In studies on environmental initiatives, the climate performance is measured as the achieved reduction in the amount of CO_2 equivalent (CO_2e) emissions[1] (Cohen and Winn, 2007; Gohar and Shine, 2007; Meyskens and Carsrud, 2013). Therefore, we operationalize potential climate performance as the potential reduction in CO_2e emissions caused by a start-up's technology in comparison to the conventional alternative (Bjornali and Ellingsen, 2014; Rasmussen et al., 2012).
The assessment of the start-up's climate performance took place in the form of expert coding by the authors and industry experts (Hallgren, 2012). As part of their application to the Climate-KIC accelerator the start-ups provide descriptions of their business idea and how their business will contribute to reducing the emission of greenhouse gases. We use these descriptions to assess the start-ups' potential to reduce CO_2e emission. The authors reviewed each start-up's potential to reduce CO_2e emission if their business idea becomes successful. We then scored this potential on a 5-point scale, in which a one stood for a very low potential and a five for a very high potential. This method allows us to circumvent the problem that start-ups often lack the resources to collect and report data on their climate performance (Horne et al., 2020; Kratzer, 2020).

To increase the reliability of the measure we verified the author assessments with those of a group of experts from Climate-KIC. The expert scores were only available for 127 out of the 197 start-ups and could thus not be used as the climate performance measure. However, by calculating the inter-rater-reliability (IRR) between the expert and author scores we could, through one-way, single-measure Inter Class Correlations (ICC), verify the reliability of the author scores (Hallgren, 2012). The ICC values between the author scores and the panel member mean is 0.627 showing a good IRR and thus proving that the climate performance assessment of the author is a reliable measure (Cicchetti, 1994; Hallgren, 2012).

6.3.2.3 Independent variable: Technology

Typically, patents are the most frequently used measure to study technology (Fontana et al., 2009; Harhoff et al., 1999; Verhoeven et al., 2016). However, patents are not a reliable indicator for start-up's, because they often do not file for them (Graham and Sichelham, 2008; Helmers and Rogers, 2011). To operationalize both technology characteristics we instead use the technology and product descriptions from the start-up's application form to the Climate-KIC accelerator. This form of archival data presents an unique database with access to descriptions of the technology at the time the start-up entered the accelerator.

To measure *technology type*, we coded whether or not the start-up uses hardware (physical) technology (software = 0, hardware = 1). Combinations were coded as

1 CO2-equivalent is an often-used measure to calculate the climate impact of emissions based on their global warming potential (Olivier et al., 2017).

hardware because of the expected capital costs that comes with hardware products. We performed a robustness test by including hardware-software combinations as a separate category. This did not alter the results and the coefficients showed that the hardware-software combination start-ups were indeed highly similar to the hardware start-ups.

The few existing start-up studies that measure technological novelty do so in the form of self-assessment by the start-ups (Hyytinen et al., 2015; Soetanto and Jack, 2013). We instead use the technology descriptions to employ a more data driven method. In this study, technological novelty is a start-up characteristic which resembles how the technological diversity of the system changes due to the introduction of that particular start-up's technology. This measure thus reflects how much technological novelty the start-up adds to the technological system, it measures the change in *"the evenness in a distribution of elements among a number of categories in a system"* (van Rijnsoever et al., 2015, p. 1096). As such, measuring the diversity change caused by a start-up requires mapping the technological system and determining the position of each start-up within this system. In this study we form the technological system through the technological descriptions of 920 sustainable start-ups who applied to the Climate-KIC accelerator. This broadened set of start-ups represent the range of possible technological options for climate-focused start-ups. Including an even broader set of companies by using website texts proved to be unfeasible because most websites contained very little information on technologies.

Previous studies have shown that text-mining is a particularly well-suited approach to map technological systems because it can be used to accurately assess a technology's complex features and identify patterns between different technologies (Aharonson and Schilling, 2016; Arts et al., 2013; Blei, 2011; Páez-Avilés et al., 2018). The technology description sections of the application forms are well suited for text-mining because they are similar in length to the abstracts which are often used as the input in text-mining models (Grün and Hornik, 2011; Páez-Avilés et al., 2018; Zhao et al., 2015).

We use the latent Dirichlet allocation probabilistic topic model (LDA) (Blei, 2011; Lee et al., 2012; Steyvers and Griffiths, 2007). LDA is a text-mining approach which analyses the words of documents to discover the themes that run through the documents and the connections between these themes (Blei, 2011). This methodology is outlined in (Blei, 2011) and has successfully been applied in various studies such as a sustainable entrepreneurship literature review (Tiba et al., 2019) and an assessment of nanotechnology innovation projects (Páez-Avilés et al., 2018).

To run the LDA we first performed the necessary data transformation steps (Feinerer, 2017; Meyer et al., 2008). We then use the Gibbs sampling algorithm to run the LDA (Blei, 2011; Srivastava and Shami, 2009; Su and Liao, 2013). To determine the appropriate amount of topics, we estimate multiple models (Blei and Lafferty, 2009; Su and Liao, 2013). The appropriate amount of topics is determined by the first time where the rate of perplexity change (RPC) is smaller than the following number of topics (Zhao et al., 2015). This is the case for the model with 14 topics (Appendix E). The LDA thus gives 14 topics (clusters of words) and for each document (start-up technology) the percentage with which they fit each topic. To characterise the topics, the 10 most frequent words for the first five topics are shown in Table 6.1 while the complete topic overview is depicted in Appendix E. The LDA is a content based approach and these topics and the words they contain are thus determined by the algorithm.

To calculate the diversity we use the Shannon-Weaver entropy index, which contains variety and balance (Shannon, 1948) and has been applied successfully in other technology studies (Páez-Avilés et al., 2018; van Rijnsoever et al., 2015).

$$H = -\sum_{i=1}^{R} p_i \, ln p_i \quad (1)$$

Here, H is the entropy value for diversity and p is the proportion of start-ups with a specific topic (i) (Páez-Avilés et al., 2018; Stirling, 2007). The technological novelty of a start-up (ΔH) can be calculated through the difference between the entropy of the population of sustainable start-ups (H_1) and a hypothetical population in which that particular start-up does not exist (H_0).

$$\Delta H = H_1 - H_0 \quad (2)$$

Table 6.1. The ten most frequent (stemmed) terms for the first five topics resulting from the topic modelling of the technology descriptions of 920 sustainable start-ups.

(Offshore) Wind	*Water management*	*Heating*	*Online applications*	*Transportation*
wind	water	heat	people	transport
storage	treatment	engine	carbon	app
module	filter	cool	online	clean
turbine	pump	fuel	climate	smartphone
tank	flow	gas	find	europe
air	drink	thermal	social	park
ship	region	air	shop	match
scalable	reus	hydrogen	footprint	rout
compress	shower	exchange	marketplace	driver
pollute	human	oil	engage	travel

6.3.2.4 Control variables

We include start-up age because previous research finds a positive significant relation with business performance (Ortín-Ángel and Vendrell-Herrero, 2014; Soetanto and Jack, 2016, 2013; Song et al., 2008). Furthermore, although all start-ups in our sample were less than 10 years old at the moment we measured their performance the start-ups in our sample vary in age. To isolate this effect we control for start-up age which we operationalize as the number of years between foundation and the performance survey.

The number of founders is included because previous research finds a positive significant relation with business performance (Klepper, 2001; Soetanto and Jack, 2013). This is operationalized as a count variable of the number of founders at the time of founding. Furthermore, the founding team's level of experience as a measure of human capital is positively related to start-up business performance (Shepherd and Wiklund, 2006; Unger et al., 2011). We operationalize this through a count variable of the cumulative years working experience (Colombo and Grilli, 2010; Rauch and Rijsdijk, 2013).

To account for specific experience, we use a binary indicator to indicate whether any founder had experience as a start-up founder (Cassar, 2014; Shane and Khurana, 2003). Similarly, industry experience is operationalized as a binary measure that represents whether any founder has working experience in an industry relevant to the start-up (Dahl and Reichstein, 2007; Toft-Kehler et al., 2014). Finally, management experience is also operationalized through a binary variable indicating whether the founding team has previous management experience (Dencker and Gruber, 2015). These three variables are author coded based on the resume of all founders, and in the case of industry-experience through a combined review with the activities of the start-up.

Furthermore, we control for the share of males in the founding team, because previous studies show that founding teams with a higher share of males have a higher business performance (Chowdhury, 2005; Kanze et al., 2018; Malmström et al., 2017; Verheul and Thurik, 2001). Previous studies also find that the market environment influence start-up performance (Schwartz and Hornych, 2010; Song et al., 2008; Wright and Stigliani, 2012). Therefore, we include the type of market as a control variable, this is operationalized as a binary variable that represents whether the start-up sells its products to businesses (B2B) or consumers (B2C) (B2B = 0, B2C = 1). Finally, there are small differences between the accelerator programs and they are located in countries with different institutional contexts and cultures (Climate-KIC, 2017). As such a categorical control variable which represents the accelerator region is also used.

6.3.3 Data analysis

6.3.3.1 Regression analyses

13 of the 197 start-ups in our sample had ceased to exist at the time of the survey. The sample size for the business performance models is thus 184[2], while the sample for the potential climate model is 197. The descriptive statistics and correlations are shown in

2 A robustness check with 197 start-ups, which includes the non-surviving start-ups as having zero employees showed very similar results to the outcomes A robustness check with 197 start-ups, which includes the non-surviving start-ups as having zero employees showed very similar results to the outcomes presented in this study.

Table 6.2. To test the hypotheses, we perform multiple regression analyses. The number of employees is an overdispersed count variable for which we use a negative binomial model. The revenues, investments and climate performance variables are ordinal by nature. Therefore, we use an Ordinal Logit Model (OLM) for these dependent variables. We use the McFadden Pseudo R^2 to report the performance of the respective models (Hoetker, 2007; Jackman, 2017; Zeileis and Hothorn, 2002). For each of the analyses we verify that the appropriate assumptions hold. The Spearman's correlations show no particularly worrisome correlations and the Variance inflation factor (VIF) scores are all below 2. As such there is no problem with multicollinearity (Field et al., 2012). Furthermore, scatterplots show that the residuals are homoscedastic, and there are no outliers as no observations have a Cook's Distance larger than 1 (Cook and Weisberg, 1982; Field et al., 2012). For the OLM analyses we also verified that the parallel regression assumptions as outlined in Ari and Yildiz (2014) hold.

6.3.4 Mediation analyses

To study the mediating effect of the potential climate performance we use the 'mediation' package in R (R Core Team, 2023; Tingley et al., 2014). This package implements the causal mediation analyses as outlined by Imai et al. (2011) and allows for the use of NBM and OLM regressions to perform the causal mediation analyses (Tingley et al., 2014). We do not use the method of Baron and Kenny (1986), as this does not appropriately test the significance of the indirect effect, nor the Sobel test, as this assumes a normal distribution of standard errors, which is not the case (Aguinis et al., 2017; Imai et al., 2010; Tingley et al., 2014). In the mediation analyses we include the same control variables as in the regression analyses. Finally, we account for the six potential issues in causal mediation analyses outlined by (Aguinis et al., 2017).

Table 6.2. Descriptive statistics and correlations

#		n	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Number of employees	184	5.57	5.01	1																
2	Revenues	180	1.26	1.18	0.50	1															
3	Investments	141	1.65	1.10	0.43	0.24	1														
4	Potential reduction in CO_2 emission	197	2.87	1.05	0.05	-0.06	0.17	1													
5	Technology type	197	0.71	0.46	-0.20	-0.19	0.06	0.25	1												
6	Technological novelty	197	0.29	1.93	0.06	0.00	0.12	0.23	0.04	1											
7	Start-up age	197	2.79	1.87	0.18	0.36	0.46	-0.06	0.06	0.04	1										
8	Number of founders	197	2.51	0.95	0.24	-0.06	0.00	-0.10	-0.07	0.03	-0.08	1									
9	Years working experience	196	19.30	19.03	-0.05	-0.11	-0.02	0.07	-0.02	-0.10	0.04	0.18	1								
10	Start-up experience	196	0.47	0.50	0.02	-0.02	0.10	0.09	0.03	0.04	0.05	0.08	0.46	1							
11	Industry experience	195	0.58	0.49	-0.06	-0.03	-0.16	0.07	-0.07	-0.03	-0.06	0.08	0.50	0.12	1						
12	Management experience	195	0.43	0.50	0.03	-0.01	0.00	0.12	-0.01	-0.02	0.06	-0.06	0.65	0.36	0.26	1					
13	% of males	197	0.89	0.23	0.10	0.15	0.17	0.03	0.03	0.00	0.13	-0.12	-0.10	0.02	0.03	0.08	1				
14	Market type	197	0.22	0.41	0.10	0.10	0.02	-0.06	-0.06	-0.08	-0.04	0.05	-0.16	0.02	-0.18	-0.11	0.01	1			
15	Netherlands	197	0.57	0.50	-0.10	0.05	0.11	-0.11	0.09	0.02	0.25	-0.29	-0.16	0.00	0.01	0.00	0.11	-0.01	1		
16	Germany, Austria, Switzerland	197	0.24	0.43	0.23	0.05	-0.02	0.04	-0.21	0.04	-0.27	0.18	-0.06	-0.22	0.04	-0.07	-0.09	0.05	-0.64	1	
17	Nordics	197	0.19	0.40	-0.12	-0.12	-0.11	0.09	0.12	-0.07	-0.02	0.18	0.26	0.24	-0.06	0.07	-0.04	-0.04	-0.56	-0.27	1

6.4 Results

6.4.1 Regression analyses

The results of the regression models are shown in Table 6.3. We find that the McFadden pseudo R^2 values for the firm size model (0.06), the revenues model (0.10) the investments model (0.12) and the climate model (0.07) indicate acceptable to good model fits (McFadden, 1974).

The results show that start-ups with a hardware technology perform significantly worse than their software counterparts for firm size and revenues ($p<0.01$). Start-ups with a software technology thus have higher growth than those with a hardware technology. However, software technology start-ups do not yield more investments. This might be due to the fact that because software start-ups often do not need high investments for manufacturing they spend less time focused on acquiring funding than start-ups with a partially or entirely physical technology who have a higher capital requirements. Hypothesis 1a is therefore partly supported. Start-ups with a hardware technology have significantly higher potential to reduce CO_2e emissions than their software counterparts ($p<0.01$), which lends support to hypothesis 1b.

The technological novelty variable does not have a significant influence on the firm size, revenues, and investments of a start-up. The results therefore do not support hypothesis 2a. A potential explanation could be that while generally risky, a novel technology sometimes has more potential to gain competitive advantage (Debackere et al., 1999; Deeds, 2001; Harrigan and DiGuardo, 2014; Zahra, 1996), which balances the effect on start-up business performance. The influence of technological novelty on the potential climate performance is positive and significant ($p<0.001$), which supports hypothesis 2b.

Table 6.3. Results of the NBM with the number of employees and the OLM models with investments and potential climate performance as the dependent variable.

	Control # of employees	# of employees	Control Revenues	Revenues	Control Investments	Investments	Control Climate	Climate
	NBM	NBM	OLM	OLM	OLM	OLM	OLM	OLM
Intercept	0.36	0.56.						
	(0.29)	(0.29)						
Technology type		-0.33**		-0.87**		0.51		1.00**
		(0.12)		(0.32)		(0.43)		(0.30)
Technological Novelty		0.21		0.72		-0.14		2.08***
		(0.24)		(0.68)		(0.82)		(0.62)
Start-up age	0.12***	0.12***	0.46***	0.47***	0.44**	0.45**	-0.00	-0.01
	(0.03)	(0.03)	(0.09)	(0.09)	(0.13)	(0.13)	(0.07)	(0.07)
Number of founders	0.20**	0.20***	-0.07	-0.08	0.10	0.12	-0.24	-0.23
	(0.06)	(0.06)	(0.16)	(0.16)	(0.20)	(0.21)	(0.16)	(0.16)
Years working experience	-0.01.	-0.01	-0.03*	-0.03*	0.00	0.00	-0.01	-0.02
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Start-up Experience	0.16	0.12	0.23	0.18	0.23	0.330	0.30	0.35
	(0.12)	(0.12)	(0.33)	(0.33)	(0.40)	(0.43)	(0.31)	(0.31)
Industry Experience	-0.24.	-0.25*	0.40	0.41	-0.74.	-0.72.	0.31	0.50
	(0.12)	(0.12)	(0.33)	(0.33)	(0.42)	(0.42)	(0.31)	(0.31)
Management Experience	0.25.	0.22	0.20	0.14	-0.17	-0.16	0.35	0.54
	(0.14)	(0.14)	(0.39)	(0.39)	(0.49)	(0.50)	(0.36)	(0.36)
Market type	0.25*	0.24.	0.60.	0.57	-0.21	-0.23	-0.21	-0.24
	(0.13)	(0.13)	(0.34)	(0.35)	(0.46)	(0.46)	(0.32)	(0.32)
Share of males	0.48.	0.52*	0.94	0.99	1.72	1.71	0.28	0.11
	(0.25)	(0.24)	(0.67)	(0.68)	(1.12)	(1.13)	(0.56)	(0.55)
Accelerator DACH	0.40**	0.36**	0.65.	0.53	0.41	0.49	0.47	0.79*
	(0.14)	(0.14)	(0.37)	(0.38)	(0.48)	(0.50)	(0.34)	(0.35)
Accelerator Nordics	-0.21	-0.18	-0.22	-0.14	-0.95.	-1.03.	0.72.	0.79*
	(0.15)	(0.15)	(0.40)	(0.41)	(0.53)	(0.55)	(0.39)	(0.38)
n	184	184	184	184	184	184	197	197
Additional df		2	2	2		2		2
LogLikelihood	-473.34	-469.31*	-220.58	-216.79*	-162.75	-161.74	-276.34	
McFadden R^2	0.05	0.06	0.09	0.10	0.11	0.12	0.02	0.07

'***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$, '.' $p<0.1$

6.4.2 Mediation analyses

6.4.2.1 Technology type

From the regression analyses we found that having hardware products increases potential climate performance and decreases the start-ups' firm size and revenues (Table 6.3). The results of the mediation model (Table 6.4) also shows that the total effect from having a hardware technology on firm size and revenues is negative and significant ($p<0.05$). We find that the causal mediation effect for firm size is positive, although only significant at $p<0.1$. This is an example of inconsistent mediation, which means that the direct effect of the independent variable has an opposing sign to the indirect effect (Aguinis et al., 2017; MacKinnon et al., 2007; van Balen et al., 2019). The negative direct effect ($p<0.05$), is thus larger than the total effect. This means that although firm size is negatively affected by having a hardware technology, there is a positive indirect effect. Namely, hardware technology improves climate performance, which in turn positively influences firm size.

For the investments, the total effect and direct effect of having a hardware technology are not significant. However, similar to the firm size model, the causal mediation effect is significant and positive ($p<0.05$). Having a hardware technology thus increases the potential climate performance which in turn increases the investments in the start-up.

We thus find that the potential climate performance serves as a significant mediator on the relation between technology type and firm size ($p<0.1$) and investments ($p<0.05$). However, because the direction of the mediation effect is opposite to the hypothesized effect, hypothesis 3a is rejected. While we hypothesized that potential climate performance negatively affected business performance, our results suggest that potential climate performance can actually contribute to business performance.

6.4.2.2 Technological novelty

In the mediation analyses for technological novelty we find no significant effects on firm size and revenues. This is in line with our regression models (Table 6.3).

For the investments we find that the positive total effect of technological novelty is not significant. However, the indirect effect of technological novelty through potential climate performance on the investments is positive and significant ($p<0.05$). The total effect is not significant due to the presence of a negative direct effect, which is not significant. So, although technological novelty does not have a total effect on investments, there is, through improving the climate performance, a positive indirect effect on the investments.

We thus find some support that the potential climate performance serves as a mediator in the relation between technological novelty and business performance, but this only applies to the investments. However, the direction of the mediation effect is opposite to the hypothesized effect, and hypothesis 3b is thus rejected.

Table 6.4. Mediation results for the influence of having a hardware instead of a software technology (technology type) and the level of technological novelty on business performance.

	Firm size	Revenues	Investments[3]
Causal Mediation Effect Technology Type	0.44.	-0.01	0.11*
Direct Effect Technology Type	-2.19*	-0.47**	0.11
Total Effect Technology Type	-1.75*	-0.48**	0.22
Causal Mediation Effect Technological Novelty	0.38	-0.13	0.24*
Direct Effect Technological Novelty	-0.15	0.40	-0.06
Total Effect Technological Novelty	0.23	0.27	0.18
# of bootstraps	10,000	10,000	10,000

'***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$, '.' $p<0.1$

6.4.3 Control variables

Regarding the control variables in the regression models, we find that *start-up age* has a positive effect on all business performance measure, which is significant (p<0.01). A larger *initial founding team* has a positive, significant effect on firm size (p<0.001). Furthermore, a larger percentage of males has a positive effect on firm size (p<0.05). These findings are in line with previous literature (Malmström et al., 2017; Soetanto and Jack, 2013; Song et al., 2008). Start-ups selling their products to *consumers* have a significantly larger number of employees than their counterparts who deliver to *businesses* (p<0.1). Furthermore, we find that start-ups from the *DACH* region are significantly larger than their counterparts from the *Netherlands* and *Nordics* (p<0.01). A potential explanation that came up when talking to start-ups from this region is the fact that these start-ups are dealing with a larger home market. As a result, they require larger teams to travel to different parts of their market. Start-ups from the *DACH* region and *Nordics* both have a higher climate potential than their Dutch counterparts (p<0.05). Contradictory to the existing literature is the finding that, having experience in the same industry has a significant negative effect on the number of employees (p<0.05) and the investments (p<0.1). One potential explanation is that we included relevant experience which is obtained working at a university in our industry experience variable. This could have led to the negative influence of industry experience on business performance because previous research has shown that ventures started from universities generally perform worse than other start-ups (Harrison and

3 These coefficients are calculated based on an NBM model for the sake of simplicity in reporting. We also performed the OLM model and verified the relevant assumptions. This gave the same results, however for the sake of clarity we report the outcomes of the NBM model.

Leitch, 2010). Finally, we also find a significant negative effect of the cumulative years of working experience on the revenues.

6.4.4. Robustness tests

As a first robustness test we used a binary investment measure (0= no investments, 1 = investments) to test the robustness of this variable. The results were not significantly different from the investment model as reported in this study. To test the reliability of the technological novelty variable, we performed two robustness checks. First, we use the alternative VEM algorithm to perform the LDA (Grün and Hornik, 2011). Second, we constructed the technological diversity change variable based on the 197 start-ups included in this research, instead of the larger set of 920 start-ups. In both cases the results of the regression models were very similar to our original results. Subsequently, we tested for fluctuations over the different years, during which the content of the accelerator program or the economic situation could have changed. We did this by including dummies for the year in which the start-up entered the accelerator. These dummies were not significant and did not change our findings. Finally, because hardware and high novelty technologies are considered to take longer to get to market than software and low novelty technologies we performed a robustness test in which we added the interaction effect between age and both technology type and the novelty of a technology. None of these interaction terms were significant and our results remained the same.

In our study we focus on the business performance of sustainable start-ups that are up to 10 years old. We believe that this is an appropriate timeline given that start-ups are often pressed for short term financial results (Clercq et al., 2006; Steier and Greenwood, 2000). However, hardware and novel technologies are capital intensive and as a result it can take longer for start-ups relying on these technologies to reach a high business performance (Hyytinen et al., 2015; Zhang et al., 2015). However, there is the possibility that the influence is different for the long-term business performance of these start-ups. We partially accounted for this by including age as a control variable and through the robustness test that includes an interaction between age and each of the technology variables.

6.5 Discussion

In this study, we analyzed what factors predict the potential climate performance of sustainable start-ups, and if these contradict business performance. In particular, we focused on the influence of technology characteristics, as these are crucial for both forms of performance. The results provide support for the notion that the business and climate dimensions of performance for sustainable start-ups are fundamentally different from each other. We find that the technology characteristics and also the control variables, have contradictory effects on potential climate and business performance. The negative influence of climate performance which large, established businesses encounter (Linder et al., 2014; Pinkse and Kolk, 2010) is thus likely not only a result of corporates relying on existing routines (van Mossel et al., 2018). Instead, the tensions between economic and sustainability objectives are also encountered by sustainable start-ups (Jolink and Niesten, 2015; Smith et al., 2013; Stubbs, 2017). At the same time, business performance is necessary to translate potential into actual climate performance (Bjornali and Ellingsen, 2014; Calel and Dechezlepretre, 2013; Meyskens and Carsrud, 2013). We thus confirm the existence of a paradox between the climate and business performance of sustainable start-ups.

By delving into this paradox, we show how technology influences the complex dynamic between the potential climate and business performance of sustainable start-ups. We confirm that the physical nature of hardware technologies increases the potential climate performance of sustainable start-ups (Raupach et al., 2007). On the other hand, the scalability of digital technologies (Nambisan, 2017; Zhang et al., 2015) increases the size of these start-ups. Finally, being at the beginning of technological trajectories causes start-ups with more novel technologies to have a higher potential climate performance (Aghion et al., 2014; Bjornali and Ellingsen, 2014). Technology characteristics are thus a key variable in research on both dimensions of start-up performance, particularly for sustainable start-ups.

However, we also find that potential climate performance serves as a positive mediator in the relationship between the technology characteristics and business performance for sustainable start-ups. Our findings thus confirm previous arguments that the relation between climate and business performance is strongly context specific (Hang et al., 2018; McMullen, 2018). In particular, our study helps to understand the context specific conditions under which sustainable start-ups, as hybrid organizations, prosper (McMullen, 2018). We provide evidence that the sustainable start-up paradox is dependent on the start-up's technology. Namely, sustainable start-ups can partly escape the paradox of maximizing climate and business performance by using novel and hardware-based technologies, we find this particularly for the investments.

A possible explanation for this finding is given by de Lange (2019) who finds that investors in sustainable start-ups purposely try to serve as change agents through their investments. These investors choose those sustainable start-ups that have the biggest impact potential because they also value the societal impact (de Lange, 2019; Martin and Moser, 2016). Another explanation is that the sustainable start-ups with the highest potential climate performance are (partly) able to escape the paradox between business and climate performance because the societal urge to mitigate climate change increases the demand for their products/services (de Lange, 2017).

6.5.1 Limitations and further research

A first limitation is that our sample contains a disproportionate number of surviving start-ups. This survival bias made it unfeasible to study the difference between surviving and non-surviving start-ups (Cader and Leatherman, 2011). Hence, our results should be interpreted as a study on the influence of technology on the performance of surviving firms. We encourage future research to study the influence of the type of technology and the level of technological novelty on survival. In particular, the survival bias could be the reason why our results did not confirm with hypothesis 2a which, based on the findings of Hyytinen et al. (2015) regarding innovativeness and survival rates, argues that high novelty start-ups have lower business performance. Furthermore, it would be relevant to study whether the relations between technology characteristics and potential climate performance hold when including non-surviving firm.

A further concern caused by this sampling strategy could be that the results have limited generalizability towards sustainable start-ups not participating in incubation or accelerator programs. However, this is likely not problematic. Climate technologies are generally very resource intensive, and therefore sustainable start-ups encounter large liabilities of newness and smallness (Bjornali and Ellingsen, 2014; Eyraud et al., 2013; Hyytinen et al., 2015). The start-ups often require additional resources to overcome these liabilities which they acquire by entering accelerators and incubators (Klofsten et al., 2016; Shane and Khurana, 2003; van Rijnsoever et al., 2016; van Weele et al., 2017). It can thus be expected that the majority of sustainable start-ups use the support of an acceleration or incubation program. An advantage of this sampling frame is that it allowed us to obtain a substantial sample of sustainable start-ups, which is a challenge given their relatively limited number. A limitation to the generalizability is that we look particularly at start-ups in developed Western European countries. Future research should test if our findings hold in other institutional contexts, because other studies show that the context has a clear influence on the frequency and quality of sustainable start-ups (Spence, 2011; Tiba, 2020).

In our study we focus on the business performance of sustainable start-ups that are up to 10 years old. We believe that this is an appropriate timeline given that start-ups are often pressed for short term financial results (Clercq et al., 2006; Steier and Greenwood, 2000). However, hardware and novel technologies are capital intensive and as a result it can take longer for start-ups relying on these technologies to reach a high business performance (Hyytinen et al., 2015; Zhang et al., 2015). However, there is the possibility that the influence of technology type and the novelty of a technology is different for the long term business performance of these start-ups. We partially accounted for this by including age as a control variable and through the robustness test that includes an interaction between age and each of the technology variables. Nevertheless we acknowledge that we do not look at the long term business performance of sustainable start-ups. This is a potential limitation of our study and we thus recommend future research to study if the technology type and the novelty of the technology have a different effect on the long term business performance of sustainable start-ups. Particularly interesting would be a time series analyses.

The climate measure in the form of the potential to reduce CO_2e emissions proved reliable using expert scores as a verification. However, it could be argued that quantitative numbers would, nevertheless, be preferable. These estimations could then be combined with the revenues of the start-ups, which would allow for the calculation of the ex-post realized climate performance. However, constructing such measures requires individual collaboration from each start-up, which was not available. Furthermore, as we study start-ups, there is an inherent degree of uncertainty about their CO_2e reductions because their production process and business model are still in development. We therefore elected to use subjective assessment scores instead. Future research could further delve into different measures for climate performance and possibly calculate the realized CO_2e reductions ex post.

6.5.2 Practical implications

Achieving (1) climate performance and (2) business performance simultaneously is not straightforward as both require different strategies. In terms of technological characteristics, our study shows that by using novel and hardware-based technologies, sustainable start-ups may partly escape the paradox of maximizing both climate and business performance. Additionally, having high climate ambitions partly alleviates the negative effect of hardware technologies on business performance. We therefore advice sustainable start-ups who exploit a hardware technology to dream and act 'climate-big'.

For external stakeholders, such as business advisors, investors, or incubators, our study also has implications. Because the antecedents of climate performance and business performance are different, these stakeholders can have an impact on both forms of performance by focusing on particular antecedents. Specifically, investors can urge sustainable start-ups to follow a technological strategy that is focused on software to maximize business performance. Incubators that may have a predominantly societal goal may instead urge sustainable start-ups to follow a hardware-based strategy to maximize climate performance. If external stakeholders' aim is to maximize both forms of performance, we advise to invest in sustainable start-ups with a hardware technology and high climate potential.

This research also shows that there are fundamental differences in the performance of start-ups based on their type of technology and it's novelty. We argue that start-up support programs should then also differentiate the support they offer to these start-ups. This is in line with earlier findings that different types of start-ups require different types of support (Soetanto and Jack, 2013; van Weele et al., 2019).

These results also have implications for policymakers. In particular, our results show that economic and climate ambitions are not easily combined. This challenges the idea of 'green growth' (Hockerts and Wüstenhagen, 2010). If the goal is, primarily, to stimulate start-ups for economic growth, we recommend policymakers to facilitate entrepreneurship based on software technologies. However, if the goal is to pursue green growth by combining climate potential and business performance we recommend to focus on sustainable start-ups with a hardware and novel technology. The results show that deviating from existing technological trajectories is beneficial for society as it results in start-ups with more climate potential, however, doing so does not benefit the business performance of the start-up. To mitigate the business risk of these sustainable start-ups governments should provide them with additional support. One way to do so is through co-investing and taking equity. If some of the sustainable start-ups become profitable, at least part of this investment is publicly retained. In particular, results suggest that having a diverse portfolio of sustainable start-ups can pay off. The limitations of some start-ups may be complemented by the strengths of other start-ups, thereby reducing the risks of the overall investment portfolio. The profits from the low-sustainable start-ups with software technology can then be re-invested into sustainable start-ups with a hardware technology. Finally, another strategy is to reduce the business performance liabilities of start-ups with a hardware technology. This could be done by subsidizing or giving investment guarantees for manufacturing investments or by investing in shared manufacturing facilities that can be used by start-ups.

6 The sustainable start-up paradox

7.

Greening Pastures, Ecosystems for Sustainable Entrepreneurship

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Abstract

Sustainable entrepreneurs introduce new sustainable technologies and business models to the market. They thereby can help with tackling grand environmental challenges. Regional governments are increasingly implementing policies to develop a supportive ecosystem for sustainable entrepreneurship in their region. For these policies to be effective, policy makers need to understand which regional factors influence the founding of sustainable start-ups by these entrepreneurs. We build on the sustainable entrepreneurial ecosystem and innovation system literatures to develop hypotheses about which factors could influence the presence of sustainable start-ups in a region. We test these hypotheses on data from 274 European NUTS-2 regions containing 46,741 start-ups. We use text analysis to identify which start-ups are environmentally sustainable. We find strong evidence that the quality of an entrepreneurial ecosystem is important for the presence of sustainable start-ups, even more so than for their regular counterparts. Furthermore, we find that the presence of sustainable start-ups is positively influenced by the presence of fellow (regular) start-ups, the presence of sustainability-oriented formal institutions, and to some extend sustainability-oriented resource endowments and sustainability-oriented informal institutions. We make two contributions to the literature. First, our research contributes to structuring the debate on generic versus specific entrepreneurial ecosystems using insights from the innovation systems literature. Second, we apply these insights to propose a novel conceptual framework for sustainable entrepreneurial ecosystems. We show how sustainable entrepreneurship is influenced by both the generic entrepreneurial ecosystem and through a sustainability specification. Policy makers can use our results to establish policies that help improve ecosystems for sustainable entrepreneurship in their region.

7.1 Introduction

To overcome the grand environmental challenges, such as climate change and biodiversity loss, there is a need for a transition to a more sustainable society (Alkemade et al., 2011). Sustainability transitions are, for an important part, driven by entrepreneurs who introduce new sustainable technologies and business models (Bjornali and Ellingsen, 2014; Cohen and Winn, 2007; Leendertse et al., 2021; Tiba et al., 2021). City, regional, and national governments are increasingly implementing policies to facilitate sustainability transitions (Truffer et al., 2015), and to develop their region into an ecosystem for sustainable entrepreneurship (Tiba et al., 2021). Sustainable entrepreneurship entails starting novel ventures that engage in the "discovery, creation, and exploitation of opportunities for (future) goods and services that simultaneously sustain the natural and social environment, and provide economic and non-economic gain for others" (Johnson and Schaltegger, 2020, p. 1141). These novel ventures are so called sustainable start-ups (SSUs) (Leendertse et al., 2021; Tiba et al., 2021). In this study we focus on those SSUs that address environmental sustainability.

For sustainable entrepreneurship policies to be effective, policy makers need to understand which regional factors facilitate the founding of SSUs (Giudici et al., 2019; Tiba et al., 2021). Regional factors are important for entrepreneurship because they influence the conditions (Ács et al., 2014; Acs and Audretsch, 2005; Alvedalen and Boschma, 2017; Stam, 2015) on which the occurrence of entrepreneurship depends (Shane and Venkataraman, 2000). These factors are widely studied and have been summarized in the entrepreneurial ecosystem framework (Alvedalen and Boschma, 2017; Andersson and Koster, 2011; Stam, 2015). An entrepreneurial ecosystem (EE) comprises a set of interdependent actors and factors that are governed in such a way that they enable productive entrepreneurship within a particular territory (Stam, 2015; Stam and Spigel, 2018).

The EE framework initially focused on productive entrepreneurship independent of sectors or type of entrepreneurship (Stam and van de Ven, 2021). However, recently there are several studies that make a distinction between generic and specific EEs. These studies identify specific characteristics for EEs in certain sectors, such as digital (Bejjani et al., 2023), biotech (Auerswald and Dani, 2017) and fintech (Alaassar et al., 2022) or for specific types of entrepreneurs, such as social entrepreneurs (Thompson et al., 2018) and creative entrepreneurs (Loots et al., 2021). The emergence of specific EEs might entail that understanding how EEs foster certain types of entrepreneurs could require a further specification of the generic EE framework (Wurth et al., 2023).

Sustainable entrepreneurs are one type of entrepreneur for which such a specification is likely to be necessary, because sustainable entrepreneurs have different motivations and encounter additional market and institutional challenges in comparison to regular entrepreneurs (Gibbs, 2006; Hart, 2006; Leendertse et al., 2021; Linnanen, 2002; Tiba et al., 2021). As a result, researchers have developed the sustainable entrepreneurial ecosystem (SEE) concept, which can be used to understand how ecosystems influence sustainable entrepreneurship (Cohen, 2006; Theodoraki et al., 2018; Tiba et al., 2020; Volkmann et al., 2021). There have been several papers that try to identify which factors influence the presence of SSUs (DiVito and Ingen-Housz, 2021; Giudici et al., 2019; Tiba et al., 2021). The identified factors include a combination of a high GRP per capita and either high shares of female founders or high shares of non-religious people (Tiba et al., 2021), high environmental awareness, and the presence of relevant technical knowledge (Giudici et al., 2019), the sustainability orientation of regional actors, and the size of regional markets for sustainable products (DiVito and Ingen-Housz, 2021).

However, a systematic evaluation of which generic and specific EE components influence the presence of SSUs, and thus should be included in the SEE framework, is lacking (Theodoraki et al., 2018; Volkmann et al., 2021). The existing literature does not cover how an SEE, as a specific EE, relates to the generic EE. A systematic evaluation, that does include this distinction, is needed to provide policy makers with accurate insights on how to increase the conditions for sustainable entrepreneurship in their region (Giudici et al., 2019; Tiba et al., 2021). To address this issue and contribute to our understanding of SEEs we address the following research question.

What is the influence of the generic and specific elements of sustainable entrepreneurial ecosystems on the presence of sustainable start-ups?

We answer this research question using quantitative analyses on 46,741 start-ups from 274 European NUTS-2 regions in 28 countries. We quantitatively test if, and how the factors that emerge from the generic EE literature influence the presence of SSUs. In addition, we use the related literature on innovation systems for sustainable innovation, to systematically identify and test specific SEE elements that can influence the presence of SSUs.

In doing so we make two contributions to the literature. First, our research contributes to the debate on generic versus specific EEs using insights from the literature on innovation systems. We propose that specific EEs can be considered as a further specification of generic EEs. Second, we apply these insights to the SEE literature and show how sustainable entrepreneurship is influenced by both the generic EE and through a sustainability specification. We propose a novel conceptual framework for SEEs. We use this framework and show that the presence of SSUs in a region, is positively influenced by the quality of the EE, the presence of fellow (regular) start-ups, the presence of sustainability-oriented formal institutions, and to some extend sustainability-oriented resource endowments and sustainability-oriented informal institutions.

7.2 Theory

In this section we first outline the dependent variable SSUs. Next, we cover the EE framework. Third, we conceptualize SEEs as consisting of a combination of generic and specific EE elements.

7.2.1 Sustainable start-ups

SSUs are small, flexible, and have relatively few vested interests, which allows them to come up with radical solutions for sustainability challenges (Dean and McMullen, 2007; van Rijnsoever, 2022). There is much heterogeneity among SSUs (Schaltegger and Wagner, 2011), but they face four common constraints (van Rijnsoever, 2022). These constraints cause SSUs to encounter additional challenges compared to regular start-ups.

First, many technology-based SSUs are constrained because they require more investment capital than other types of start-ups (Evans, 2018). "Hardware" SSUs, such as in clean-tech, often face higher costs due to the need to conduct large-scale R&D, or demonstration projects, as well as to set up production lines. As a result, the products or services of SSUs are more difficult to implement and have a higher chance of failure compared with other start-ups, which can deter investors to invest in SSUs (de Lange, 2017; Giudici et al., 2019; Mansouri and Momtaz, 2022; Martin and Moser, 2016). This makes it more difficult to attract capital. de Lange (2017) indeed finds that investors tend to avoid SSUs. Furthermore, Polzin and Sanders (2020) identify a shortage of venture capital for SSUs. However, recently several capital investment funds dedicated to sustainable investments have been established all over the world and particularly in Europe (Lin, 2022), as a result there is an increasing availability of capital for SSUs (Mansouri and Momtaz, 2022). This might reduce the impact of this particular constraint.

The second constraint faced by SSUs is that they operate in imperfect or failing markets (Hoogendoorn et al., 2019; Pinkse and Groot, 2015). SSUs offer solutions that reduce the negative externalities of existing products or services (Cohen and Winn, 2007). Reducing negative externalities creates public value that is often insufficiently accounted for in the prices of goods or services (Cohen and Winn, 2007; Dean and McMullen, 2007; Vedula et al., 2022). As a result, SSUs struggle to capture the value they create. Moreover, many prospective users often do not have the means to buy the goods or services that SSUs offer (Mair and Marti, 2006; Tiba et al., 2020). This makes it more difficult to sell their product or service.

Third, SSUs are often institutionally constrained (Hoogendoorn et al., 2019); their products or services do not always comply to market regulations, standards, norms, habits, or cognitive frames (Smink et al., 2015; Steinz et al., 2015). This makes it harder to get the product or service on the market and/or to subsequently sell it.

Fourth, SSUs are often founded with a combination of economic and environmental aspirations (Austin et al., 2006; Hechavarría et al., 2017; Hörisch et al., 2017). As a result, SSUs are hybrid organizations that focus both on developing a business and on solving environmental problems (McMullen and Warnick, 2016; Munoz and Cohen, 2018; Stubbs, 2017). The environmental entrepreneurship literature highlights the potential synergies between these goals and argues that these two goals might be considered a win-win (Cohen and Winn, 2007; Dean and McMullen, 2007; Vedula et al., 2022). However, empirical studies show that these two motivations do not always align and SSUs therefore experience tension in balancing these goals (Austin et al., 2006; Jolink and Niesten, 2015; Leendertse et al., 2021; Stubbs, 2017). These challenges mean that SSUs can benefit more from the support provided by an EE or support services therein (van Rijnsoever, 2022).

7.2.2 Generic and specific entrepreneurial ecosystems

The entrepreneurial ecosystem (EE) framework outlines the conditions that influence the presence of productive entrepreneurship in a particular region, city, or country (Stam, 2015; Wurth et al., 2022). In the EE, the focus is placed on the entrepreneurial actor, who is influenced by its environment, the ecosystem (Wurth et al., 2022). The EE literature provides insights into the role of different factors causing the occurrence of entrepreneurship in a region. The combination and interaction between these factors make up the EE and influences the outputs, productive entrepreneurship. The outputs in turn influence the EE through downward causation and they also influence the outcomes, the overall value creation in society. Following (Leendertse et al., 2022; Stam and van de Ven, 2021; Wurth et al., 2022) we summarize the EE literature with ten elements affecting the presence of productive entrepreneurship. These elements are formal institutions, entrepreneurial culture, networks, leadership, physical infrastructure, access to financing, talent, knowledge, intermediaries, and demand. Previous empirical work has shown that a combination of these ten elements has a strong influence on the presence of productive entrepreneurship in European regions (Leendertse et al., 2022).

The elements of the EE framework have been used to explain productive entrepreneurship independent of sectors or types of entrepreneurship (Leendertse et al., 2022; Stam and van de Ven, 2021). However, recently several studies have started addressing EEs in specific sectors, such as digital (Bejjani et al., 2023), biotech (Auerswald and Dani, 2017) and fintech (Alaassar et al., 2022), or specific types of entrepreneurs, such as social entrepreneurs (Thompson et al., 2018) and creative entrepreneurs (Loots et al., 2021). These studies identify specific characteristics for EEs in certain sectors, implying that there is a difference between generic and specific EEs. The emergence of specific EEs entails that understanding how EEs foster certain types of entrepreneurs requires a further specification of the EE framework (Wurth et al., 2023).

We argue that the innovation system literature provides a theoretical backbone that can be used to help identify these specifications. Innovation systems and EEs share a conceptual history (Cooke, 2007; Spigel and Harrison, 2018). In contrast to EEs, innovation systems have been used to understand the innovative dynamics within specific sectors or specific technologies, and to identify what is needed to make these thrive (Bergek et al., 2008; Cooke, 2002; Hekkert et al., 2007; Malerba, 2002). This makes them well suited to extend the EE framework beyond its sector independent nature. Theoretically, Click or tap here to enter text.the EE can be seen as a special case of an innovation system (van Rijnsoever, 2020; van Weele et al., 2018). An innovation system consists of (1) actors that interact and exchange resources in a network under an (2) institutional regime and an (3) infrastructure (Carlsson and Stankiewicz, 1991; van Rijnsoever et al., 2015). This conceptualization is also present in the EE framework by Stam (2015). The ten individual elements of EEs are divided in two layers: resource endowments and institutional arrangements. The institutional arrangements cover both the informal (culture) and formal institutions that make up parts of the institutional regime. A closer look at the resource endowments category reveals that this covers the combination of actors (e.g. demand, leadership, intermediaries) and their resources (e.g. knowledge, finance, talent). In addition, Stam (2015) and the empirical applications of the framework (Leendertse et al., 2022; Stam and van de Ven, 2021) include infrastructure as a resource endowment through the element physical infrastructure.

We argue that an EE for a specific sector, technology domain or type of entrepreneurship would entail a combination of the generic EE framework with an additional specification for both the (1) actors and resources, and (2) institutional regime layers (Carlsson and Stankiewicz, 1991; van Rijnsoever et al., 2015). We use this general conceptualization and apply it to sustainable entrepreneurship. This is a relevant topic to explore the integration of EE and innovation system because innovation systems approaches have already been used extensively to understand sustainability (Carlsson and Stankiewicz, 1991; Hekkert et al., 2007).

7.2.3 Sustainable entrepreneurial ecosystems

Starting with Cohen (2006), researchers developed the concept of sustainable entrepreneurial ecosystems (SEEs) (Theodoraki et al., 2018; Tiba et al., 2020; Volkmann et al., 2021). The literature on SEEs aims to understand the factors that promote the presence of SSUs, and thus to help these start-ups overcome their constraints. The SEE literature is strongly based on several existing EE frameworks. For example, the pioneering case study by Cohen (2006) adapts factors that were identified by Neck et al. (2004) to sustainability. Tiba et al. (2021) on the other hand base themselves

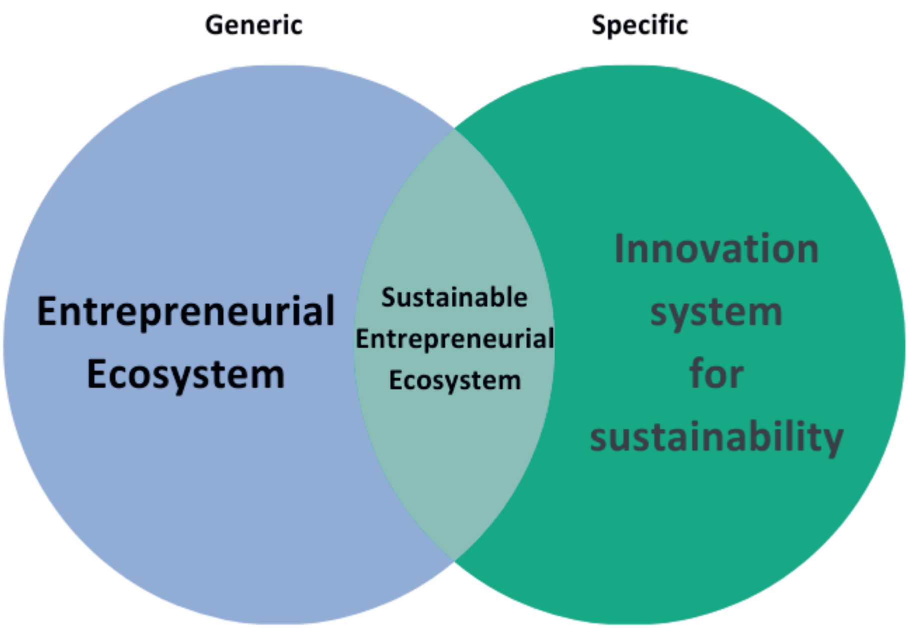

Fig. 7.1. Sustainable Entrepreneurial Ecosystems as an example of combining a generic EE with a specific innovation system.

This allows us to derive factors that promote SSUs from outside the extant EE-literature that can be categorized in the two layers of the EE. We present our conceptual framework for SEEs (Fig. 7.2) that extends the EE framework of Stam (2015). The framework shows the ten original EE elements of Stam (2015), which are combined as the quality of Entrepreneurial Ecosystems, graphically depicted as the blue box, combined with a sustainability specification for the two layers of EEs these make up the SEE, depicted as the green box.

In the next paragraphs we develop four hypotheses on how the SEE influences the presence of SSUs in a region. The occurrence of start-ups or SSUs in a region can be measured as either the presence or the prevalence. We define the presence of SSUs as the absolute number of SSUs present in a region. The prevalence is the number of HGFs in a region relative to the population of firms (e.g. Coad and Srhoj, 2023) or the human population (e.g. Leendertse et al., 2022). In this study we focus on the presence of SSUs as the societal impact is driven by the absolute number.

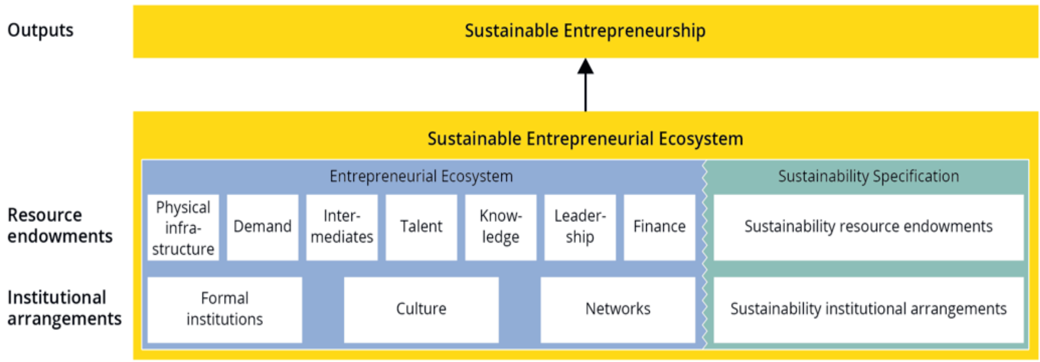

Fig. 7.2. Conceptual framework for Sustainable Entrepreneurial Ecosystems

7.2.3.1 Regular Emtrepreneural ecosystems

The EE framework outlines the conditions that influence the presence of productive entrepreneurship in a region (Stam, 2015; Wurth et al., 2022). Start-ups benefit from a supportive EE because this helps them overcome constraints and develop into new businesses (Leendertse et al., 2022). SSUs face additional financial, market and institutional constraints (Hoogendoorn, 2016; Leendertse et al., 2021) and have to balance economic and environmental aspirations (Hechavarría et al., 2017; Hörisch et al., 2017). As a result, the products or services of SSUs are more difficult to implement and have higher risks compared with other start-ups, which can deter investors from investing in SSUs (de Lange, 2017; Giudici et al., 2019; Martin and Moser, 2016). These additional constraints mean that SSUs have a larger need for the support provided by an EE or support services therein (van Rijnsoever, 2022). A well-functioning generic EE can, even more so than for regular start-ups, partially help SSUs to overcome these constraints. We thus expect that SSUs benefit from a supportive EE and hypothesize that:

H1: (a) The quality of the generic EE has a positive influence on the presence of SSUs in a region, and (b) this influence is larger than the positive influence of the quality of the generic EE on regular start-ups

7.2.3.2 Fellow start-ups

The prime actors in most EEs are entrepreneurs within their start-up businesses (Stam, 2015). Fellow start-ups in the ecosystem can help SSUs in several ways. An important function of fellow start-ups is that they often encounter similar challenges and help each other by exchanging knowledge (van Weele et al., 2018). Furthermore, start-ups have been argued to fulfil an important function in connecting fellow start-ups to relevant sources of capital, such as investors (van Rijnsoever, 2020).

Becoming embedded in the financial network is particularly important for SSUs due to the financial constraints that they face (Evans, 2018; Leendertse et al., 2021; van Rijnsoever, 2022). A similar argument holds for non-financial resources. Start-ups often help each other find relevant resources, such as potential employees, and relevant support services. Due to the constraints faced by SSUs, they are likely to be more dependent on the network functions provided by other start-ups than their non-SSU peers (van Rijnsoever, 2022). This would mean that the presence of other start-ups has a positive influence on the presence of SSUs. We therefore argue:

H2: The number of start-ups in region has a positive influence on the presence of SSUs in a region.

7.2.3.3 Sustainability Specification – Resource Endowments

The combination of sustainability actors and resources forms the sustainability specification for the resource endowments layer of an SEE. The SEE contains non-start-up actors that influence the success of SSUs, such a universities, incumbent firms, governments, consumers, investors, and incubators (DiVito and Ingen-Housz, 2021). They can help SSUs overcome their constraints, by supplying resources, or connecting them to other relevant public or private partners who in turn can provide the SSU with resources (Clarysse et al., 2014; van Rijnsoever, 2022). Actors and resources are thereby closely intertwined in the EE, as actors are in possession of resources for start-ups. The (prospective) exchanging of resources, such as knowledge, reputation or investments for future rents, shares or goods, is an important driver of relationships between SSUs and other actors. For SSUs, actors and resources with a specific focus on sustainability are extra important (DiVito and Ingen-Housz, 2021). The presence of these sustainability-oriented actors helps these start-ups gain access to markets (ibid). First, by connecting them with the networks of these established actors and second, these actors can function as direct clients. Thereby they can help SSUs overcome their market constraints. Furthermore, these sustainability-oriented actors can provide SSUs with access to resources under their control. Giudici et al. (2019) indeed find that the presence of sustainability patents, a resource, owned by actors located in a region has a positive influence on the presence of SSUs in that region. We therefore hypothesize that:

H3: The presence of sustainability-oriented actors and resources has a positive influence on the presence of SSUs in a region.

7.2.3.4 Sustainability Specification -Institutional Arrangements

The innovation system approach further outlines that actors operate under an institutional regime, which is a semi-coherent set of rules that guide actors' behavior (Kemp, 1994). The regime is continuously reproduced by the actors that adhere to these rules (Geels, 2004; Geels and Schot, 2007). In line with the innovation systems literature, we make the distinction between formal and informal institutions (Douglass, 1990; Edquist and Johnson, 1997; Scott, 2008). Both types of institutions are part of the institutional regime and together form the sustainability specification of the institutional arrangements in an SEE. For SSUs, formal institutions can consist of favorable and unfavorable policies that stimulate or hinder sustainability. Favorable policies can be subsidy schemes or regulations that promote the use of sustainable technologies while unfavorable policies can be tax benefits for existing technologies or regulations that prevent the use of sustainable technologies. Such policies can help SSUs overcome the constraints that they have compared to regular start-ups.

Informal institutions are the norms or values about sustainability, such as the importance that a regional population gives to climate change. Hoogendoorn et al. (2019) find that the institutional regime often causes SSUs to face institutional constraints. Possible reasons are that their products or services do not comply to the market's regulations, standards, norms, habits, or cognitive frames (Smink et al., 2015; Steinz et al., 2015). It follows that the degree to which an institutional regime is favorable towards sustainability can have a positive or negative effect on the presence of SSUs in a region.

Giudici et al. (2019) also find that a high environmental awareness, which is an informal institution, in a region has a positive influence on the presence of SSUs. More favourable norms and values about sustainability in a region means more people are motivated to tackle environmental problems, which we expect to lead to more founders starting an SSU. In addition, a larger environmental awareness might increase the demand for sustainability solutions (DiVito and Ingen-Housz, 2021). This demand can also serve as a driver for entrepreneurs to establish SSUs (Boluk and Mottiar, 2014; Hörisch et al., 2017). Furthermore, this could also reduce the potential tension in balancing the environmental and economic motivations as there is more support for combining these goals. We therefore hypothesize that:

H4: The presence of favourable a) formal and b) informal institutions regarding sustainability has a positive influence on the presence of SSUs in a region.

7.3 Methodology

7.3.1 Research design

To test our hypotheses, we focus on the European context and collect data about SSUs and SEEs in 28 European countries. We follow the argumentation of Leendertse et al. (2022) that, in the European context, the most relevant spatial level of analysis for EEs is between the municipal and national level. They argue that the spatial reaches of the different EE elements are most likely to coincide with regional boundaries (e.g. the daily urban system, a 50-mile radius, for talent).

We use 273 NUTS-2 regions over the 27 EU member states and the United Kingdom in our analyses as we do not consider 7 Spanish and French regions located outside of Europe and merge two London regions (UKI3 and UKI4) as it was impossible to distinguish between them for our dependent variable. The boundaries of these NUTS-2 regions are based on existing administrative boundaries and population thresholds (European Commission, 2018). We use a lag of several years between our dependent (2017-2021) and independent (2013-2019) variables.

7.3.2 Sample and data collection

We collect data from a variety of different sources. First, to identify the number of SSUs and regular start-ups, we use Crunchbase, which contains the most comprehensive start-up database available at the European level. From Crunchbase we downloaded the names, locations, websites, industries, short descriptions, and some additional data. We downloaded the Crunchbase data on the 6th of July 2022 using academic access. To identify SSUs we used information for 46,741 start-up firms which are founded in the last 5 full years of the data (2017-2021). To identify the regular start-ups we used 48,681 start-ups founded between 2015-2017 to ensure a lag with the dependent variable.

Second, for the quality of the EE, we use the data collected by Leendertse et al. (2022) who composed a set of comparable metrics to measure the quality of EEs in European regions using the ten elements by Stam (2015). The data used to construct this metric is mainly recorded between 2013 and 2019. Third, for our sustainability-oriented actors and resources variable, we use the CORDIS and PATSTAT databases. The CORDIS database contains data on which actors are a member of public-private consortia that are subsidized as part of the Horizon 2020 program of the European Union (CORDIS, 2022; European Commission, 2022). CORDIS contains data on 15,005 public-private consortia that are subsidized as part of the Horizon 2020 program of the European Union between 2014-2017 (CORDIS, 2022; European Commission, 2022). From the PATSTAT database we selected patents with priority year 2013-2017, as the priority year is closest to the actual development of the patent.

PATSTAT contains information about 293,005 patents filed during this timeframe. Fifth, for our formal institutions variable, we use OECD data on the environmental tax revenues. This data contains the share of the total taxes that comes from environmental taxes between 2013-2017. Sixth, for our informal institutions variable, we use data from the European Social Survey 8, conducted in 2016. There is microdata available on the NUTS-2 level but contains data on 211 instead of 273 regions as several countries didn't participate in the 8th wave of the European Social Survey. Finally, we use Eurostat to collect data on our control variables. We perform a series of robustness tests in which we use slightly different timeframes for the dependent and independent variables. Our findings remain robust when using these alternative timeframes.

7.3.3 Dependent variable

To determine in which region the start-ups are located we use geocoding followed by region allocation. This process looks as follows. First, we use the tmap package in R to geocode the given locations using OpenStreetMap (OpenStreetMap, 2022; Tennekes, 2018). This is an online map that allows users to pass a list of locations into the software and obtain their coordinates. We geocode the location data provided by Crunchbase. This process results in a clear location match for 95% of the regions. For the regions, and embedded start-ups, without a consistent match in this procedure, we manually check their coordinates using Google Maps (Google Maps, 2022). Subsequently, we use Eurostat shapefiles to determine in which NUTS-2 region these coordinates are located. These shapefiles contain an exact overview of the NUTS-2 boundaries (Eurostat, 2022). We then use the rgdal package in R to assign the coordinates to the corresponding NUTS-2 region (Bivand et al., 2019; Eurostat, 2022). We then count the number of start-ups in each NUTS-2 region.

Next, we determine which of these start-ups are SSUs. For this we combine two data sources. First, Crunchbase, which provides short descriptions that describe the core business of each start-up. These descriptions come with the limitation that they are only 24 words on average[1]. To obtain a larger amount of text, and to better identify whether start-ups are SSUs, we used the Internet Archive, which is available at https://archive.org. This allowed us to retrieve archived webpages of the start-ups. The Internet Archive is the largest public Web Archive, and it regularly archives all the websites available on the internet (Ainsworth et al., 2011; AlNoamany et al., 2014). We use the Internet Archive rather than the actual websites because not all start-ups are still in business. We download the webpages using the Wayback CDX Server API and collect all unique webpages available in the first 5 years after the founding of a start-up.[2] We download only those webpages with html content available. This results in a total of 22 million webpages. Given the size of the gathered data, we cap each website domain, which represents a start-up, at the ten webpages with the shortest URL. We use the URL length as a proxy for the level of a webpage within that website (Dean, 2022; Google, 2022). This is based on the hierarchical structure of websites and the assumption that http://www.start-up.com/product is closer to the home page, and thus more relevant, than www.start-up.com/product/new-release. This results in 353,036 webpages for 43,585 start-ups founded between 2017-2021. We were thus able

1 We explored using the 'Sustainability' category present in Crunchbase to define SSUs. However, testing against a manual sample revealed that this categorization was not a good predictor of SSUs.

2 More information on the webscraping is available at https://github.com/UtrechtUniversity/ia-webscraping

to find website data for 93% of the start-ups in our sample. We then extract the text from these web pages for our analyses. On average our dataset includes 8 webpages for each website and these pages contain 816 words. Around 60% of these websites have English text, others are written in different languages. Similar to Tiba et al. (2021), we use the Detectlanguage and Googletranslate functions from Google Sheets to identify the language of each webpage and subsequently translate it to English.

Next, we employ a thesaurus-based approach to determine whether a start-up claims to be actively working on environmental sustainability. A thesaurus approach utilizes a set of search terms that are used to determine whether a document matches a particular topic. Romero Goyeneche et al. (2022) successfully employ this method in determining whether publications cover the Sustainable Development Goals (SDGs). As a first step to identify a thesaurus, we manually coded a sample of 100 start-ups on whether they could be considered as environmentally sustainable. After careful study of the results we found that each of the environmental SSUs belonged to at least one of the following SDGs: SDG 6, 7, 11, 12, 13, 14, and 15. We thus found that a subset of the SDGs functioned as a credible operationalization of environmental sustainability and decided to build on the thesaurus created by Romero Goyeneche et al. (2022). This thesaurus is specifically built for use on publications (Romero Goyeneche et al., 2022, 2021) and has also been applied to the websites of large international organizations (Bogers et al., 2022).

When testing the thesaurus on two random samples of 100 environmental SSUs and 100 non-environmental SSUs we found that there were still a significant number of false positives (start-ups falsely considered to be environmentally sustainable) and false negatives (environmentally SSUs not identified as such). Hence, we went through these samples to identify the cause of these false matches. We then adjusted the thesaurus accordingly, hereby ensuring that the thesaurus worked for start-ups. The final thesaurus contains 953 combinations of keywords that should occur consecutively e.g. 'Renewable Energy', should both be present in a text e.g. 'Climate & Insulation' or a combination of both e.g. 'Life Cycle & Ecological'. We then use a search function in R to count the number of times a keyword combination occurs in the website and Crunchbase text for each start-up. The full thesaurus is available upon request to the authors.

We conceptualize environmental sustainability as explicitly mentioning the search terms associated with the aforementioned subset of SDGs. To control for the size of the text on a particular website we look at the number of matches per 100 words. This is to prevent that longer website texts lead to more identified SSUs. An example of why this step is necessary is the website of a recruiting company that lists many job postings, one of which addressed environmental sustainability. We identify a start-up as an SSU if it exceeds a cut-off of 1 match per 100 words in either the Crunchbase or the website text.

This cut-off value was derived based on manual evaluation of the start-ups surrounding the cut-off. The chosen cut-off reflected SSUs for which environmental sustainability was a central component to their business most closely. To verify the thesaurus and the chosen cut-off we then manually coded a final random sample of 500 start-ups, a little over 1% of our data, to test the effectiveness of the thesaurus. We find that the thesaurus had an accuracy of 97.2% in identifying environmental SSUs.

We perform robustness check using both a harsher and more lenient cut-off values. With a cut-off value of 1 match per 50 words we identify 4.4% of start-ups as SSUs and with a more lenient cut-off value of 1 match per 200 words we identify 8.2% of all start-ups as SSUs. The resulting measures for the presence (and inherently also the prevalence) of SSUs per region have correlations above 0.96. Our final results remained highly similar, showing that our analyses is robust for the specific cut-off value. The main method had the highest accuracy in defining SSUs while the accuracy of all robustness tests was over 95%.

As a result, we know which of the 46,714 European start-ups are actively claiming to be working on environmental sustainability in their business. In total we have 2,877 SSUs and they account for 6.2% of all start-ups. This percentage is in line with earlier studies who find that environmental SSUs make up between 1 and 14% of the start-up population (Giudici et al., 2019; Tiba, 2020). We use this data to construct our dependent variables, the presence of SSUs in each region. We define this as the absolute number of SSUs founded in a region between 2017-2021.

7.3.4 Independent variables

A full overview of the independent variables and their empirical indicators is shown in Table 7.1. We record most of the independent variables between 2013-2017, creating a time lag with our dependent variable, which is recorded from 2017-2021.

7.3.4.1 Generic entrepreneurial ecosystems

Leendertse et al. (2022) composed a set of comparable metrics to measure the quality of EEs in European regions using the ten elements by Stam (2015). They combine data from various sources to construct a metric for each of the ten elements of EEs. We follow Leendertse et al. (2022) in their operationalization of these elements. A description, the empirical indicators, the data sources, and the timeframes used to operationalize each element, as well as how the elements are combined in an index is provided in Appendix F.

7.3.4.2 Fellow start-ups

As fellow start-ups, we use the absolute number of start-ups in each region (regular and SSUs), which is obtained after the geocoding of the start-ups from Crunchbase. In total we identify 48,681 start-ups founded from 2015-2017. The start-ups founded in this period can thus support SSUs founded in the future, between 2017-2021.

7.3.4.3 Sustainability Specification – Resource Endowments

To measure the degree to which actors in a region are sustainability oriented we look at the number of times actors in the region are participating in public-private partnerships focused on contributing to environmental sustainability. We use the thesaurus and geocoding approach outlined in section 3.3 to determine the number of public-private consortia on environmental sustainability in each region. As our measure we look at the number of partner-project pairs present in one region, in total our data includes 27,514 occurrences of regional actors participating in environmentally sustainable public-private consortia. We perform two additional robustness tests for this measure. First, we look only at the number of unique sustainable projects in which a regional actor is involved, this measure has a correlation over 0.99 with our selected measure. Second, we only look at the number of unique actors that are involved in public private consortia, ignoring the number of projects these actors are involved in. This measure has a correlation higher than 0.95 with our measure. Both measures do not alter our results.

We operationalize the presence of favorable resources as the absolute number of patents on environmental technologies in a region. Patents have been used to represent the technological impact and market value of technologies (Debackere et al., 1999; Verhoeven et al., 2016) as well as knowledge (Breschi and Lissoni, 2004) present in a region, making this a fitting operationalization of sustainability resources. We use the absolute number of environmental technology patents, as evidenced by patents filed in the Y02 class taken from the Cooperative Patent Classification (CPC) table. The Y02 class identifies patents relating to inventions or technologies for mitigation or adaptation against global climate change and has been widely adopted by researchers (Hille et al., 2020; Veefkind et al., 2012). In total, there are 33,025 Y02 patents filed. We then calculate the favorability of the actors and resources towards sustainability by first standardizing the individual measures. We then construct a variable, by calculating the average of the standardized indicators. The created variable has a Cronbach's alpha of 0.796.

7.3.4.4 Sustainability Specification – Institutional Arrangements

For the formal institutions we look at the strength of tax regulations regarding environmental sustainability. We operationalize formal institutions through the degree to which existing regulations penalize negative impacts on the environment. In particular, the share of total tax revenues that comes from environmental taxes. We calculate our measure as the average of the five years between 2013-2017, thereby aligning the timeframe with our other independent variables. This data source is only available at the country level, and we therefore use the country scores for each individual region.

To measure the informal institutions, we consider the importance that citizens of a region give to addressing climate change. We use five questions from the 8th wave of the European Social Survey that focus particularly on the perceptions of citizens on the seriousness and impact of climate change or about feelings of being personally responsible. An overview of these five questions is provided in Appendix F. We use all responses of citizens in a region to calculate the average regional score to the answer for each question. The Cronbach's alpha between the five individual questions is 0.773. We therefore construct one overall variable based on the average of the five questions. To ensure that each question has a proportionate influence on the constructed variable we first standardize the individual measures.

Table 7.1. Operationalization of the independent variables

Elements	Description	Empirical indicators	Data source	Year
Entrepreneurial Ecosystem quality	The quality of the regional entrepreneurial ecosystem.	EEI score based on the ten Entrepreneurial Ecosystem elements.	Leendertse et al. (2022)	2013-2019
Fellow start-ups	The number of start-ups in a region.	The absolute number of start-ups in a region.	Crunchbase	2015-2017
Sustainability Resource Endowments	The degree to which regional actors are actively participating in public-private partnerships focused on environmental sustainability.	The absolute number of Horizon2020 projects that are about environmental sustainability.	CORDIS	2013-2017
	The degree to which actors in the region already produce knowledge on environmental technologies.	The absolute number of patents on environmental technology as evidenced by patents filed in the Y02 class.	PATSTAT	2013-2017
Sustainability Formal Institutions	The degree to which taxing environmental damage is implemented as part of the tax system.	The share of tax revenues which comes in through environmental taxes.	Eurostat	2013-2017
Sustainability Informal institutions	The degree to which environmental sustainability is important to citizens.	The degree to which citizens indicate that they are worried about the consequences of climate change.	European Social Survey S8	2016

Table 7.2. Correlation matrix.

		mean	S.D.	1	2	3	4	5	6	7
1	Presence of SSUs	10.538	32.975							
2	EE index	8.934	6.462	0.468						
3	Fellow start-ups	178.319	520.896	0.984	0.646					
4	Sustainability Resource Endowments	0.000	1.823	0.530	0.449	0.540				
5	Sustainability Formal Institutions	6.992	1.666	-0.011	-0.180	0.019	-0.136			
6	Sustainability Informal Institutions	-0.003	3.626	0.094	0.055	0.074	0.227	-0.512		
7	Population (per 10,000 inhabitants)	185.427	151.471	0.349	0.088	0.366	0.636	-0.140	0.271	
8	GRP	96.401	35.697	0.307	0.691	0.311	0.430	-0.325	0.178	0.118

7.3.5 Control variables

We use two control variables. First, we control for the size of the region through the population as measured by the total number of inhabitants. We use the average population between 2013-2017 per 10,000 inhabitants. Second, we control for the wealth of each region through the Gross Regional Product (GRP) per capita, for which we use the standardized average between 2015-2017 as present in the RCI.

7.3.6 Analysis

Table 7.2 shows the mean, standard deviation, and the correlation matrix of the variables used in our research. To test our hypotheses, we fitted a series of (mostly) negative binomial regression models in the R-program (R Core Team, 2023). This is the appropriate model for our dependent variable, which is an overdispersed count variable. First, we fitted a model with only the control variables. We tested hypothesis 1a, by adding the EE index as predictor to the model. With hypothesis 1b, we test whether SSUs profit more from the quality of an EE than their regular counterparts. To do so we use the prevalence of SSUs, defined as the share of start-ups in a region that are SSUs. This measure is also used by Tiba et al. (2021). If EE quality has a significant effect on the prevalence of SSUs we can confirm that EE quality is more important for SSUs than for regular start-ups. We perform the analysis for hypothesis 1b through beta regression models, because they allow modelling dependent variables with a value between 0 and 1 (Ferrari and Cribari-Neto, 2004). We tested hypothesis 2 and 3 by adding the number of start-ups in a region and the sustainability-oriented actors and resources variable in two separate models to the model with the control variables and EE index. This follows our argumentation that the additional components of an SEE function on top of the quality of the generic EE. We test hypothesis 4a and b in a similar manner using the sustainability formal and informal institutions variables. Finally, we fit a model with all independent and control variables included. We use the Conditional R^2 to report the performance of our models and for each of the analyses we verified that the variance inflation factors are below the recommended value of 5.

7.4 Results

7.4.1 Descriptive results

Fig. 7.3 shows a map with the presence of SSUs per region and Fig. 7.4 gives an overview of the ten regions with the highest presence of SSUs. We find that Inner London has the most SSUs followed by Berlin, Île-de-France (Paris), and the Dutch regions Noord-Holland and Zuid-Holland. In general, we see that the regions with the highest presence of SSUs are also regions that have been identified as regions with strong entrepreneurial ecosystems (Leendertse et al., 2022). Looking at the remainder

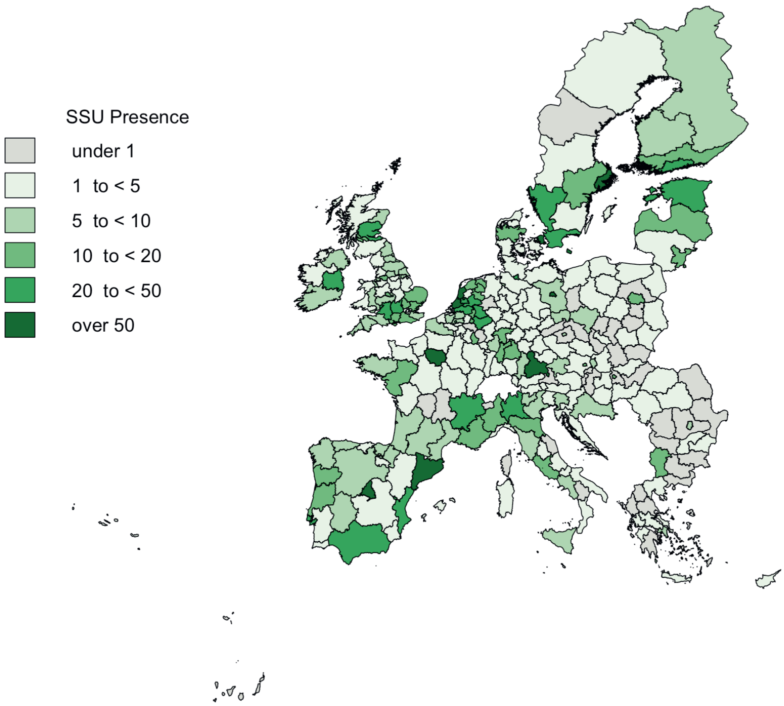

Fig. 7.3. The presence of environmentally sustainable start-ups per region in Europe

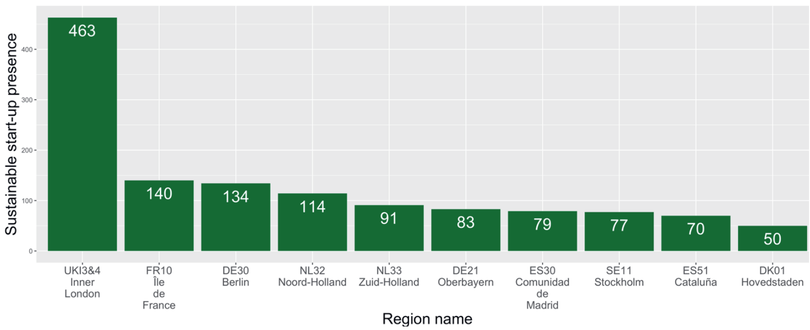

Fig. 7.4. The ten European regions with the highest number of environmentally sustainable start-ups

Table 7.3. SSUs over time for all European regions

	2017	2018	2019	2020	2021
The share of start-ups that are environmentally sustainable start-ups	5.2%	5.7%	6.6%	7.3%	9.0%

7.4.2 Regression analyses

Table 7.4 displays the results of the negative binomial regression models. The conditional R^2 values vary between 0.524 for the control model and 0.703 for the full model, which indicates that our models predict the presence of SSUs relatively well.

The variance inflation factors all remained below 4, which means there is no substantial multicollinearity. In model 2, we find a significant positive relationship between the EE index and the presence of SSUs. This provides support for H1a, there is a positive influence of the quality of an EE on the presence of SSUs. Moreover, the EE index adds more than 10% of explained variance to model 2 in comparison to model 1. This shows that the quality of generic EEs is important to SSUs. In the beta-regression analysis to test H1b (Table 7.5), we find that EE quality has a positive significant effect on the prevalence of SSUs, defined as the share of start-ups in a region. This shows that, in line with our arguments, the quality of an EE is more important for SSUs than for regular start-ups.

In models 3-7 we add the other SEE variables to model 2. This leads to a moderate, and significant improvement in the Conditional R^2, with a value of 0.703 in the full model (7). In model 3 we find that fellow start-ups have a positive and significant effect on the presence of SSUs, which supports H2. This indicates that SSUs benefit from peer effects. In line with H3, we find that regions with sustainability-oriented actors and resources present in the region have a higher presence of SSUs. SSUs thus benefit from these sustainability-oriented resource endowments they control. In line with H4a, we find that sustainability formal institutions (model 5) have a positive significant effect on the presence of SSUs in a region.

The effects of H1a, H2, H3, and H4a remain significant in the full model that includes all independent and control variables (model 7), this adds to the robustness of our findings regarding these hypotheses. Although the sustainability-oriented resource endowments is only significant at the 10% level. A possible explanation for the weaker significance of sustainability-oriented resource endowments in model 7 is that this model over 60 less observations than the previous models. This is due to missing values for our sustainability informal institutions variable. To exclude this explanation, we run an additional model which includes all variables except for informal institutions (Appendix: Table F3). This analysis gives similar results, except for the sustainability-oriented resource endowments variable which is not significant in this robustness test. This alternative explanation does thus not explain our findings.

Regarding sustainability informal institutions (H4b) we do not find a significant effect on the presence of SSUs in model 6 but we do find a significant effect in the full model 7, albeit only at the 10% level. Thereby, we are unable to fully confirm the finding of Giudici et al. (2019) that a high environmental awareness in a region has a positive influence on the presence of SSUs. Our negative result could be the result of the attitude behavior gap (Ajzen and Fishbein, 2000). The environmental concerns of citizens do not always translate into the behavior that creates market demand for the products and services of SSUs (see Boluk and Mottiar, 2014; Hörisch et al., 2017). However, the absence of a significant effect for these models could also be due to missing values for several countries. Another potential explanation for the weaker significance of the effect of sustainability-oriented resource endowments and sustainability informal institutions on the presence of SSUs in the full model is that these influences are explained by the presence of sustainability formal institutions.

We perform an additional robustness test in which we run a multilevel model that includes a random intercept for countries. The main results are similar to those of our main analyses and the conditional R^2 of the multilevel models are higher than those of the main models. The biggest difference is that the sustainability resource endowments (H3) and informal institutions variables (H4a) are not significant in the multilevel models (Appendix: Table F4). The country-specific effects explain away the effect of these variables. This likely means that there is insufficient variation of these two variables across regions within a country. It does not mean that there is no effect from these variables, but we need to be careful with interpreting them as regional phenomena.

Of the control variables, population has a positive significant effect on the presence of SSUs in all models, while GRP is only significant in models 1, 3, and 5. This loss of significance has no further consequence for our hypotheses.

Table 7.4. Negative binomial regression results.

	Dependent variable:						
	Sustainable start-up presence						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Entrepreneurial Ecosystem index		0.118*** (0.011)	0.081*** (0.012)	0.109*** (0.012)	0.116*** (0.011)	0.141*** (0.013)	0.095*** (0.014)
Fellow start-ups			0.001*** (0.000)				0.000*** (0.000)
Sustainability Resource Endowments				0.087* (0.042)			0.072[a] (0.040)
Sustainability Formal institutions					0.152*** (0.035)		0.175*** (0.051)

Sustainability Informal institutions						-0.005 (0.019)	0.035[a] (0.020)
Population (per 10,000 inhabitants)	0.005*** (0.000)	0.004*** (0.000)	0.003*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.000*** (0.000)
GRP	0.022*** (0.002)	0.004[a] (0.002)	0.005* (0.002)	0.003 (0.002)	-0.006** (0.002)	-0.003 (0.003)	-0.001 (0.003)
Constant	-1.289*** (0.214)	-0.653*** (0.182)	-0.370* (0.177)	-0.433. (0.229)	-1.974*** (0.350)	-0.207 (0.233)	-1.034* (0.429)
Observations	273	272	272	272	272	210	210
Conditional R^2	0.524	0.638	0.682	0.646	0.669	0.649	0.703
Log Likelihood	-772.793	-722.162	-711.305	-721.240	-712.536	-721.240	-705.672
Note:							a p<0.1; *p<0.05; **p<0.01; ***p<0.001

We use the r.squaredGLMM function of the MuMIn package (Bartoń, 2023) to calculate the conditional ^{R2} . This measure includes a penalty for the number of fixed effects included in the model.

Overall, we find that the quality of the entrepreneurial ecosystem, the presence of fellow start-ups and the presence of sustainability formal institutions have a strong influence on the presence of SSUs in a region. We find full support that aligns with H1a, H1b, H2, and H4a. We find partial support for H3 and H4b. A clear evaluation of the combined influence of sustainability-oriented resource endowments and institutions on the presence of SSUs in regions requires further research.

Table 7.5. Beta regression models to predict the prevalence of SSUs

	Dependent variable:	
	Sustainable start-up prevalence	
	(1)	(2)
Entrepreneurial Ecosystem index		0.030** (0.011)
Population	0.000* (0.000)	0.000[a] (0.000)
GRP	0.007*** (0.001)	0.004[a] (0.002)

Constant	-3.519***	-3.420***
	(0.174)	(0.176)
Observations	273	272
McFadden R^2	0.072	0.090
Log Likelihood	508.797	510.260
Note:	a p<0.1; *p<0.05; **p<0.01; ***p<0.001	

7.5 Discussion

7.5.1 Conclusions and theoretical implications

In this paper we answered the question: What is the influence of the generic and specific elements of sustainable entrepreneurial ecosystems on the presence of sustainable start-ups? We conceptualized an SEE as combination of the existing EE framework of Stam (2015), which we consider the generic EE and a sustainability specification. Specifically, we use the (1) actors and resources, and (2) institutional regime concepts to structure the SEE and propose two additional layers that influence sustainable entrepreneurship on top of the quality of the generic EE. In doing so we conceptualize an SEE as both embedded in the generic EE and extended to include a sustainability specification along the two layers of EEs. As such, we developed a novel conceptual framework that represents the SEE as a specific EE. We find that the quality of the generic EE is most important for the presence of SSUs as it explains the most variance. The presence of fellow start-ups then explains an additional share of the variance in SSU presence, as does adding the specific sustainability EE elements to the model. This is evidence for the validity of our conceptual model.

Our first result is that the quality of a regular EE has a strong positive influence on the presence of SSUs and on the prevalence of SSUs, which supports the notion that the quality of an EE is more important for SSUs than for regular start-ups. This aligns with the expectations that, because SSUs encounter additional financial, market and institutional constraints (Hoogendoorn et al., 2019; Leendertse et al., 2021; van Rijnsoever, 2022) and must balance economic and environmental aspirations (Hechavarría et al., 2017; Hörisch et al., 2017) they benefit more from a supportive EE than their regular counterparts. Second, we find that the presence of fellow start-ups, and to a certain extent also sustainability-oriented resource endowments, have a positive influence on the presence of SSUs in the future. This supports our expectations that fellow start-ups can help SSUs overcome their constraints by exchanging knowledge (van Weele et al., 2018) and by connecting them to relevant networks, resources (van Rijnsoever, 2022) and markets (DiVito and Ingen-Housz, 2021). Third, we find that the presence of sustainability formal institutions has a clear positive influence on the presence of SSUs, this is in line with our expectation that weaker institutional constraints are important for SSUs (Hoogendoorn et al., 2019; Steinz et al., 2015). We find limited evidence for the effect of sustainability informal institutions on the presence of SSUs. It is possible that this could be the result of the attitude behavior gap (Ajzen and Fishbein, 2000), environmental concerns of citizens do not always translate into the behavior that creates market demand for the products and services of SSUs (see Boluk and Mottiar, 2014; Hörisch et al., 2017).

Overall, this paper makes two core contributions to the literature. First, we show that a specific EE can be conceptualized at the nexus between the generic EE and a specific innovation system. In doing so our research contributes to the debate on generic versus specific EEs. We propose a way to structure future work that aims to extend the EE literature beyond its sector-agnostic origins (Stam and van de Ven, 2021). Second, we apply these insights to the SEE literature and empirically test our conceptual framework for SEEs. This is a relevant application because sustainable entrepreneurs are one type of entrepreneur for which such a specification is likely to be necessary. This is due to the fact that sustainable entrepreneurs have different motivations and encounter additional market and institutional challenges in comparison to regular entrepreneurs (Gibbs, 2006; Hart, 2006; Leendertse et al., 2021; Linnanen, 2002; Tiba et al., 2021). However, a systematic evaluation of which generic and specific EE components influence the presence of SSUs, and thus should be included in the SEE framework, is lacking (Theodoraki et al., 2018; Volkmann et al., 2021). We addressed this research gap. We show that both generic EE and specific SEE elements are important for the presence of SSUs.

7.5.2 Limitations and further research

Our research comes with several limitations. First of all, the use of text data to determine whether organizations are working on environmental sustainability runs the risk of greenwashing. This is a serious issue as identifying SSUs on a large scale remains a huge challenge. Other studies have found success in using text data (Horne et al., 2020; Leendertse et al., 2021; Tiba et al., 2021) but it is important to remain critical to the limitations. While this limitation is important, its impact on our work is likely limited, as we do not look at individual start-ups but at the entire region. As of now there is no evidence to expect different levels of greenwashing in different regions. Nevertheless, we encourage research on measuring the actual environmental input. In that context, it is worth to keep an eye on new EU regulations requiring more environmental reporting. In the same context, the emergence of Artificial Intelligence might provide opportunities to better identify which start-ups address sustainability and how close sustainability is to the core business of these start-ups. Second, we follow previous studies in using the NUTS-2 level to measure EEs (Leendertse et al., 2022; Stam and van de Ven, 2021). However, there is still an ongoing debate about the most appropriate scale to consider EEs. In a recent study Coad and Srhoj (2023) utilize the more fine-grained NUTS-3 level. As such, the jury is still out on the most appropriate scale to study EEs. The chosen scale is thus a potential limitation of our study. Future research on the different geographical scales for (S)EEs can shed more insight on this. Third, to further model a causal relation between our independent and dependent variables could have employed a panel based econometric approach. However, the required longitudinal data on the inputs of EEs is not yet systematically available (Leendertse et al., 2022). We argue that the impact of this limitation is relatively limited due to two reasons. First, we partially account for the influence of reverse causality by using a time lag between our independent and dependent variables. Nevertheless, a longitudinal research approach would further validate our findings and is an important next step in (S)EE research (Leendertse et al., 2022). Second, as discussed by Coad and Srhoj (2023), many of the components of generic EEs are relatively stable over time which means that our findings on the relation between EE elements and SSUs are not likely to be influenced by fast changing conditions in EEs. Fourth, in our study we focus specifically on those SSUs that address environmental sustainability. There is still a need to study whether the SEE framework that we developed also applies for those SSUs focused on the social dimensions of sustainability or other sectors, such as health, biotech, or fintech. This is an area for future research.

In addition, we recommend future research to identify additional factors of SEEs within this structure, and to differentiate these towards the various technological and sector fields that SEEs are active in. Further, we only explained the presence of SSUs in a region. Future research could study how the SEE elements influence the success of SSUs.

7.5.3 Practical implications

Policy makers can use our results to develop policies that help build ecosystems for sustainable entrepreneurship in their region. In line with our results, policy makers with this aim could strive to improve both the generic EE and a sustainability specification. We argue that a first step is to focus on building a strong generic entrepreneurial ecosystem. As the quality of entrepreneurial ecosystems is more important for SSUs than their regular counterparts. In addition, we find that a higher number of regular start-ups likely leads to more SSUs in the future. This is likely due to the fact that regular start-ups fulfil an important network function that constrained start-ups, such as SSUs, profit from (van Rijnsoever, 2022).

In addition, we show that a favorable SEE also has sustainability specifications. We find the strongest influence for the presence of sustainability-oriented formal institutions. This indicates that policy makers can have a strong influence on SSUs by implementing favorable regulations, such as environmental taxes. Furthermore, the presence of sustainability-oriented resource endowments in the form of patents and public-private partnerships on sustainability can have a positive influence on SSUs. Facilitating a supportive environment for these actors thus also has positive effects on SSUs. These actors can provide SSUs with access to markets, resources, and thereby help them overcome the constraints they face, but we need more evidence for this relationship.

8.

Discussions

8.1 Main findings

In the introduction I outlined that the topic of ecosystems for sustainable entrepreneurship has great theoretical and practical relevance. The theoretical relevance is linked to the fact that sustainable start-ups are influenced by different causal mechanisms than their regular counterparts. Sustainable start-ups are constrained in several ways, and this causes them to encounter additional challenges in founding their business and in maintaining a healthy business performance compared to regular start-ups. The practical relevance is linked to the potential of sustainable start-ups to contribute to addressing societal challenges, a promise that can only be fulfilled if they are able to overcome their constraints.

I identified four constraints. First, many technology-based sustainable start-ups are constrained because they require more investment capital than other types of start-ups (Evans, 2018). Second, sustainable start-ups operate in imperfect or failing markets (Hoogendoorn et al., 2019; Pinkse and Groot, 2015). Third, sustainable start-ups are often institutionally constrained (Hoogendoorn et al., 2019). Fourth, sustainable start-ups are hybrid organizations that must balance economic and environmental aspirations (Hechavarría et al., 2017; Hörisch et al., 2017; McMullen and Warnick, 2016; Munoz and Cohen, 2018).

In this dissertation I studied how these constraints influence sustainable start-ups and what can be done to help sustainable start-ups overcome these constraints. The constraints are caused by a combination of internal and external factors. Balancing environmental and economic aspirations is mostly an internal constraint. While the access to finance, the market, and the institutional constraints are mostly external. The dominance of external constraints leads to the overall research question of my dissertation: *How do entrepreneurial ecosystems influence the presence of sustainable start-ups?*

I find that the ecosystem for sustainable start-ups, the sustainable entrepreneurial ecosystem, has a strong influence on the presence of sustainable start-ups. The sustainable entrepreneurial ecosystem is nested in the generic entrepreneurial ecosystem but contains specific elements that are of additional importance, sustainability institutional arrangements and sustainability resource endowments. This shows how the sustainable entrepreneurial ecosystem are part of and nested in the generic entrepreneurial ecosystem.

In addition, I find evidence that sustainability resource endowments and institutional arrangements have a positive influence on the presence of sustainable start-ups in the future. This is evidence that the sustainable entrepreneurial ecosystem has specific elements that build on top of the entrepreneurial ecosystem.

8.2 Summary of empirical findings

In my dissertation I employed the sustainable entrepreneurial ecosystem framework, as an extension of the entrepreneurial ecosystem framework, to identify how contextual factors influence sustainable start-ups. However, there are several research questions that needed to be addressed before this framework could be used to study the main research question.

First, I addressed research questions regarding the generic entrepreneurial ecosystem framework that are needed to study the main research question (chapters 2-5). Second, I addressed the research questions that specifically relate to sustainable start-ups and the sustainable entrepreneurial ecosystem framework (chapters 6 and 7).

In chapter 2 my colleagues and I addressed two research questions regarding the generic entrepreneurial ecosystem framework. First, at the time of writing there was no large-scale operationalization of the entrepreneurial ecosystem framework. I provided such an operationalization. This chapter thus provides an answer to the research question *How can we operationalize the elements of entrepreneurial ecosystems?* This chapter brings together a wide variety of data sources and shows a viable way to operationalize the ten elements of entrepreneurial ecosystems. This operationalization then enables the next step in entrepreneurial ecosystem research. That is to quantitatively test the relation between the inputs and outputs of entrepreneurial ecosystem. I answered the research question *How do the elements of entrepreneurial ecosystems influence the presence of start-ups?* I showed that the inputs of the entrepreneurial ecosystem framework have a strong relation with the outputs that holds using a wide variety of robustness tests. Furthermore, I presented evidence that this relation is non-linear. The relation between inputs and outputs is stronger in high-quality entrepreneurial ecosystems.

In chapter 3 my colleagues and I engaged with a recent debate on the persistence of high-growth firms. The entrepreneurial ecosystem framework rests on the assumption that there is persistence of high-growth firms because regional entrepreneurial ecosystem conditions are relatively stable. In recent work Coad & Srhoj (2023) question the validity of the entrepreneurial ecosystem framework based on a lack of persistence of high-growth firms, a proxy for productive entrepreneurship, at the regional level in Croatia and Slovenia. This critique leads to the research question: *Is there regional persistence of productive entrepreneurship?* We outlined three hypotheses on the mechanism between entrepreneurial ecosystems and their outputs and provided empirical evidence for these mechanisms. We find that there is persistence in the prevalence of productive entrepreneurship in the Netherlands (using several proxies) and in Europe. Based on these findings we argue that the interpretation and generalization by Coad & Shroj (2023) are incorrect. We find differential persistence in the prevalence of productive entrepreneurship in high- and low-quality entrepreneurial ecosystems and use this to further articulate the entrepreneurial ecosystem framework. We conclude that only high-quality entrepreneurial ecosystems and entrepreneurial ecosystems of sufficient size consistently produce high-growth firms.

In chapter 4 my colleagues and I engaged with another recent debate in the entrepreneurial ecosystem literature, the boundaries of entrepreneurial ecosystem. Recently, several authors (e.g. Fischer et al., 2022; Schäfer, 2021) question the relevance of regional boundaries. They critique existing research that pre-defines the spatial boundaries of an entrepreneurial ecosystem as coinciding with administrative borders (Cobben et al., 2022; Schäfer, 2021; Wurth et al., 2022). An approach that my colleagues and I also followed in chapters 2, 3, and chapter 7. In chapter 4, we studied whether the use of regional boundaries is a sensible approach by asking entrepreneurial ecosystem actors how they perceive the boundaries of their ecosystem. We find that regional, administrative boundaries play an important role in the perception of entrepreneurial ecosystem actors. In particular, because several entrepreneurial ecosystem actors dynamically enact boundaries of the entrepreneurial ecosystem that coincide with the boundaries of the administrative units.

Furthermore, in chapters 4 and 5 I address the lack of research on how start-ups can overcome the constraints faced in the *resource endowments and institutional arrangements* layers of the entrepreneurial ecosystems. I address how start-ups can get access to resources from outside their entrepreneurial ecosystem (chapter 4) and discuss how entrepreneurial support organizations can change the institutions in an entrepreneurial ecosystem (chapter 5).

In chapter 4 my colleagues and I build on the discussion of boundaries by looking at the interactions across the boundaries of entrepreneurial ecosystem. The current use of boundaries in entrepreneurial ecosystem research entails the often-implicit assumption that start-ups only acquire resources from actors located within their own entrepreneurial ecosystem. This lead to the research question: *What drives and hinders interactions across the boundaries of entrepreneurial ecosystems?* We find that entrepreneurs interact across entrepreneurial ecosystem boundaries to get access to resources and sometimes even to more favorable institutions. We find interactions related to all ten entrepreneurial ecosystem elements. The access to resources is a more frequent driver of interactions than the access to institutions. Furthermore, we find that the ability of actors to engage in cross-entrepreneurial ecosystem interactions is influenced by two logics. The start-up development logic, which does allow for interactions, and the regional development logic that often prevents interactions as it causes actors to transform administrative boundaries into entrepreneurial ecosystem boundaries.

In chapter 5 my colleagues and I focused on the institutional arrangements layer of the entrepreneurial ecosystem. I established that institutional constraints are an important barrier for sustainable start-ups. In addition, chapter 4 showed that the regional development logics, a form of institutions, can prevent start-ups from cross-entrepreneurial ecosystem interactions. These institutional constraints could be reduced by actors who engage in institutional entrepreneurship, the process of creating new or changing existing institutions (Battilana et al., 2009; DiMaggio, 1988; Dorado, 2005; Gurses and Ozcan, 2015). In this chapter we studied how and when incubators change institutions in the entrepreneurial ecosystem: *How do public and private entrepreneurial support organizations differ in the strategies that they use to change or create normative, regulative and cultural-cognitive institutions in different institutional contexts?* We find that incubators act as institutional entrepreneurs to change the institutions of the entrepreneurial ecosystem. We find that public incubators in so-called transparent ecosystems are most active as institutional entrepreneurs, highlighting a special role for this type of entrepreneurial support organization.

These four chapters laid the groundwork for part two of this dissertation and for answering the main research question. In Chapter 6 my colleagues and I moved from the entrepreneurial ecosystem to the individual sustainable start-ups. This chapter takes a micro-perspective by looking at the performance of sustainable start-ups and in this we addressed the following research question: *What is the influence of the technology characteristics of sustainable start-ups on their business and climate performance?* We find that achieving climate performance and business performance simultaneously is not straightforward as both require different strategies. This creates a paradox. We find that start-ups using novel and hardware-based technologies may partly escape the paradox and that having high climate ambitions partly alleviates the negative impact of hardware technologies on business performance.

In chapter 7 my colleagues and I bring together the perspectives and insights of the studies on entrepreneurial ecosystems and on sustainable start-ups. We combined innovation systems and entrepreneurial ecosystem literature to argue the elements of an ecosystem for sustainable entrepreneurship, a sustainable entrepreneurial ecosystem. We then tested if the resulting framework indeed predicts the presence of sustainable start-ups. In doing so we answered the following research question. *What is the influence of the generic and specific elements of sustainable entrepreneurial ecosystems on the presence of sustainable start-ups?* The answer is that the quality of the generic entrepreneurial ecosystem has a strong positive influence on the presence and prevalence of sustainable start-ups. The quality of a generic entrepreneurial ecosystem is important for the presence of sustainable start-ups, even more so than for their regular counterparts. Furthermore, we find that the presence of sustainable start-ups is positively influenced by the presence of fellow (regular) start-ups, the presence of sustainability-oriented formal institutions, and to some extend sustainability-oriented resource endowments and sustainability-oriented informal institutions. We conclude that the sustainable entrepreneurial ecosystem is nested in the generic entrepreneurial ecosystem and contains specific sustainability elements that are of additional importance.

8.3 Theoretical implications

The first and foremost theoretical implication of my dissertation is the development of a sustainable entrepreneurial ecosystem framework that systematically outlines the influence of context on sustainable entrepreneurship. I conceptualize the context using the entrepreneurial ecosystem framework and show that its application to sustainable entrepreneurship requires an extended perspective, the *sustainable entrepreneurial* ecosystem framework. This framework builds on the common theoretical basis between the entrepreneurial ecosystem and the innovation system literature to identify the generic and specific elements that make up a sustainable entrepreneurial ecosystem.
Through the combination of chapters 6 and 7 I show that conventional entrepreneurial thinking is necessary but not sufficient to understand the prevalence of sustainable start-ups. In particular, because the antecedents for environmental performance are different from business performance. As a result, sustainable entrepreneurial ecosystems are crucial to help sustainable entrepreneurs overcome the constraints they face.

My findings show that sustainable entrepreneurial ecosystems should be considered as nested within generic entrepreneurial ecosystems, it can be considered a sub-ecosystem. The quality of the elements of the generic entrepreneurial ecosystem and the number of 'regular' start-ups in an entrepreneurial ecosystem both have a positive influence on the presence and prevalence of sustainable entrepreneurs. However, at the same time the sustainable entrepreneurial ecosystem extends beyond the generic entrepreneurial ecosystem. Sustainable entrepreneurs also depend on specific sustainability actors, sustainability resources, and sustainability institutions. In sum, the sustainable entrepreneurial ecosystem is simultaneously nested in the entrepreneurial ecosystem and extends beyond it to additional specific sustainability components. This framework and perspective on ecosystems for sustainable entrepreneurship provides a foundation that future research can build upon.

I propose that this perspective can be extended beyond (environmentally) sustainable entrepreneurs to other forms of entrepreneurship that encounter additional constraints, such as socially sustainable entrepreneurship and deep-tech entrepreneurship. This would mean that these types of entrepreneurs would require both the regular entrepreneurial ecosystem and specific resources and institutions. Given the societal relevance of these types of entrepreneurs future research could study the dynamics between entrepreneurial ecosystems and these types of entrepreneurs. Are the dynamics the same? What are the specific components that influence different types of constrained entrepreneurship?

In the lead up to this primary theoretical implication there are several additional implications that can be drawn based on my dissertation.
First, based on chapters 2 and 3, I provide insight in how the mechanism between the inputs and outputs of entrepreneurial ecosystem works. This mechanism is one of the five mechanisms of entrepreneurial ecosystems as described by Wurth et al. (2022). I provide the theoretical foundation for three propositions on the nature of this mechanism. First, higher quality entrepreneurial ecosystems have more productive entrepreneurship than lower quality entrepreneurial ecosystems. Second, higher quality entrepreneurial ecosystems have more persistence of productive entrepreneurship than their lower quality counterparts. Third, persistence can only be found in entrepreneurial ecosystems of sufficient size. These three propositions should be considered in future research on the mechanism between entrepreneurial ecosystem inputs and outputs.

Second, in Chapter 4 I provide evidence that administrative borders often coincide with the boundaries of entrepreneurial ecosystems. I also show that some boundaries are purely geographical and others a mix between geographical and sectoral, not all entrepreneurial ecosystem boundaries are the same. The theoretical implication is that every study on entrepreneurial ecosystems should be explicit in how and why they use certain boundaries. In this the identification of start-up development logics and regional development logics is a central point. These logics strongly influence the strength of entrepreneurial ecosystem boundaries and are an important starting point for future research on interactions across entrepreneurial ecosystem boundaries. Furthermore, these logics and their respective strength are an additional specification of the institutional arrangements layer.

In chapter 5, I build on this by showing that entrepreneurial support organizations act as institutional entrepreneurs to change the institutions in an entrepreneurial ecosystem. The capabilities of entrepreneurial support organizations to act as institutional entrepreneurs vary between different types of entrepreneurial support organizations and different types of ecosystems. I thus showed that 'institutional entrepreneurship capabilities' are another potential component of the institutional arrangements layer. Based on chapters 4 and 5 I thus argue that there is still room to improve the conceptualization of the elements of entrepreneurial ecosystems. This aligns with the discussion in chapter 2 where I provide several avenues for improvement regarding the measurements and conceptualization of the entrepreneurial ecosystem elements. The theoretical implication is that the layers, rather than the elements, should be the theoretical foundation for future entrepreneurial ecosystem research. The theoretical base for the layers is further developed than for the elements and can serve as the foundation in which theoretical and methodological improvements to the elements of entrepreneurial ecosystems can be integrated. Furthermore, using the layers as the starting point enables research on sub-entrepreneurial ecosystems that feature additional specified elements and in which specific elements are of different value. This dissertation illustrates this in chapter 7 for sustainable entrepreneurial ecosystems. Furthermore, these findings contradict the existing argument that the institutional layer of entrepreneurial ecosystems is stable (Coad and Srhoj, 2023). This shows potential for a more dynamic perspective on institutions in entrepreneurial ecosystems.

8.4 Implications for policy makers and practitioners

Only 6% of start-ups are currently addressing environmental sustainability and I find that their environmental and business performance often do not align. The findings of my dissertation thus show that the reality is still a long way away from the better future I sketched in the introduction. However, my dissertation also provides detailed analyses that can help policy makers and other practitioners take a significant step forward in the facilitation of a context that is favorable for sustainable start-ups. So how can policy makers and other practitioners use this dissertation to establish policies that help sustainable entrepreneurs overcome their constraints? How can they develop sustainable entrepreneurial ecosystems in their region?

A first step is to focus on building a stronger entrepreneurial ecosystem, sustainable entrepreneurs are even more dependent on the quality of the entrepreneurial ecosystem than regular entrepreneurs. In addition, supporting sustainability actors and resources in a region is particularly important for sustainable start-ups.

In my dissertation, I provide detailed information on the quality of (sustainable) entrepreneurial ecosystems, on the amount of sustainable start-ups currently present in each region, and on top performing regions. This allows policy makers to look not only at how their regions are doing, but also to identify and learn from other regions. It is crucial to not just try to improve the numbers but instead to use them as a starting point for data-and-dialogue-driven policy approach. Policy makers can use the data presented in my dissertation to start a dialogue with entrepreneurial ecosystem actors. Do they recognize the strong and the weak points and what are the causes? Large scale metrics provide insight into where to look for improvement, but not how this improvement should be achieved. This can only follow from in-depth analysis of each entrepreneurial ecosystem. It is thus important to combine metrics with qualitative insights about specific entrepreneurial ecosystems. We provide (sustainable) entrepreneurial ecosystem metrics that should facilitate a collective learning process that combines data and dialogue.

Based on my dissertation I identify a few points that should be considered in these analyses.First, entrepreneurial ecosystem policy makers should consider the start-up development and regional development logics. We find that regional development logics, although they make sense from a policy maker perspective, can hurt entrepreneurs. If several regions engage in this logic, it creates a suboptimal environment for entrepreneurs that also hurts the overall regional development outcomes. I thus recommend that policy makers to do two things 1) discuss logics 2) connect across entrepreneurial ecosystems. I recommend discussing the logics as my research shows that the negative results of conflicting logics is often a blind spot for policy makers. Discussing logics sheds a light on these blind spots, which enables addressing the underlying issue. Connecting across entrepreneurial ecosystems then allows for mitigating the conflicts between logics. Connections create shared goals, and this alignment might reduce the artificial competition between regions that we currently find. In particular, actors that are influenced less by regional boundaries, such as universities, entrepreneurial support organizations, or national organizations seem well suited to engage in changing these institutional logics.

This connects to a second point. I find that, especially public entrepreneurial support organizations in transparent ecosystems, act as institutional entrepreneurs. They engage in the process of changing institutions, which is an important part of improving entrepreneurial ecosystems. The institutional perspective on entrepreneurial support organizations is an important new insight to consider in debates on private versus public entrepreneurial support organizations. I recommend policy makers to take this role into account in debates on whether to fund public entrepreneurial support organizations. Furthermore, entrepreneurial support organizations who are currently not active as institutional entrepreneur can use the overview of change strategies to start acting as institutional entrepreneurs themselves. This can help address the institutional barriers that influence cross-entrepreneurial ecosystem interactions and help sustainable start-ups overcome the institutional barriers that they face.

Third, to help sustainable entrepreneurs it is crucial to create an environment in which sustainable start-ups can sell their product. This includes governments acting as a direct customer but extends to creating more favorable regulations, and strong networks that allow sustainable start-ups to find potential customers. Addressing these issues helps sustainable start-ups balance their environmental & economic aspirations, to overcome market constraints and to lessen institutional constraints.

8.5 Limitations and future research

The entrepreneurial ecosystem framework is still in development and as a result there is room for improvement regarding both theoretical development and empirics. My dissertation has addressed several of these areas but there are others that still require future work.

First, the operationalization of the entrepreneurial ecosystem framework (chapter 2) and the resulting quantitative analyses (chapters 2, 3, and 7) are a major step forward. However, the next step is to go from identifying correlations to causations, from capturing and analyzing pictures to videos (i.e. long term evolution). This requires longitudinal research. Chapter 3 does take a longitudinal perspective on the outputs of entrepreneurial ecosystems but not yet on the inputs. This need for longitudinal work is a next step to build on several chapters. Chapters 2 and 3 can be built upon to study the causation in entrepreneurial ecosystems. Chapter 6 can be built upon to study the performance of different technology types in sustainable start-ups over time, e.g. does hardware take longer but will it catch up in the long run? And chapter 7 can be built upon to establish causal relations for sustainable entrepreneurial ecosystems.

Second, in my dissertation I very much focus on the influence of entrepreneurial ecosystems on the presence of (sustainable) entrepreneurship. This limitation applies to chapters 2,3, and 7. Future research should move from presence to performance. Particularly the influence of these entrepreneurs on the environmental, social, and economic performance of the societal level. In my dissertation, I address performance in chapter 6, using a micro-perspective on individual firms. However, I do not yet include performance in the studies on the influence of the context, the sustainable entrepreneurial ecosystem. Doing so is a relevant next step for future research.

Furthermore, the promise of entrepreneurial ecosystems and their influence on productive entrepreneurship is that they can contribute to 'aggregate well-being outcomes'. A more systematically inclusion of different types of environmental, social, and economic performance as the outcomes of entrepreneurial ecosystems is needed to fulfil this promise. Improved measures for the societal outcomes is a crucial step that will enable this type of research.

Third, the metrics behind the quantitative analyses can still be improved. I want to reinforce the call for better metrics that I make in several chapters. I, based on chapters

2 and 7, recommend future work on the elements of entrepreneurial ecosystems to start with the 'networks' element as the metrics for this element are perhaps the least well developed. Using newly available data and techniques, such as web scraping, should enable the development of better metrics for networks. These could even include different types of networks. Furthermore, better operationalizations of networks can also help to understand how different network characteristics influence entrepreneurs and to better understand the boundaries of entrepreneurial ecosystems. This dissertation also shows the relevance of regional development and start-up development institutional logics (chapter 4) as well as institutional entrepreneurship capabilities (chapter 5) in entrepreneurial ecosystems. As such, a further specification of the institutional arrangements layer also seems a worthwhile endeavor.

Fourth, and related, future research should dive more into the combination of elements. How do different combinations influence productive entrepreneurship and sustainable entrepreneurship? It remains an outstanding debate whether all components are necessary or whether some can act as substitutes. This applies to chapters 2,3, and 7. Other scholars (e.g. Schrijvers et al., 2023) have started to embark on this research avenue using QCA (Qualitative Comparative Analysis). However, the existing studies tend to give a plethora of solutions that are not yet able to really provide a clear picture. Additional research in this direction is needed and as proposed by Chiu and Xu (2023) decision tree models might be a promising alternative to QCAs.

Fifth, the entrepreneurial ecosystem concept finds roots in ecology and ecological ecosystems literature provides insight in a variety of concepts such as quality, diversity, and resilience that are important for healthy ecosystems (Acs et al., 2017; O'Connor and Audretsch, 2023). My dissertation and the existing literature really focus on the quality of entrepreneurial ecosystems. However, taking the natural ecosystem metaphor seriously there is a need for much more work on resilience and diversity in the context of entrepreneurial ecosystems (O'Connor and Audretsch, 2023; Roundy et al., 2017). These are not just theoretical endeavors but also have practical value. Many ecosystem builders are currently discussing that there needs to be 'focus' and specialization. This assumption is in line with findings on industrial clusters (Delgado et al., 2010; Rocha, 2004; Rocha and Sternberg, 2005). However, there is no empiric evidence that this is the best strategy for productive entrepreneurship. It is thus urgent to start addressing resilience and diversity.

Sixth, sustainable entrepreneurship (and social, deep-tech etc.) comes with the challenge of how to identify whether and to what extent a start-up is really sustainable. The correct categorization of these types of start-ups is a difficult endeavor that requires careful navigation (Delmestri et al., 2020). In my dissertation I show two feasible approaches in chapters 6 and 7. In chapter 6 I use a subjective assessment that gives

more depth, and in chapter 7 I use large scale text-mining that enables studying many cases. Both methods have an inherent risk of greenwashing and while we do not find widespread greenwashing (e.g. 6% of start-ups met our criteria on environmentally sustainability) this is a relevant avenue in future research.
Seventh, the concept of entrepreneurship is theoretically not limited to new businesses or start-ups. Entrepreneurship supposedly also includes intrapreneurship, entrepreneurship by employees at large firms (Stam, 2015, 2013). However, this is not the reality in entrepreneurial ecosystem research. This limitation in the general literature is also very much present in every chapter of my dissertation, in which start-ups and entrepreneurship can be used almost interchangeably. Perhaps this is due to the difficulties in measuring intrapreneurship (Gawke et al., 2019) and the additional box, the firm, that needs to be unpacked. Nevertheless, future research is needed on the differences in entrepreneurial ecosystems for intrapreneurship versus start-ups.

Finally, to further develop the understanding on how sustainable entrepreneurial ecosystems can help entrepreneurs address societal challenges it can be linked to the Multi-Level Perspective (MLP) framework. The MLP is the dominant framework in transition studies. The central premise in the transitions literature entails a disruption of the incumbent socio-technical system and eventual replacement by or merge with an alternative, newly developed socio-technical system(s), which often emerge from so-called niche systems (Geels, 2005). However, entrepreneurship is theoretically underdeveloped in transition studies (Long et al., 2019). The sustainable entrepreneurial ecosystem framework is not a transition perspective by itself. Yet, it can be used to help unpack the black box that entrepreneurship still is in transition research. Research that conceptualizes the sustainable entrepreneurial ecosystem as a specific type of niche is a promising avenue.

8.6 Epilogue

Currently, it is a rainy November in 2023 in Utrecht, the Netherlands. I am finishing up my dissertation and reflecting on the questions that I asked myself during that sunny May in 2017 Talinn, Estonia. Since then, I set out to better understand how context influences sustainable start-ups and in my dissertation I answer many of the questions that plagued me at that time.

I found out that for start-ups technology indeed matters, but differently for business and environmental performance. I found out that the country, and even the region, that sustainable start-ups come from matters, and I found out how it matters. Based on the answers provided in my dissertation I provide policy makers with new insights to improve the regional conditions for sustainable start-ups, which enables them to help start-ups achieve a better future.

Yet, sitting at home I now wonder about a new set of questions: How can we ensure that sustainable start-ups actually have a positive influence on society? How can we increase the performance of sustainable start-ups? How can we help them overcome the paradox between different performance dimensions? How can we improve the regional conditions to get more sustainable start-ups? And are we really providing the right recommendations based on our analyses?

I ended my preface by saying that I hoped my dissertation would spark your interest in the influence of context on sustainable entrepreneurship and answers many of the questions that come along with this interest. Building on this I want to end the epilogue with the hope that this dissertation inspires you to join me in studying and answering this next wave of questions to better understand and to better support sustainable entrepreneurs.

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Appendix
Appendix A: Appendices to chapter 2

Table A1. Description of indicator data sources

Table A1. Description of indicator data sources

Element	Indicators	Measurement and description	Source	Geographical level	Year
Formal institutions	Quality of Governance indicators for Corruption, Impartiality, and Quality and accountability	Average of z-score for the three indicators (Corruption, Impartiality, and Quality and accountability) based on survey answers	Quality of Government Index	NUTS 2 NUTS 1 for BE, DE, EL, SE, and UK Country for IE and LT	2017
Formal institutions	Ease of doing business index	Index based on several dimensions: starting a business, dealing with permits, registering property, credit access, protecting investors, taxes, trade, contract enforcement and closing a business	World Bank Doing Business Report	Country	2015
Entrepreneurship culture	Entrepreneurial motivation	Percentage of early stage entrepreneurs motivated by a desire to improve their income or a desire for independence	Global Entrepreneurship Monitor	Country	2014
Entrepreneurship culture	Cultural and social norms	The extent to which social and cultural norms encourage or allow actions leading to new business methods or activities that can potentially increase personal wealth and income. Rating: 1=highly insufficient, 5=highly sufficient	Global Entrepreneurship Monitor	Country	2014
Entrepreneurship culture	Innovative and creative	Percentage of respondents that agree to: it is important to think of new ideas and be creative	European Social Survey	NUTS 2 NUTS 1 for DE, UK Missing for FRM0, ITF2, LU00, MT00, PT20, PT30	2008 - 2016
Entrepreneurship culture	Trust	Survey question on scale 0-1: Most people can be trusted	European Social Survey	NUTS 2 NUTS 1 for DE, UK Missing for FRM0, ITF2, LU00, MT00, PT20, PT30	2008 - 2016
Entrepreneurship culture robustness	Birth of new firms	Number of new firms per capita	Eurostat, OECD, and national statistics offices	NUTS 2 NUTS 1 for DE and UK Country for EL	2010-2016
Networks	Innovative SMEs collaborating with others	Percentage of innovative SMEs in SME business population collaborating with others	RIS & EIS (for countries which are a NUTS 2 region) (also available in RCI)	NUTS 2 NUTS 1 for BE, UK, FR, and AT	2016
Physical Infrastructure	Accessibility via road	Population accessible within 1h30 by road, as share of the population in a neighborhood of 120 km radius	DG Regio (RCI)	NUTS 2	2016
Physical Infrastructure	Accessibility via rail	Population accessible within 1h30 by rail (using optimal connections), as share of the population in a neighborhood of 120 km radius	DG Regio (RCI)	NUTS 2	2014
Physical Infrastructure	Number of passenger flights	Daily number of passenger flights accessible in 90 min drive	Eurostat / Eurogeographics /	NUTS 2	2016

			National Statistical Institutes (RCI)		
Physical Infrastructure	Household access to internet	Percentage of households with access to internet	Eurostat (RCI)	NUTS 2	2018
Finance	Venture capital	The average amount of venture capital for the last five years per capita	Invest Europe	NUTS 2	2014-2019
Finance	Credit constrained SMEs	Percentage of SMEs that is credit constrained because they either were rejected for loans or received less or were discouraged to apply because it was too expensive or they expected to be turned down.	Investment Survey European Investment Bank	Country	2018
Leadership	The presence of actors taking a leadership role in the ecosystem	The number of coordinators on H2020 innovation projects per capita	CORDIS (Community Research and Development Information Service)	NUTS 2	2014-2019
Talent	Tertiary education	Percentage of total population that completed tertiary education	Eurostat	NUTS 2 NUTS 1 for BE, DE, and UK	2013
Talent	Lifelong learning	Percentage of population aged 25-64 participating in education and training	Eurostat	NUTS 2 NUTS 1 for BE, DE, and UK	2013
Talent	Business and entrepreneurship education	The extent to which training in creating or managing SMEs is incorporated within the education and training system The extent to which training in creating or managing SMEs is incorporated within the education and training system. Rating: 1=highly insufficient, 5=highly sufficient	Global Entrepreneurship Monitor	Country	2014
Talent	E-skills	Percentage of individuals in active population with high levels of e-skills	Eurostat	Country	2014
New knowledge	R&D expenditure	Intramural R&D expenditure as percentage of Gross Regional Product	Eurostat	NUTS 2	2015
Demand	Disposable income per capita	Net adjusted disposable household income in PPCS per capita (index EU average=100)	Eurostat	NUTS 2	2014
Demand	Potential market size in GRP	Index GRP PPS (EU population-weighted average=100)	Eurostat	NUTS 2	2016
Demand	Potential market size in population	Index population (EU average=100)	Eurostat	NUTS 2	2018
Intermediate services	Incubators	Percentage of incubators in total business population	Own data	NUTS 2	2019
Intermediate services	Knowledge intensive services	Percentage employment in knowledge-intensive market services	Eurostat	NUTS 2	2018
Productive entrepreneurship	Innovative new firms	Number of new firms registered in Crunchbase in the last five years per capita	Crunchbase	NUTS 2	2019
Productive entrepreneurship	High-value new firms (unicorns)	Absolute number of entrepreneurial firms valued above $1 billion founded in the last ten years	CB Insights & Dealroom	NUTS 2	2019

Table A2. Piecewise regression results of the additive and logarithmic index on the Dealroom output variable

	Dealroom output	
	(1)	(2)
EE index additive	0.057***	
	(0.015)	
Difference slope EE index additive	0.163*** (0.031)	
EE index log		0.042***
		(0.010)
Difference slope EE index log		0.544*** (0.099)
Constant	0.239***	0.980***
	(0.079)	(0.136)
Observations	272	272
R2	0.447	0.477
Adjusted R2	0.441	0.472
F Statistic	72.262***(df=3;268)	81.605***(df=3;268)

Notes: Clustered standard errors at country level in parentheses.

** p<0.05 ** p<0.01 *** p<0.001*

Table A3. Correlation table

	Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate	EE index add	EE index log	Crunchbase output
Culture	0.781****												
Networks	0.606****	0.457****											
Physical infrastructure	0.623****	0.596****	0.520****										
Finance	0.684****	0.657****	0.531****	0.761****									
Leadership	0.302****	0.329****	0.390****	0.461****	0.420****								
Talent	0.809****	0.693****	0.686****	0.586****	0.677****	0.455****							
Knowledge	0.463****	0.465****	0.406****	0.565****	0.633****	0.581****	0.452****						
Demand	0.469****	0.453****	0.439****	0.842****	0.661****	0.345****	0.348****	0.572****					
Intermediate	0.319****	0.359****	0.445****	0.592****	0.493****	0.653****	0.480****	0.441****	0.447****				
EE index add	0.796****	0.755****	0.729****	0.832****	0.836****	0.625****	0.802****	0.676****	0.699****	0.675****			
EE index log	0.801****	0.751****	0.709****	0.859****	0.856****	0.624****	0.805****	0.710****	0.736****	0.676****	0.985****		
Crunchbase output	0.461****	0.402****	0.469****	0.551****	0.497****	0.742****	0.617****	0.462****	0.359****	0.782****	0.696****	0.695****	
Unicorn output	0.170**	0.214***	0.127*	0.307****	0.364****	0.363****	0.269****	0.205****	0.258****	0.370****	0.351****	0.362****	0.401****

Note: *p<0.05; **p<0.01; ***p<0.001; ****p<0.0001

Fig. A1. Pairwise scatter plot of output and index with clusters of regions

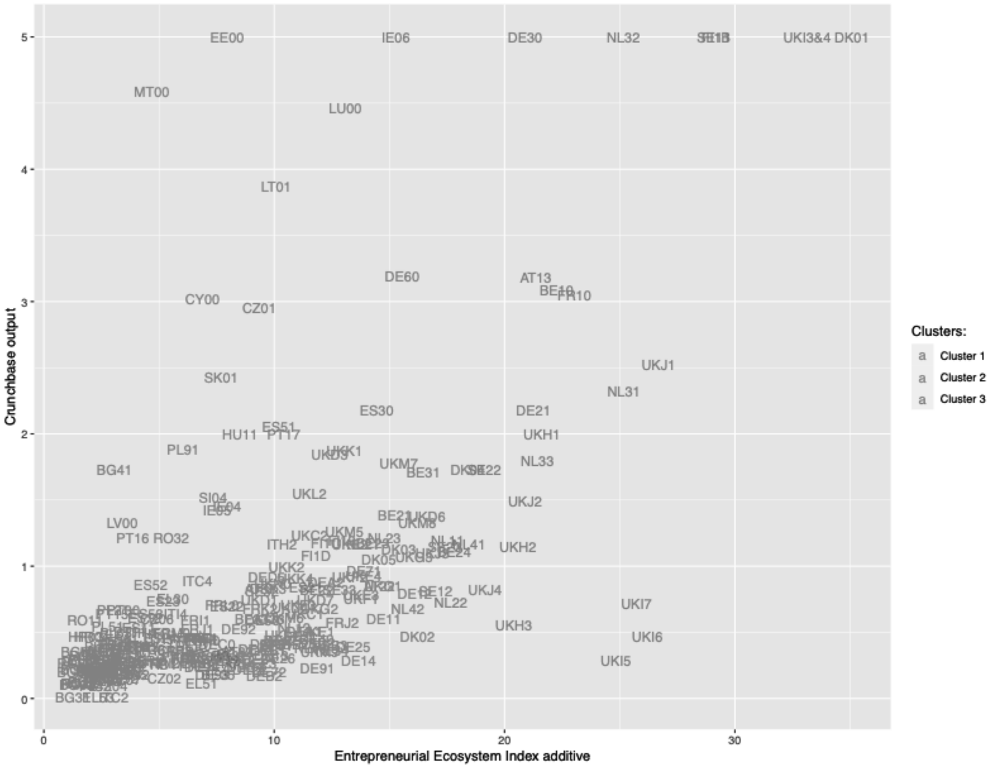

Table A4. Regression results of the additive and logarithmic index on the Crunchbase output variable including non-linear effects

	Crunchbase output			
	(1)	(2)	(3)	(4)
EE index additive	0.097***	0.013		
	(0.013)	(0.025)		
EE index additive squared		0.003***		
		(0.001)		
EE index logarithmic			0.076***	0.148***
			(0.009)	(0.024)
EE index logarithmic squared				0.006***
				(0.001)
Observations	272	272	272	272
R^2	0.378	0.415	0.283	0.385
Adjusted R^2	0.376	0.410	0.280	0.380
F Statistic	164.043*** (df = 1; 270)	95.339*** (df = 2; 269)	106.371*** (df = 1; 270)	84.062*** (df = 2; 269)

*Notes: Clustered standard errors at country level in parentheses. * p<0.05 ** p<0.01 *** p<0.001*

Table A5. Regression results of the additive and logarithmic index on the unicorn output variable. This is an overdispersed count variable and hence we used a quasipoisson regression.

	Unicorn output	
	(1)	(2)
EE index additive	0.195***	
	(0.032)	
EE index logarithmic		0.358***
		(0.069)
Constant	-4.713***	-2.055***
	(0.645)	(0.393)
Observations	271	271
Dispersion parameter	0.959	0.924
R^2	0.240	0.274

Notes: Clustered standard errors at country level in parentheses.
*p<0.05; **p<0.01; ***p<0.001

Index robustness

As a first robustness test we do not execute any of the modifications outlined in section 3.16. This robustness test actually results in a higher R2 of 0.62 (Table C1). However, the results are now strongly influenced by the extreme values measured in several regions that we discussed in section 3.16. Therefore, we performed a second robustness test which follows the approach outlined in the methodology section but instead removes those regions with a value more than four standard deviations from the mean. This concerned Inner London (as a result of a high number of incubators, leadership, and Crunchbase firms), Braunschweig (as a result of the high R&D intensity) in Germany, and Hovedstaden (as a result of leadership) in Denmark (Table C2). Since we prefer not to discard observations of which the data is reliably measured, we also performed the regression with all observations after transforming the data. We transformed the data using the Tukey transformation (Tukey, 1957) for all the variables with a huge range of variation (standard deviations above 4), instead of only the output variable as we did in the main analysis (Table C3). The result of this transformation is a distribution of data which is close to a normal distribution, thus reducing the standard deviations from the variables with extreme values. Fourth, we used a categorical approach to create each of the index elements and the output by using quantiles to give each element a score from 1-10. The index then has a minimum value of 10 and maximum value of 100 (Table C4).

Furthermore, as discussed in section 4.3 we find that many of the top performing regions are regions in which a capital city is located (see Fig. 2.3). To test whether the explanatory power of our index holds after controlling for the influence of capital cities on the output variable we run the regressions with a capital city indicator added, which is a dummy variable indicating whether a region contains a capital city (no = 0, yes = 1). The results are displayed in Table C5 and indeed show that capital regions perform significantly better than non-capital regions ($p<0.001$). Nevertheless, the effect of the Entrepreneurial Ecosystem Index remains significant ($p<0.001$) and only shows a small decrease in coefficients. Next, we also performed a regression using the principal components discussed in section 4.1. This method does not build on the assumption that all ecosystem elements have equal weights and for PC1 we find highly similar outcomes as for our index (Table C6). Finally, we perform a regression in which we control for the GRP per capita, which is one of the existing measured we compared our index with in section 4.6. The results show that the regression with the index significantly outperforms the regression with only the GRP (Table C7). It is important to note that the GRP of a region is already included in our measure for demand. Nevertheless, it is only a small part of our index measure and we considered it important to test the robustness of our index when we control for economic development. In sum, the findings of all seven robustness tests are consistent with those presented in the main analysis, indicating the robustness of our chosen approach of calculating our index.

Table A6. Regression with no transformation of extreme values

	Crunchbase output	
	(1)	(2)
EE index additive	0.525***	
	(0.065)	
EE index logarithmic		0.504***
		(0.100)
Constant	-4.240***	6.636***
	(0.577)	(1.175)
Observations	272	272
R^2	0.619	0.049
Adjusted R^2	0.619	0.045
F Statistic	438.82*** (df = 1; 270)	13.85*** (df = 1; 270)

Notes: Clustered standard errors at country level in parentheses.
*p<0.05; **p<0.01; ***p<0.001

Table A7. Regression excluding observations with extreme values

	Crunchbase output	
	(1)	(2)
EE index additive	0.051***	
	(0.017)	
EE index logarithmic		0.035**
		(0.011)
Constant	-0.108	0.559***
	(0.115)	(0.119)
Observations	269	269
R^2	0.152	0.089
Adjusted R^2	0.149	0.086
F Statistic	47.77*** (df = 1; 267)	26.19*** (df = 1; 267)

Notes: Clustered standard errors at country level in parentheses.
*p<0.05; **p<0.01; ***p<0.001

Table A8. Regression including Tukey transformation to variables with extreme values

	Crunchbase output	
	(1)	(2)
EE index additive	0.096***	
	(0.004)	
EE index logarithmic		0.071***
		(0.005)
Constant	-0.066	1.210***
	(0.060)	(0.052)
Observations	272	272
R^2	0.383	0.266
Adjusted R^2	0.381	0.264
F Statistic	167.87*** (df = 1; 270)	98.03*** (df = 1; 270)

Notes: Clustered standard errors at country level in parentheses.
*p<0.05; **p<0.01; ***p<0.001

Table A9. Regression with categorical calculation of the index

	Crunchbase output
	(1)
Categorical Index	0.092***
	(0.007)
Constant	0.471
	(0.413)
Observations	272
R^2	0.477
Adjusted R^2	0.475
F Statistic	245.98*** (df = 1; 270)

Notes: Clustered standard errors at country level in parentheses.
*p<0.05; **p<0.01; ***p<0.001

Table A10.

Regression with dummies for capital cities

	Crunchbase output	
	(1)	(2)
EE index additive	0.078***	
	(0.009)	
EE index logarithmic		0.059***
		(0.006)
Capital city	0.930**	1.141***
	(0.274)	(0.283)
Constant	0.039	1.065***
	(0.100)	(0.092)
Observations	272	272
R^2	0.456	0.410
Adjusted R^2	0.452	0.406
F Statistic	112.89*** (df = 2; 269)	93.53*** (df = 2; 269)

Notes: Clustered standard errors at country level in parentheses.

*p<0.05; **p<0.01; ***p<0.001

Table A11.

Regression with principal components

	Crunchbase output		
	(1)	(2)	(3)
Principal Component 1	0.289***	0.289***	0.289***
	(0.043)	(0.025)	(0.025)
Principal Component 2		0.394***	0.394***
		(0.001)	(0.001)
Principal Component 3			0.133***
			(0.009)
Constant	0.852***	0.852***	0.852***
	(0.092)	(0.025)	(0.025)
Observations	272	272	272
R^2	0.360	0.551	0.572
Adjusted R^2	0.357	0.548	0.567
F Statistic	151.61*** (df = 1; 270)	165.122*** (df = 2; 269)	119.46*** (df = 3; 268)

Notes: Clustered standard errors at country level in parentheses.

** p<0.05 ** p<0.01 *** p<0.001*

Table A12. Regression with GRP as a control variable

	Crunchbase output		
	(1)	(2)	(3)
EE index additive		0.074***	
		(0.018)	
EE index logarithmic			0.043***
			(0.014)
GRP per capita	0.015***	0.006**	0.009***
	(0.002)	(0.004)	(0.004)
Constant	-0.607***	-0.379	0.271
	(0.181)	(0.194)	(0.356)
Observations	273	271	271
R^2	0.281	0.400	0.326
Adjusted R^2	0.279	0.396	0.321
F Statistic	106.17*** (df = 1; 271)	89.362*** (df = 2; 268)	64.81 *** (df = 2; 268)

Notes: Clustered standard errors at country level in parentheses.

*p<0.05; **p<0.01; ***p<0.001

Table A13. Data overview for all ten elements and the EE index.

NUTS2 code	Crunchbase output	Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate	EE index additive	EE index log
AT12	0.44	1.09	0.32	1.44	1.34	0.81	0.40	1.13	1.48	1.83	0.47	10.32	-1.16
AT13	3.19	1.17	0.42	1.44	1.34	3.33	5.00	2.14	1.48	1.83	3.20	21.36	5.68
AT11	0.31	1.13	0.26	1.44	0.63	1.44	0.21	0.89	0.25	1.31	0.29	7.85	-4.99
AT21	0.41	1.05	0.46	2.10	0.24	1.78	0.53	1.08	1.81	0.68	0.37	10.10	-2.18
AT22	0.85	1.11	0.34	2.10	0.36	1.82	1.33	1.01	5.00	0.81	0.69	14.57	0.66
AT31	0.83	1.08	0.28	1.55	0.50	1.26	0.34	1.05	1.86	1.10	0.39	9.41	-2.49
AT32	0.36	1.20	0.81	1.55	0.42	1.34	0.28	1.15	0.40	0.86	0.40	8.41	-3.28
AT33	0.60	1.29	0.49	1.55	0.31	1.46	0.49	1.08	1.74	0.87	0.50	9.78	-1.73
AT34	0.26	1.32	0.57	1.55	0.72	1.18	0.19	1.04	0.52	1.14	0.25	8.48	-3.53
BE10	3.09	0.35	0.25	3.19	1.61	1.87	5.00	0.74	1.89	2.36	5.00	22.26	4.22
BE24	1.11	0.61	0.35	3.19	1.61	1.37	5.00	0.54	1.89	2.36	0.89	17.81	2.78
BE31	1.71	0.41	0.43	3.19	1.61	1.33	3.28	0.44	1.89	2.36	1.54	16.48	2.47
BE21	1.39	0.61	0.42	5.00	1.96	1.37	0.52	0.54	1.84	2.36	0.63	15.24	0.95
BE22	0.82	0.61	0.32	5.00	1.07	1.37	0.25	0.54	0.35	1.97	0.37	11.85	-2.98
BE23	1.17	0.61	0.38	5.00	1.13	1.37	1.53	0.54	1.02	2.32	0.40	14.29	0.32
BE25	0.41	0.61	0.29	5.00	0.86	1.37	0.19	0.54	0.28	1.67	0.29	11.10	-4.20
BE32	0.33	0.41	0.21	2.48	0.80	1.33	0.24	0.44	0.45	1.47	0.26	8.09	-5.49
BE33	0.60	0.41	0.19	2.48	1.38	1.33	0.33	0.44	0.69	1.31	0.46	9.03	-3.85
BE34	0.32	0.41	0.16	2.48	0.53	1.33	0.19	0.44	0.21	0.79	0.42	6.97	-7.28
BE35	0.18	0.41	0.30	2.48	0.65	1.33	0.26	0.44	0.32	1.14	0.25	7.58	-5.90
BG31	0.01	0.11	0.03	0.16	0.06	0.23	0.19	0.09	0.17	0.13	0.10	1.26	-21.96
BG32	0.11	0.22	0.03	0.16	0.08	0.19	0.18	0.10	0.16	0.17	0.16	1.45	-20.66
BG33	0.36	0.18	0.04	0.16	0.12	0.17	0.20	0.12	0.14	0.14	0.25	1.51	-19.85
BG34	0.20	0.12	0.04	0.16	0.12	0.19	0.19	0.09	0.14	0.12	0.19	1.35	-20.88
BG41	1.73	0.14	0.04	0.17	0.21	0.29	0.26	0.18	0.41	0.32	1.05	3.07	-14.76
BG42	0.22	0.16	0.03	0.17	0.18	0.20	0.19	0.09	0.16	0.15	0.15	1.48	-20.24
CY00	3.03	0.23	0.19	0.79	0.46	0.51	2.31	0.34	0.16	0.25	1.66	6.89	-7.82
CZ01	2.96	0.51	0.46	0.38	0.67	1.23	0.50	0.47	1.08	0.96	3.10	9.35	-2.90
CZ02	0.16	0.40	0.31	0.38	0.67	0.58	0.23	0.26	1.08	0.96	0.36	5.23	-7.82
CZ03	0.22	0.48	0.40	0.30	0.26	0.47	0.21	0.23	0.43	0.40	0.17	3.34	-11.55
CZ04	0.09	0.33	0.27	0.31	0.28	0.47	0.18	0.19	0.14	0.55	0.18	2.90	-13.24
CZ05	0.18	0.51	0.43	0.62	0.23	0.47	0.19	0.27	0.34	0.50	0.19	3.76	-10.59
CZ06	0.60	0.56	0.32	0.30	0.33	0.58	0.29	0.30	1.36	0.49	0.38	4.91	-8.39
CZ07	0.14	0.55	0.35	0.50	0.24	0.47	0.19	0.22	0.33	0.49	0.16	3.49	-11.36
CZ08	0.27	0.48	0.30	0.40	0.33	0.56	0.19	0.23	0.30	0.61	0.18	3.58	-11.09
DE30	5.00	1.20	1.20	0.60	3.04	5.00	0.88	0.84	1.44	1.67	5.00	20.89	4.78
DE40	0.45	1.29	0.76	0.60	3.04	1.95	0.30	0.52	1.44	1.67	0.26	11.84	-1.08
DE11	0.60	1.54	1.54	0.39	1.02	1.39	0.27	0.64	5.00	2.64	0.33	14.76	-0.02
DE12	0.79	1.54	1.54	0.35	2.05	1.39	0.75	0.64	5.00	2.62	0.24	16.10	1.24
DE13	0.33	1.54	1.54	0.33	0.85	1.39	0.33	0.64	1.16	1.91	0.18	9.87	-2.53
DE14	0.29	1.54	1.54	0.43	0.56	1.39	0.32	0.64	5.00	2.07	0.17	13.66	-1.23
DE21	2.18	1.77	1.21	0.36	2.06	2.47	3.77	0.58	5.00	2.59	1.45	21.26	5.09
DE22	0.22	1.77	1.21	0.17	0.77	2.47	0.20	0.58	0.32	1.29	0.17	8.94	-5.22
DE23	0.27	1.77	1.21	0.23	0.82	2.47	0.26	0.58	0.64	1.18	0.19	9.35	-3.84
DE24	0.30	1.77	1.21	0.31	0.64	2.47	0.26	0.58	0.60	1.34	0.14	9.33	-4.03
DE25	0.40	1.77	1.21	0.31	1.37	2.47	0.37	0.58	3.29	1.74	0.32	13.43	-0.12
DE26	0.31	1.77	1.21	0.38	0.92	2.47	0.27	0.58	0.70	1.64	0.23	10.17	-2.56
DE27	0.45	1.77	1.21	0.48	1.13	2.47	0.21	0.58	0.43	1.81	0.20	10.30	-2.92
DE50	0.60	1.55	1.31	0.41	0.93	0.75	0.80	0.56	1.30	1.42	0.46	9.49	-1.52
DE60	3.19	1.68	0.92	0.29	2.18	2.94	0.53	0.74	0.79	2.70	2.79	15.56	1.92
DE71	0.97	1.53	1.40	0.35	2.73	1.28	0.31	0.61	1.82	2.72	1.14	13.89	1.04
DE72	0.20	1.53	1.40	0.40	1.31	1.28	0.23	0.61	1.06	1.74	0.22	9.78	-2.50
DE73	0.29	1.53	1.40	0.25	0.69	1.28	0.20	0.61	0.43	1.21	0.21	7.80	-5.07
DE80	0.27	1.61	0.87	0.37	0.49	0.93	0.26	0.48	0.57	0.52	0.18	6.28	-6.43
DE91	0.23	1.68	1.03	0.29	0.71	0.73	0.41	0.46	5.00	1.32	0.25	11.88	-2.51
DE92	0.53	1.68	1.03	0.52	1.03	0.73	0.26	0.46	0.93	1.57	0.24	8.45	-3.55
DE93	0.19	1.68	1.03	0.37	0.82	0.73	0.20	0.46	0.24	1.54	0.24	7.31	-5.77
DE94	0.24	1.68	1.03	0.34	0.72	0.73	0.21	0.46	0.24	1.25	0.20	6.85	-6.34

NUTS2 code	Crunchbase output	Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate	EE index additive	EE index log
DEA1	0.51	1.30	1.03	0.29	2.39	1.27	0.23	0.48	0.51	3.37	0.44	11.30	-2.32
DEA2	0.88	1.30	1.03	0.50	2.19	1.27	0.56	0.48	1.34	2.92	0.67	12.24	0.25
DEA3	0.38	1.30	1.03	0.56	1.53	1.27	0.23	0.48	0.28	2.34	0.21	9.23	-3.80
DEA4	0.34	1.30	1.03	0.39	0.94	1.27	0.22	0.48	0.56	1.89	0.20	8.28	-4.25
DEA5	0.41	1.30	1.03	0.54	1.80	1.27	0.24	0.48	0.46	2.39	0.23	9.73	-3.04
DEB1	0.37	1.58	1.28	0.34	1.56	1.77	0.19	0.52	0.19	2.11	0.21	9.74	-4.18
DEB2	0.18	1.58	1.28	0.53	0.59	1.77	0.21	0.52	1.50	1.42	0.18	9.57	-3.08
DEB3	0.40	1.58	1.28	0.36	1.90	1.77	0.33	0.52	2.15	2.27	0.27	12.42	-0.61
DEC0	0.42	1.50	0.88	0.56	0.86	0.98	0.26	0.41	0.42	1.45	0.20	7.52	-4.83
DED2	0.42	1.34	1.32	0.63	0.61	1.57	0.49	0.60	3.94	0.99	0.34	11.84	-0.87
DED4	0.24	1.34	1.32	1.34	0.57	1.57	0.21	0.60	0.52	1.11	0.16	8.74	-3.73
DED5	0.92	1.34	1.32	0.93	1.18	1.57	0.37	0.60	0.66	1.10	0.60	9.68	-1.22
DEE0	0.40	1.19	0.62	0.66	0.93	0.99	0.22	0.48	0.36	0.87	0.17	6.49	-5.96
DEF0	0.27	1.56	0.90	0.44	0.96	0.90	0.26	0.47	0.39	1.41	0.33	7.62	-4.43
DEG0	0.33	1.44	0.89	0.44	0.58	1.26	0.28	0.56	0.64	0.93	0.18	7.20	-4.96
DK01	5.00	2.98	5.00	0.63	4.68	2.11	5.00	5.00	5.00	0.90	3.78	35.08	10.58
DK02	0.47	2.81	3.48	0.60	1.18	1.88	0.28	4.76	0.29	0.58	0.36	16.22	0.03
DK03	1.13	3.01	3.90	0.74	0.56	0.44	0.40	5.00	0.60	0.42	0.35	15.40	-1.01
DK04	1.73	3.50	3.89	0.58	0.58	0.99	1.90	5.00	1.10	0.42	0.45	18.40	2.19
DK05	1.06	2.99	3.75	0.50	0.55	0.91	0.73	4.05	0.40	0.29	0.37	14.54	-1.03
EE00	5.00	0.93	0.69	0.66	0.41	1.01	1.34	1.65	0.40	0.10	0.76	7.96	-4.39
EL30	0.76	0.13	0.34	0.94	0.65	0.10	0.34	0.37	0.29	0.93	1.51	5.60	-8.87
EL41	0.31	0.11	0.48	0.64	0.19	0.05	1.56	0.23	0.20	0.03	0.35	3.85	-15.07
EL42	0.34	0.11	0.79	0.33	0.17	0.05	0.19	0.17	0.12	0.09	0.32	2.35	-17.30
EL43	0.23	0.11	0.47	1.59	0.13	0.07	0.28	0.20	0.42	0.11	0.20	3.58	-14.80
EL51	0.12	0.10	0.51	0.56	0.12	0.06	4.70	0.20	0.19	0.12	0.29	6.85	-13.58
EL52	0.32	0.10	0.27	0.63	0.18	0.12	1.20	0.25	0.22	0.27	0.31	3.57	-13.03
EL53	0.01	0.10	0.13	1.14	0.11	0.05	0.19	0.22	0.15	0.15	0.12	2.37	-18.41
EL54	0.28	0.10	0.13	0.26	0.10	0.06	0.26	0.22	0.31	0.11	0.23	1.78	-18.53
EL61	0.22	0.13	0.45	0.58	0.11	0.06	0.23	0.24	0.19	0.17	0.23	2.39	-16.18
EL62	0.30	0.13	0.14	0.43	0.17	0.05	0.20	0.17	0.16	0.09	0.21	1.75	-18.76
EL63	0.19	0.13	0.28	0.58	0.10	0.05	0.32	0.21	0.34	0.14	0.13	2.27	-16.96
EL64	0.21	0.13	0.26	0.41	0.12	0.07	0.19	0.17	0.17	0.31	0.25	2.09	-16.77
EL65	0.12	0.13	0.21	0.32	0.15	0.06	0.18	0.18	0.15	0.17	0.21	1.75	-18.16
ES11	0.53	0.33	0.29	0.40	0.35	0.77	0.29	0.68	0.23	0.35	0.43	4.13	-9.54
ES12	0.61	0.46	0.16	0.36	0.41	0.71	0.55	0.77	0.20	0.35	0.38	4.37	-9.29
ES13	0.28	0.52	0.80	0.24	0.44	0.41	0.35	0.76	0.22	0.38	0.26	4.38	-9.17
ES21	0.85	0.58	0.44	0.70	0.58	1.03	4.63	1.19	0.59	1.06	0.57	11.37	-1.56
ES22	0.70	0.54	0.45	0.35	0.42	1.67	1.90	0.99	0.45	0.64	0.53	7.94	-4.06
ES23	0.73	0.47	0.86	0.29	0.32	0.44	1.25	0.80	0.23	0.37	0.15	5.18	-8.45
ES24	0.46	0.44	0.26	0.25	1.08	0.49	0.95	0.77	0.23	0.28	0.29	5.04	-8.47
ES30	2.18	0.37	0.92	0.26	3.21	1.90	2.11	1.19	0.49	2.05	1.97	14.45	0.97
ES41	0.40	0.35	0.45	0.24	0.44	0.92	0.32	0.74	0.25	0.28	0.22	4.21	-9.77
ES42	0.18	0.35	0.41	0.25	0.75	0.67	0.20	0.57	0.17	0.31	0.18	3.85	-10.90
ES43	0.26	0.42	0.32	0.24	0.27	0.70	0.25	0.53	0.19	0.13	0.16	3.20	-12.65
ES51	2.06	0.34	0.64	0.26	1.30	2.01	2.46	0.71	0.41	0.87	1.20	10.21	-2.22
ES52	0.86	0.33	0.38	0.24	0.60	0.69	0.48	0.70	0.26	0.53	0.43	4.64	-8.30
ES53	0.65	0.31	0.37	0.13	0.62	1.43	0.23	0.52	0.14	0.32	0.38	4.45	-10.53
ES61	0.45	0.28	0.39	0.23	0.38	0.44	0.30	0.54	0.26	0.31	0.25	3.38	-11.21
ES62	0.40	0.39	0.28	0.21	0.56	0.63	0.35	0.56	0.22	0.40	0.31	3.91	-10.04
ES70	0.41	0.29	0.33	0.17	0.49	0.37	0.25	0.54	0.16	0.21	0.26	3.07	-12.55
FI19	1.20	1.88	2.86	0.95	0.41	1.27	0.52	3.13	1.42	0.17	0.33	12.94	-1.09
FI1B	5.00	2.05	3.05	0.89	1.55	3.13	5.00	5.00	2.76	0.75	5.00	29.18	8.85
FI1C	1.18	1.95	2.28	1.23	0.64	1.23	0.37	2.98	0.64	0.27	0.65	12.24	-0.62
FI1D	1.08	1.99	2.41	0.78	0.30	1.33	0.59	2.92	1.04	0.05	0.40	11.81	-2.87
FI20	0.72	3.16	2.43	NA	NA	NA	0.18	3.06	0.13	0.07	4.83	NA	NA
FR10	3.05	0.64	0.68	0.77	5.00	2.96	2.64	1.95	1.48	3.58	3.32	23.03	6.12
FRB0	0.36	0.61	0.87	0.47	0.71	0.72	0.21	1.13	0.46	0.74	0.18	6.10	-6.30
FRC1	0.37	0.57	0.66	0.47	0.41	0.54	0.21	1.10	0.25	0.49	0.20	4.90	-8.40
FRC2	0.31	0.54	1.03	0.47	0.26	0.55	0.22	1.19	1.25	0.63	0.22	6.38	-6.32

NUTS2 code	Crunchbase output	Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate	EE index additive	EE index log
FRD1	0.26	0.61	0.84	0.47	0.33	0.62	0.22	0.87	0.33	0.52	0.22	5.01	-7.99
FRD2	0.30	0.63	0.68	0.47	0.85	0.73	0.19	1.09	0.38	1.01	0.29	6.31	-5.87
FRE1	0.46	0.58	0.75	0.54	0.98	1.00	0.21	1.22	0.23	1.02	0.25	6.79	-5.64
FRE2	0.25	0.61	0.58	0.54	1.24	0.67	0.21	0.77	0.37	1.25	0.39	6.63	-5.36
FRF1	0.45	0.60	0.48	0.48	0.72	1.03	0.33	1.32	0.49	1.20	0.20	6.84	-5.28
FRF2	0.32	0.59	1.19	0.48	0.97	0.75	0.19	0.84	0.20	0.47	0.19	5.87	-7.28
FRF3	0.37	0.56	0.85	0.48	0.47	0.83	0.18	1.08	0.32	0.76	0.16	5.68	-7.32
FRG0	0.46	0.72	0.89	0.64	0.50	0.85	0.22	1.44	0.31	0.68	0.32	6.56	-5.62
FRH0	0.44	0.74	0.57	0.64	0.36	1.19	0.25	1.65	0.64	0.57	0.25	6.86	-5.42
FRI1	0.59	0.71	0.80	0.68	0.52	0.93	0.26	1.42	0.44	0.53	0.29	6.59	-5.35
FRI2	0.27	0.68	0.73	0.68	0.17	0.54	0.22	1.39	0.25	0.37	0.19	5.24	-8.66
FRI3	0.28	0.58	0.48	0.68	0.35	0.44	0.19	1.03	0.24	0.51	0.21	4.71	-8.83
FRJ1	0.53	0.53	0.76	0.57	0.53	1.08	0.22	1.26	0.92	0.51	0.30	6.67	-5.30
FRJ2	0.58	0.62	0.63	0.57	0.46	1.55	0.35	2.45	5.00	0.51	0.82	12.96	-1.26
FRK1	0.44	0.62	0.87	0.77	0.34	0.91	0.21	1.06	0.80	0.49	0.13	6.21	-6.51
FRK2	0.68	0.67	0.81	0.77	0.60	1.57	0.31	2.09	1.31	0.95	0.32	9.39	-2.31
FRL0	0.71	0.55	0.83	0.45	0.75	1.24	0.25	1.40	1.01	0.75	0.51	7.74	-3.68
FRM0	0.50	0.51	1.00	0.45	0.24	1.56	0.18	0.80	0.13	0.14	0.53	5.55	-9.00
HR03	0.47	0.16	0.07	0.22	0.22	0.12	0.21	0.15	0.14	0.12	0.42	1.82	-18.09
HR04	0.47	0.16	0.10	0.29	0.22	0.15	0.22	0.14	0.27	0.24	0.28	2.08	-16.23
HU11	2.00	0.14	0.24	0.32	0.69	0.82	0.69	0.46	0.57	0.73	3.86	8.52	-5.78
HU12	0.27	0.14	0.24	0.32	0.69	0.82	0.20	0.46	0.57	0.73	0.25	4.41	-9.78
HU21	0.36	0.18	0.16	0.22	0.34	0.50	0.22	0.24	0.24	0.46	0.14	2.71	-13.92
HU22	0.25	0.18	0.18	0.26	0.31	0.48	0.21	0.25	0.17	0.38	0.13	2.55	-14.41
HU23	0.24	0.18	0.35	0.21	0.15	0.52	0.18	0.25	0.15	0.22	0.13	2.34	-15.45
HU31	0.21	0.17	0.15	0.25	0.16	0.44	0.20	0.24	0.16	0.33	0.14	2.24	-15.65
HU32	0.36	0.16	0.16	0.18	0.14	0.60	0.20	0.26	0.28	0.26	0.12	2.35	-15.61
HU33	0.30	0.21	0.14	0.25	0.17	0.50	0.22	0.25	0.46	0.25	0.14	2.57	-14.49
IE04	1.46	1.67	1.06	0.63	0.18	1.27	1.43	0.62	0.57	0.20	0.32	7.96	-4.76
IE	1.43	1.60	1.08	0.69	0.29	0.70	0.97	0.89	0.28	0.37	0.65	7.52	-4.26
IE06	5.00	1.60	0.79	0.68	0.88	1.95	3.97	0.89	0.30	0.66	3.58	15.28	1.28
ITC1	0.49	0.17	0.34	0.39	0.80	0.37	0.38	0.18	0.74	1.25	0.54	5.15	-8.38
ITC2	0.01	0.23	0.37	0.20	0.24	0.28	0.25	0.18	0.19	0.77	0.32	3.02	-12.96
ITC3	0.38	0.17	0.17	0.22	0.66	0.34	0.83	0.21	0.38	0.86	0.77	4.62	-9.65
ITC4	0.89	0.25	0.40	0.27	0.76	0.78	0.48	0.20	0.32	2.07	1.14	6.67	-6.74
ITF1	0.29	0.12	0.27	0.28	0.27	0.46	0.22	0.19	0.24	0.58	0.47	3.10	-12.71
ITF2	0.24	0.17	0.14	0.27	0.13	0.28	0.21	0.18	0.19	0.50	0.32	2.39	-15.17
ITF3	0.22	0.12	0.41	0.17	0.38	0.41	0.23	0.16	0.32	0.68	0.49	3.37	-12.19
ITF4	0.22	0.14	0.57	0.29	0.30	0.43	0.21	0.16	0.25	0.42	0.36	3.14	-12.45
ITF5	0.38	0.14	0.70	0.16	0.18	0.30	0.21	0.17	0.18	0.34	0.36	2.73	-14.26
ITF6	0.20	0.10	0.60	0.26	0.21	0.30	0.21	0.17	0.19	0.27	0.32	2.64	-14.32
ITG1	0.15	0.14	0.20	0.22	0.27	0.29	0.19	0.15	0.25	0.38	0.34	2.42	-14.65
ITG2	0.43	0.17	0.19	0.60	0.30	0.71	0.21	0.18	0.21	0.23	0.35	3.15	-12.83
ITH1	0.33	0.27	0.67	0.28	0.17	0.28	0.44	0.22	0.20	0.77	0.19	3.49	-11.88
ITH2	1.17	0.27	1.91	0.45	0.21	0.28	5.00	0.24	0.53	1.02	0.42	10.33	-5.59
ITH3	0.40	0.26	0.49	0.24	0.51	0.34	0.37	0.18	0.28	1.25	0.42	4.34	-9.86
ITH4	0.50	0.25	0.44	0.30	0.37	0.61	0.41	0.22	0.42	0.82	0.32	4.19	-9.45
ITH5	0.46	0.26	0.43	0.22	0.53	0.45	0.58	0.21	0.53	1.41	0.37	4.99	-8.53
ITI1	0.40	0.21	0.40	0.26	0.39	0.53	0.43	0.20	0.34	0.87	0.47	4.11	-9.82
ITI2	0.35	0.15	0.25	0.27	0.25	0.37	0.33	0.23	0.25	0.68	0.39	3.17	-12.31
ITI3	0.28	0.16	0.40	0.28	0.41	0.51	0.25	0.21	0.22	0.68	0.35	3.47	-11.49
ITI4	0.65	0.15	0.50	0.42	0.89	0.40	0.85	0.24	0.44	1.16	0.66	5.72	-7.17
LT01	3.87	0.55	0.28	1.71	0.28	0.10	0.54	1.09	0.26	0.28	4.99	10.09	-6.41
LT02	0.39	0.55	0.28	0.87	0.19	0.10	0.22	1.09	0.26	0.19	0.18	3.95	-12.02
LU00	4.47	0.54	1.26	0.50	0.70	2.26	1.16	2.69	0.33	1.91	1.73	13.08	0.60
LV00	1.33	0.61	0.52	0.15	0.23	0.10	0.27	0.83	0.18	0.11	0.41	3.41	-13.16
MT00	4.59	0.19	0.04	0.20	0.42	0.39	0.58	0.19	0.21	0.25	2.23	4.69	-12.60
NL23	1.22	1.18	3.90	0.99	2.81	1.07	0.23	1.22	0.48	1.81	1.09	14.79	1.30
NL32	5.00	1.05	5.00	0.99	2.81	3.02	3.08	1.92	0.48	1.81	5.00	25.16	7.03
NL11	1.20	1.19	4.68	1.41	0.87	1.39	4.47	1.38	0.69	0.73	0.73	17.53	3.06

NUTS2 code	Crunchbase output	Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate	EE index additive	EE index log
NL12	0.54	1.19	3.92	0.89	1.13	0.99	0.23	1.01	0.22	0.73	0.56	10.86	-2.34
NL13	0.38	1.19	3.67	1.45	0.79	1.43	0.20	1.06	0.21	0.89	0.69	11.59	-1.63
NL21	1.16	1.18	4.29	1.03	1.57	1.66	0.65	1.24	0.56	1.16	0.51	13.86	1.30
NL22	0.73	1.18	5.00	1.10	2.83	1.62	1.24	1.41	0.74	1.69	0.85	17.67	4.02
NL31	2.33	1.05	4.19	1.37	3.58	2.84	5.00	2.29	0.79	2.32	1.77	25.18	7.72
NL33	1.80	1.05	4.50	1.15	3.02	2.09	2.62	1.43	0.75	2.03	2.78	21.43	6.30
NL34	0.36	1.05	4.35	1.21	1.03	1.45	0.19	0.98	0.17	1.56	0.53	12.52	-1.51
NL41	1.17	1.12	4.80	1.08	3.13	1.69	0.65	1.33	1.26	1.93	1.48	18.46	4.55
NL42	0.69	1.12	5.00	1.05	2.07	1.59	0.72	1.01	0.56	1.81	0.86	15.80	2.51
PL21	0.67	0.44	0.28	0.17	0.22	0.25	0.21	0.22	0.40	0.59	0.21	3.01	-12.79
PL22	0.19	0.43	0.33	0.20	0.29	0.19	0.19	0.20	0.18	0.88	0.22	3.11	-13.09
PL41	0.40	0.43	0.21	0.16	0.25	0.19	0.20	0.20	0.20	0.45	0.17	2.46	-14.71
PL42	0.31	0.45	0.38	0.17	0.29	0.20	0.20	0.19	0.14	0.26	0.22	2.50	-14.49
PL43	0.10	0.44	0.30	0.15	0.23	0.16	0.18	0.18	0.12	0.31	0.16	2.23	-15.75
PL51	0.54	0.43	0.35	0.17	0.23	0.19	0.21	0.23	0.22	0.51	0.24	2.77	-13.46
PL52	0.13	0.47	0.49	0.19	0.21	0.15	0.19	0.18	0.14	0.48	0.18	2.67	-14.39
PL61	0.17	0.46	0.33	0.18	0.25	0.16	0.19	0.17	0.15	0.37	0.18	2.45	-14.81
PL62	0.20	0.46	0.16	0.17	0.22	0.22	0.19	0.18	0.14	0.21	0.13	2.07	-16.43
PL63	0.50	0.51	0.41	0.17	0.39	0.19	0.20	0.23	0.28	0.34	0.40	3.13	-12.27
PL71	0.21	0.39	0.18	0.15	0.28	0.19	0.19	0.20	0.19	0.52	0.24	2.52	-14.53
PL72	0.14	0.42	0.44	0.18	0.14	0.15	0.20	0.20	0.18	0.38	0.12	2.41	-15.32
PL81	0.19	0.39	0.28	0.18	0.17	0.16	0.20	0.23	0.27	0.27	0.14	2.28	-15.24
PL82	0.20	0.40	0.35	0.20	0.18	0.15	0.19	0.18	0.33	0.29	0.16	2.43	-14.73
PL84	0.21	0.43	0.42	0.18	0.20	0.16	0.19	0.22	0.20	0.19	0.13	2.31	-15.39
PL91	1.89	0.42	0.38	0.18	0.63	0.35	0.35	0.35	0.50	0.99	1.88	6.05	-7.18
PL92	0.16	0.42	0.38	0.18	0.28	0.35	0.18	0.35	0.50	0.59	0.16	3.40	-11.68
PT11	0.51	0.52	0.24	0.26	0.32	0.41	0.38	0.66	0.35	0.40	0.21	3.75	-10.36
PT15	0.64	0.46	0.24	0.14	0.38	0.21	0.27	0.69	0.14	0.21	0.23	2.96	-13.41
PT16	1.22	0.55	0.22	0.42	0.26	0.41	0.42	0.73	0.31	0.33	0.22	3.86	-10.22
PT17	2.00	0.56	0.43	0.34	1.29	0.62	0.80	1.17	0.41	1.05	3.74	10.41	-2.30
PT18	0.40	0.61	0.28	0.30	0.17	0.25	0.34	0.63	0.16	0.25	0.14	3.13	-12.84
PT20	0.27	0.54	0.59	0.16	0.39	0.28	0.18	0.50	0.14	0.04	0.23	3.05	-14.18
PT30	0.67	0.58	0.59	0.21	0.36	0.33	0.29	0.64	0.14	0.13	0.18	3.45	-12.16
RO11	0.60	0.13	0.46	0.14	0.15	0.10	0.20	0.08	0.15	0.22	0.17	1.80	-18.35
RO12	0.28	0.16	0.27	0.14	0.10	0.10	0.18	0.08	0.14	0.22	0.13	1.52	-19.49
RO21	0.27	0.14	0.23	0.12	0.10	0.10	0.19	0.07	0.15	0.17	0.08	1.36	-20.60
RO22	0.12	0.12	0.30	0.15	0.10	0.10	0.19	0.07	0.11	0.19	0.19	1.51	-19.69
RO31	0.13	0.19	0.28	0.14	0.15	0.14	0.19	0.07	0.14	0.35	0.21	1.84	-17.74
RO32	1.22	0.14	0.27	0.16	0.55	0.14	0.26	0.15	0.23	1.91	1.71	5.53	-11.14
RO41	0.12	0.14	0.37	0.12	0.12	0.13	0.18	0.08	0.12	0.18	0.10	1.54	-19.62
RO42	0.33	0.16	0.54	0.13	0.16	0.10	0.19	0.07	0.15	0.21	0.15	1.87	-18.22
SE11	5.00	2.34	3.88	0.46	1.66	4.59	2.22	4.33	3.34	1.26	5.00	29.08	8.78
SE12	0.82	2.34	2.50	0.80	0.62	1.77	0.96	2.69	3.77	0.42	1.13	17.01	3.17
SE21	0.47	2.37	3.35	0.72	0.36	1.03	0.23	1.92	0.41	0.20	0.54	11.13	-3.16
SE22	1.73	2.37	3.04	0.38	1.07	2.44	1.13	2.99	2.04	0.63	3.03	19.11	4.53
SE23	1.15	2.37	2.80	0.39	0.61	1.83	0.89	3.14	3.43	0.43	1.51	17.40	2.89
SE31	0.40	2.18	2.65	1.32	0.32	0.97	0.24	1.50	0.34	0.12	0.44	10.07	-4.18
SE32	0.82	2.18	2.41	0.74	0.32	1.21	0.18	1.80	0.20	0.05	0.37	9.47	-6.34
SE33	0.83	2.18	3.73	0.68	0.29	1.54	0.66	2.19	1.22	0.03	0.32	12.84	-3.13
SI03	0.37	0.31	0.31	0.52	0.29	0.32	0.26	0.35	0.45	0.47	0.18	3.47	-11.00
SI04	1.52	0.31	0.37	0.71	0.47	0.51	2.09	0.53	1.17	0.51	0.67	7.34	-4.75
SK01	2.43	0.24	0.67	0.51	0.72	1.06	0.62	0.77	0.55	1.25	1.32	7.70	-3.62
SK02	0.15	0.23	0.25	0.23	0.19	0.40	0.20	0.29	0.23	0.52	0.16	2.69	-13.73
SK03	0.16	0.28	0.33	0.35	0.11	0.32	0.19	0.31	0.29	0.39	0.14	2.71	-13.75
SK04	0.23	0.28	0.26	0.33	0.12	0.36	0.19	0.31	0.20	0.30	0.14	2.51	-14.41
UKH2	1.15	2.26	1.23	2.27	5.00	2.03	0.27	1.65	0.34	4.76	0.76	20.57	3.55
UKH3	0.56	2.26	1.23	2.27	5.00	2.03	0.23	1.65	0.34	4.76	0.63	20.40	3.21
UKI3&4	5.00	2.18	1.74	2.27	5.00	3.66	5.00	3.18	0.34	4.76	5.00	33.13	9.92
UKI5	0.29	2.18	1.74	2.27	5.00	3.66	0.21	3.18	0.34	4.76	1.49	24.83	5.55
UKI6	0.47	2.18	1.74	2.27	5.00	3.66	0.20	3.18	0.34	4.76	2.86	26.20	6.15

NUTS2 code	Crunchbase output	Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate	EE index additive	EE index log
UKI7	0.72	2.18	1.74	2.27	5.00	3.66	0.24	3.18	0.34	4.76	2.35	25.72	6.11
UKC1	0.64	2.33	1.07	3.56	0.57	0.87	0.38	1.21	0.25	0.83	0.30	11.36	-2.09
UKC2	1.23	2.33	1.07	3.56	0.64	0.87	0.50	1.21	0.32	0.62	0.43	11.54	-1.39
UKD1	0.75	1.91	1.13	1.90	0.38	0.93	0.18	1.53	0.31	0.59	0.49	9.36	-3.31
UKD3	1.85	1.91	1.13	1.90	1.42	0.93	0.46	1.53	0.24	1.91	0.97	12.40	0.54
UKD4	0.69	1.91	1.13	1.90	1.01	0.93	0.29	1.53	0.23	1.50	0.25	10.68	-1.89
UKD6	1.38	1.91	1.13	1.90	1.35	0.93	0.24	1.53	4.19	2.29	1.15	16.63	3.06
UKD7	0.75	1.91	1.13	1.90	1.59	0.93	0.39	1.53	0.43	1.64	0.33	11.79	-0.16
UKE1	0.51	2.09	0.71	4.75	0.62	0.76	0.22	1.40	0.21	0.87	0.22	11.85	-3.21
UKE2	1.17	2.09	0.71	4.75	0.70	0.76	0.66	1.40	0.45	1.30	0.46	13.28	-0.08
UKE3	0.79	2.09	0.71	4.75	1.16	0.76	0.69	1.40	0.32	1.59	0.29	13.77	-0.11
UKE4	0.93	2.09	0.71	4.75	1.22	0.76	0.55	1.40	0.26	1.67	0.47	13.88	0.03
UKF1	0.75	2.06	1.01	3.81	0.97	0.66	0.48	1.47	1.25	1.67	0.37	13.77	1.04
UKF2	0.92	2.06	1.01	3.81	1.47	0.66	0.29	1.47	0.30	1.66	0.55	13.28	-0.13
UKF3	0.71	2.06	1.01	3.81	0.39	0.66	0.26	1.47	0.14	0.97	0.26	11.04	-3.58
UKG1	0.85	2.33	0.93	2.94	1.47	1.09	0.24	1.29	2.04	1.73	0.69	14.72	2.00
UKG2	0.68	2.33	0.93	2.94	1.17	1.09	0.21	1.29	0.18	1.54	0.29	11.96	-1.72
UKG3	1.07	2.33	0.93	2.94	2.37	1.09	2.20	1.29	0.57	1.54	0.82	16.07	3.51
UKH1	1.99	2.26	1.23	1.97	0.69	2.03	5.00	1.65	5.00	1.08	0.70	21.62	5.49
UKJ1	2.53	2.21	1.25	3.66	3.55	1.37	4.80	2.24	2.81	3.14	1.64	26.68	8.95
UKJ2	1.49	2.21	1.25	3.66	4.66	1.37	0.37	2.24	0.43	3.51	1.18	20.88	4.55
UKJ3	1.10	2.21	1.25	3.66	2.33	1.37	0.41	2.24	0.73	1.95	0.71	16.87	3.42
UKJ4	0.83	2.21	1.25	3.66	4.96	1.37	0.26	2.24	0.32	2.34	0.53	19.15	2.77
UKK1	1.87	2.32	0.90	1.45	1.18	1.30	1.00	1.96	0.69	1.53	0.73	13.05	1.94
UKK2	0.99	2.32	0.90	1.45	0.56	1.30	0.27	1.96	0.22	1.10	0.46	10.54	-2.03
UKK3	0.84	2.32	0.90	1.45	0.54	1.30	0.18	1.96	0.15	0.37	0.58	9.74	-3.75
UKK4	0.91	2.32	0.90	1.45	0.58	1.30	1.11	1.96	0.28	0.63	0.40	10.92	-1.04
UKL1	0.48	2.23	1.20	2.50	0.55	0.95	0.26	1.65	0.21	0.51	0.27	10.34	-3.11
UKL2	1.55	2.23	1.20	2.50	0.77	0.95	0.48	1.65	0.30	0.87	0.57	11.53	-0.54
UKM5	1.26	2.15	1.17	3.29	0.47	0.79	0.39	2.11	0.37	0.49	1.83	13.04	-0.20
UKM6	0.61	2.15	1.17	3.29	0.26	0.79	0.25	2.11	0.16	0.14	0.13	10.45	-5.94
UKM7	1.78	2.15	1.17	3.29	1.13	0.79	2.68	2.11	0.71	0.78	0.60	15.40	2.63
UKM8	1.33	2.15	1.17	3.29	3.84	0.79	0.96	2.11	0.28	1.02	0.61	16.21	2.18
UKM9	0.36	2.15	1.17	3.29	1.16	0.79	0.19	2.11	0.32	0.60	0.20	11.97	-2.17
UKN0	0.87	1.72	0.96	2.93	0.68	0.74	0.32	1.21	0.45	0.47	0.45	9.94	-2.40

Appendix B: Appendices to chapter 3

Table B1. Average absolute number of HGFs per NUTS region over available time period

NUTS CODE	Name region	Employment HGFs (2010-2019)	Sales HGFs (2013 - 2020)	Innovative startups (2015-2021)
NL11	Groningen	58.5	21.0	55.6
NL12	Friesland (NL)	55.5	13.9	50.9
NL13	Drenthe	47.5	4.1	37.9
NL21	Overijssel	133.0	42.6	104.7
NL22	Gelderland	245.0	49.0	174.1
NL23	Flevoland	46.5	8.8	49.1
NL31	Utrecht	197.5	86.4	161.6
NL32	Noord-Holland	469.0	138.8	538.6
NL33	Zuid-Holland	466.0	106.9	404.3
NL34	Zeeland	39.5	8.3	21.4
NL41	Noord-Brabant	343.0	95.5	223.9

Table B2. Regional persistence of employment HGFs in the Netherlands (NUTS-2 level, 12 regions).

Employment HGFs per 10,000 firms		
	(1)	(2)
	Pearson correlation [p-value]	Spearman's rank correlation [p-value]
Pooled (2010-2020)	0.854 [0.000]	0.823 [0.000]
Period: 2010-2012 and 2013 – 2015	0.786 [0.002]	0.762 [0.006]
Period: 2010 – 2012 and 2016 - 2018	0.528 [0.078]	0.364 [0.246]
Period: 2013 – 2015 and 2016 - 2018	0.912 [0.000]	0.811 [0.002]

Table B3. Regional persistence of sales HGFs in the Netherlands (NUTS-3 level, 40 regions).

Sales HGFs per 10,000 firms		
	(1)	(2)
	Pearson correlation [p-value]	Spearman's rank correlation [p-value]
Pooled (2013-2020)	0.799 [0.000]	0.771 [0.000]
Period: 2013 - 2015 and 2016 – 2018	0.739 [0.000]	0.691 [0.000]

Table B4. Regional persistence of innovative start-ups (potential HGFs) in the Netherlands (NUTS-2 level, 12 regions).

Innovative start-ups (potential HGFs) per 10,000 firms		
	(1)	(2)
	Pearson correlation [p-value]	Spearman's rank correlation [p-value]
Pooled (2015-2020)	0.869 [0.000]	0.848 [0.000]
Period: 2015-2017 and 2018 – 2020	0.965 [0.000]	0.909 [0.000]
Period: 2015 and 2020	0.835 [0.000]	0.853 [0.000]

Table B5. Regression results for three measures of HGFs in the Netherlands at NUTS-2 and NUTS-3 level.

	Dependent variable				
	Employment HGF			Sales HGF	Innovative start-ups
	2016 – 2018		2013 – 2015	2016 – 2018	2018 – 2020
	1	2	3		
Employment HGF 2013 – 2015	1.465*** (0.028)				
Employment HGF 2010 – 2012		1.404*** (0.072)	0.963*** (0.035)		
Sales HGF 2013 – 2015				1.797*** (0.045)	
Innovative start-ups 2015 – 2017					0.718*** (0.015)
Constant	4.673 (5.559)	-2.354 (14.841)	-5.499 (7.158)	-0.245 (0.747)	-3.099 (4.302)
Observations	12	12	12	40	12
Adjusted R^2	0.996	0.972	0.986	0.976	0.996

Note: . $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; standard errors reported in brackets

Table B6. Regression results for sales HGFs at the NUTS-3 level in the Netherlands, two year averages

	Dependent variable					
	HGF 2019 - 2020			HGF 2017 - 2018		HGF 2015 - 2016
	1	2	3	4	5	6
HGF 2017 – 2018	0.868***					
HGF 2015 – 2016		0.952***		0.949***		
HGF 2013 – 2014			1.236***		1.271***	0.834***
Constant	15.871	25.181	32.183	19.482	24.840	25.760
	(8.009)	(11.108)	(11.991)	(10.347)	(11.051)	(8.86)
Observations	40	40	40	40	40	40
Adjusted R^2	0.690	0.449	0.346	0.483	0.399	0.307

Note: . $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; standard errors reported in brackets

Table B7. Regression results for innovative start-ups (potential HGFs) at the NUTS-2 level in the Netherlands, two year averages

	Dependent variable		
	HGF 2019 – 2020		HGF 2017 – 2018
	1	2	3
HGF 2017 – 2018	0.554***		
	(0.091)		
HGF 2015 – 2016		0.596***	0.980***
		(0.071)	(0.088)
Constant	-0.003	-0.003	0.002
	(0.003)	(0.002)	(0.002)
Observations	12	12	12
Adjusted R^2	0.766	0.864	0.917
Note:	. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets		

Table B8. Regional persistence of innovative start-ups in Europe (NUTS-2 level, 273 regions)

Innovative start-ups per 10,000 inhabitants		
	(1)	(2)
	Pearson correlation [p-value]	Spearman's rank correlation [p-value]
Pooled (2015-2020)	0.962 [0.00]	0.884 [0.00]
Period: 2015-2017 and 2018 – 2020	0.987 [0.00]	0.921 [0.00]
Period: 2015 and 2020	0.909 [0.00]	0.789 [0.00]

Table B9. The relation between EE quality and presence of innovative start-ups in Europe (NUTS-2 level, 273 regions)

	Dependent variable	
	Innovative start-ups presence (negative binomial)[1]	
	HGF 2015 – 2017	HGF 2018 – 2020
	1	2
EE index	0.135***	0.148***
	(0.010)	(0.011)
Constant	2.359***	1.605***
	(0.112)	(0.119)
Observations	272	272
Adjusted R^2	0.440	0.460
Note:	. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets	

Table B10.

The influence of EE quality on the persistence of presence innovative start-ups in European NUTS-2 regions [2]

	Dependent variable	
	Persistence of innovative start-up presence	Persistence of innovative start-up presence
	2	2
EE index	0.018***	
	(0.003)	
Log(EE index)		0.183***
		(-0.025)
Constant	0.747***	-0.937***
	(0.034)	(0.051)
Observations	271	271
Adjusted R^2	0.112	0.167
Note:	. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets	

1 The reported R2 values for the negative binomial models are the McFadden R2 (McFadden, 1974)

2 One region is removed from the analyses as this region did not record any innovative start-ups in any year. Hence, the mean was 0 and it was impossible to calculate our measure for this region.

Table B11.

The influence of EE quality and region size (population) on the persistence of innovative start-ups in European NUTS-2 regions using quantile dummies. Dummies use bottom 10% as reference category.

Dependent variable: Innovative start-ups persistence		
Independent variable	EE quality dummies	Population size dummies
	1	2
Bottom 10%		
10-20%	0.301*** (0.085)	0.271** (0.088)
20-30%	0.337*** (0.086)	0.369*** (0.088)
30-40%	0.389*** (0.086)	0.415*** (0.088)
40-50%	0.360*** (0.086)	0.439*** (0.088)
50-60%	0.397*** (0.086)	0.527*** (0.088)
60-70%	0.476*** (0.086)	0.480*** (0.088)
70-80%	0.484*** (0.086)	0.500*** (0.088)
80-90%	0.513*** (0.086)	0.510*** (0.088)
Top 10 %	0.544*** (0.086)	0.606*** (0.088)
Constant	-0.968*** (0.061)	-1.006*** (0.063)
Observations	271	272
Adjusted R^2	0.158	0.177
Note:	. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets	

Table B12.

Regional persistence of innovative start-ups for the bottom 10% of European regional EEs (NUTS-2 level, 27 regions)

Innovative start-ups (Crunchbase start-ups per 10.000 inhabitants)		
	(1)	(2)
	Pearson correlation [p-value]	Spearman's rank correlation [p-value]
Pooled (2015-2020)	0.625 [0.000]	0.540 [0.000]
Period: 2015-2017 and 2018 – 2020	0.684 [0.000]	0.646 [0.000]
Period: 2015 and 2020	0.224 [0.261]	0.128 [0.525]

Table B13.

The influence of EE quality and population size on the prevalence of innovative start-ups in European NUTS-2 regions including random intercepts

Dependent variable: Persistence of innovative start-up prevalence		
	1	2
Random effects (variance) Country (Intercept)	0.030 (0.172)	0.034 (0.185)
Fixed effects		
Log (EE index)	0.198*** (0.037)	
Log (Population (per 10,000 inhabitants))		0.219*** (0.024)
Constant	-0.960*** (0.078)	-1.67*** (0.121)
Observations	271	272
Conditional R^2	0.407	0.466
Note:	. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; standard errors reported in brackets	

Appendix C: Appendices to chapter 4

Table C1. An overview of the organizations represented by the interview informants.

	Eindhoven	Wageningen	Utrecht
01	Incubator	Incubator	Municipality
02	University professor	University staff	Start-up office provider
03	Regional development agency	Regional development agency	Incubator
04	Start-up	University staff – campus development	Regional development agency
05	Municipality	Network organization	University staff – director entrepreneurship & regional collaborations
06	University professor	Start-up	Municipality
07	Incubator	Network organization	Social entrepreneurship support organization
08	Start-up	University – Corporate Value Creation	Province
09	Regional development agency	University – Technology Transfer Office	Start-up platform
10	Investment fund	University staff –Centre of entrepreneurship	University - Centre for entrepreneurship
11	Deep-tech ecosystem manager/consultant	University staff – campus development	Incubator
12	Start-up	University staff – campus development	University – Technology Transfer Office
13	Investor	University staff –Centre of entrepreneurship	Municipality
14	Investor	Start-up	University staff – Corporate offices
15	Regional development agency	Start-up	University – Technology Transfer office
16	University professor	Start-up	Game Incubator
17		Start-up	Start-up
18			Start-up
19			Start-up

Table C2. Interview guide EWUU Alliance cross-collaboration ecosystem research.

Note: Make sure to ask for the why on all questions.

Topic	**Questions**
Start	Can I record this interview? We use our results to provide advice to the EWUU alliance and also for a scientific paper on the topic. Everything we share will be anonymized.
Introduction	First of all, could you give a short description of what you do and how you ended up doing this?
	What is your ambition in your current work? What are you trying to accomplish?
	What is societal impact for you? Optional: What kind of impact do you aim to achieve in your work?
Regional ecosystem	**Which actors do you consider part of your regional entrepreneurial ecosystem? Could you explain how you would define/describe the boundaries of your entrepreneurial ecosystem?** Get an extensive list here
	What are the three most important actors for you in the regional ecosystem? Can you please describe the interactions you have with A, B, C?
	How often do you interact with them? Please be specific (e.g. once a week, month, etc.). [examples]
	What do your interactions with these actors look like? [examples]
	What do you gain/provide from these interactions? [examples]
	Are you also friends with people there?
	What motivates you to work together with others?
	Are there actors you faced challenges within collaborating?
	Are there actors you do not like to collaborate with?
	What do you like best about how your EE is organized?
	What would you like to change in your EE?
	Could you provide an example of an unsuccessful ecosystem collaboration? Why did it not work out?
Inter ecosystem	**What actors outside your local entrepreneurial ecosystem do you interact with? Ask for specific examples and for these examples: Also make sure to include start-ups.**

	Where are they located?
	Why this specific actor? What caused the connection?
	How dependent are you on these collaborations beyond your local ecosystem? How important are these collaboration?
	What do you gain/provide from these interactions?
	How intense is the collaboration/ how often?
	Are you satisfied with these collaborations?
	Who do you not like to collaborate with? /Are there collaborations outside of home region that have failed? (ask for example)
	What helps you to collaborate with actors from other regions?
	What barriers do you encounter when collaborating with actors from other regions?
To conclude	What would you like to learn from other entrepreneurial ecosystems?
	What have we not yet discussed but do you think I should also know?
	You named X, Y, Z as examples. Would you be able to connect us with them for interview?
	Who else should we talk to with these questions?

Checklist:	*Could you provide an example of a successful ecosystem collaboration that resulted in societal impact? Please elaborate…* • *Actors involved* • *Frequency of interactions* • *Form of interactions (e.g. online, f2f, etc.)* • *Intensity of collaboration* • *Perceived gains & societal impact*

Table C3. Boundaries of the three entrepreneurial ecosystems.

	Geographical boundaries	Sectoral boundaries
Eindhoven	The Eindhoven agglomeration (NUTS-3) embedded in the province (NUTS-2)	Weak boundaries around high-tech
Wageningen	The province (NUTS-2) with a nested component around the university campus	Strong boundaries around agrifood
Utrecht	The province level (both NUTS-2 and NUTS-3) level	Not applicable

In Utrecht, the boundaries of the entrepreneurial ecosystem are almost universally considered to be at the province level, which coincides with both the NUTS-2 and NUTS-3 level. In Eindhoven, the regional boundaries of the entrepreneurial ecosystem are considered to be around a combination of the NUTS-2 and the NUTS-3 level. Actors in this entrepreneurial ecosystem point to a nestedness between these two levels. Some actors, such as the regional development agency BOM, identify stronger boundaries at the province level (NUTS-2). While other actors, such as the municipality Eindhoven and the Brainport region, identify stronger boundaries around the smaller regional scale (NUTS-3). In addition, there is a weak sectoral boundary around the high-tech sector. In Wageningen, we find that the geographical boundaries of the entrepreneurial ecosystem are considered at the province, the NUTS-2 level, with a nested element around the university campus in Wageningen. However, as a result of the specialization of Wageningen in the agrifood sector, we find that the boundaries of the entrepreneurial ecosystem are considered to be stronger around the agrifood sector than around the region

Appendix D: Appendices to chapter 5

Table D1. List of interviewees

City	**Organization**	**Nature**	**Interviews conducted**
Transparent ecosystems			
Utrecht	Incubator	Public	MD U1 Staff U2 Staff U3
	Incubator	Private	MD U4 Staff U5
	Incubator	Public	MD U6
	Incubator	Private	MD U7
	Municipality Utrecht	Local government	Civil servant U8
Amsterdam	Incubator	Public	MD A1 Staff A2
	Incubator	Private	Staff A3
	Incubator	Private	Staff A4 Staff A5
	Technology transfer office	Technology transfer office universities	Staff A6
	Platform	Governmental platform	MD A7 MD A8
Intransparent ecosystems			
Nijmegen	Incubator	Public	Staff N1
	Incubator	Private	MD N2
Rotterdam	Incubator	Public	Staff R1
	Incubator	Private	MD + staff R2
Delft	Incubator	Public	Staff D1
	Municipality Delft	Local government	Aldermen D2
Wageningen	Incubator	Public	Staff W1
	Incubator	Public	Staff W2
Eindhoven	Incubator	Private	Staff E1
	Incubator	Public	Staff E2
	Platform	Regional government	Staff E3
National			
Netherlands	Platform	Organization representing the Dutch startup ecosystem	SU1

Interview guide

Introduction

- Introduce researcher, research and goal of the interview.
- Ask for permission to record the interview.

Personal questions

- What is your function in this organization?
- What is your personal background?
    - Education, previous employment
- How long have you been active in this ecosystem?

Public/Private incubator

- What sources of income does this incubator possess?
- Who is the owner/owners of this incubator?
- Is the incubator accountable to another actor/organization?

Regulative institutions

For incubators

- To what extent do you lobby with government of new legislation?
- Do you create a system of sanctions? If so, how?
- To what extent do you create rules and guidelines in the ecosystem? If so, how?

For non-incubators

- To what extent do incubators influence rules and regulations in this ecosystem?

Normative institutions

For incubators

- To what extent to you push people to become entrepreneurs?
- Do you expect certain behavior from your incubatees?
    - If yes, how do you create this kind of behavior?
- Do you expect certain behavior from your partners?
    - If yes, how do you create this kind of behavior?
- Do you often talk with your incubatees or partners about their activities and actions?
- Are there certain norms and values actors in the ecosystem have to adhere to?
    - Do you play a part in creating these?

For non-incubators

- To what extent do incubators inspire/push you to change your behavior?
- To what extent do incubators inspire/push your partners to change their behavior?
- Do you talk with incubators about certain norms and values in the ecosystem?

Cultural-cognitive institutions

- Is there a deeper culture of entrepreneurship in the region?
- How do you contribute to the local ecosystem?
- Do you contribute to such a culture?
    - If so, how?

Field-level conditions

- To what extent in this ecosystem institutionalized?
    - Are there many rules and regulations?
    - Is there a certain code of behavior? Or are there many different codes?
- Do rules and regulations vary between organizations?
- Do the actors in this ecosystem act in a different way?
- Do current institutions/or lack thereover enable you to change the current ecosystem?

Social position

- Do you have partners/incubatees from many different fields?
- To what extent do have influence over other actors?
- To what extent do other actors listen to your opinion?
- Do you mobilize resources to implement institutional change?
- Do you try to gain allies and support when you try to implement institutional change?
- Do you think the ecosystem needs changing?

End of interview

- Thank you for your cooperation, do you have any further questions?
- Can you recommend any other promising actors worth talking to?

Appendix E: Appendices to chapter 6

Table E1. The ten most frequent (stemmed) terms for the fourteen topics resulting from the technologies of 920 sustainable start-ups.

Topic 1	*Topic 2*	*Topic 3*	*Topic 4*	*Topic 5*	*Topic 6*	*Topic 7*	*Topic 8*	*Topic 9*	*Topic 10*	*Topic 11*	*Topic 12*	*Topic 13*	*Topic 14*
green	wind	water	heat	people	transport	waste	solar	bike	sensor	vehicle	project	chemic	plant
flexible	storage	treatment	engine	carbon	app	recycle	smart	share	measure	charge	renew	fibre	food
layer	module	filter	cool	online	clean	organ	home	city	machine	battery	database	composite	soil
box	turbine	pump	fuel	climate	smart-phone	contain	panel	plastic	intelligent	car	risk	structure	farm
space	tank	flow	gas	find	europe	pallet	house	delivery	predict	light	client	extract	farmer
concrete	air	drink	thermal	social	park	wood	hardware	package	cloud	station	rate	receive	fertile
print	ship	region	air	shop	match	fruit	grid	digit	detect	drive	financi	atmosphere	agriculture
trade	scalable	reus	hydrogen	footprint	rout	dry	household	urban	health	electron	finance	renew	organ
call	compress	shower	exchange	market place	driver	biomass	meter	bicycle	compute	weight	startup	coffee	nutrient
side	pollute	human	oil	engage	travel	raw	roof	bag	day	public	solve	hand	crop

Appendix F: Appendices to chapter 7

Table F1. Operationalization of the indicators of ten entrepreneurial ecosystem elements from Leendertse et al. (2022).

Elements	**Description**	**Empirical indicators**	**Data source**	**Years**
Formal institutions	The rules of the game in society	Two composite indicators measuring the overall quality of government (consisting of scores for corruption, accountability, and impartiality) and the ease of doing business	Quality of Government Survey (QOG) and the World Bank Doing Business Report	2015-2017
Entrepreneurship culture	The degree to which entrepreneurship is valued in a region	A composite measure capturing the regional entrepreneurial culture, consisting of entrepreneurial motivation, cultural and social norms, importance to be innovative, and trust in others	European Social Survey (ESS), Global Entrepreneurship Monitor (GEM), and OECD, Eurostat, and national statistics offices	2008-2016
Networks	The connectedness of businesses for new value creation	Percentage of SMEs that engage in innovative collaborations as a percentage of all SMEs in the business population	Regional Innovation Scoreboard (RIS)	2016
Physical Infrastructure	Transportation infrastructure and digital infrastructure	Four components in which the transportation infrastructure is measured as the accessibility by road, accessibility by railway and number of passenger flights and digital infrastructure is measured by the percentage of households with access to internet	Regional Competitiveness Index (RCI)	2014-2018
Finance	The availability of venture capital and access to finance	Two components: The average amount of venture capital per capita and the percentage of SMEs that is credit constrained	Invest Europe and European Investment Bank (EIB)	2014-2019
Leadership	The presence of actors taking a leadership role in the ecosystem	The number of coordinators on H2020 innovation projects per capita	Community Research and Development Information Service (CORDIS)	2014-2019

Talent	The prevalence of individuals with high levels of human capital, both in terms of formal education and skills	Four components: The percentage of the population with tertiary education, the percentage of the working population engaged in lifelong learning, the percentage of the population with an entrepreneurship education, the percentage of the population with e-skills	Eurostat and the Global Entrepreneurship Monitor (GEM)	2013-2014
New Knowledge	Investments in new knowledge	Intramural R&D expenditure as a percentage of Gross Regional Product	Eurostat	2015
Demand	Potential market demand	Three components: disposable income per capita, potential market size expressed in GRP, potential market size in population. All relative to EU average.	Regional Competitiveness Index (RCI)	2014-2018
Intermediate services	The supply and accessibility of intermediate business services	Two components: the percentage of employment in knowledge-intensive market services and the number of incubators/accelerators per capita	Eurostat and Crunchbase	2018-2019

Index construction

To determine the quality of EEs Leendertse et al. (2022) combine the measures of the ten elements of the EE into an index. To calculate this index they first standardize the empirical indicators for each element. This ensures that all elements get similar weights in the creation of the index. They then take the inverse natural log of the standardized values. This is necessary because the mean is 0 after standardization and the next step, normalizing the data, requires division by the mean. The element values are normalized by setting the European average of each element to 1 and letting all other regional values deviate from this. After exploring various alternatives way of calculating such index they settle on reporting an index that is created in an additive way (E1 + E2 +...+E10) where regions with an average value on each element will thus score an index value of 10.

Table F3. Full negative binomial model for the presence of SSUs without informal institutions

	Dependent variable:
	Sustainable start-up presence
Entrepreneurial Ecosystem index	0.086 ***
	(0.0.012)
Fellow start-ups	0.001***
	(0.000)
Sustainability Resource Endowments	0.023
	(0.040)
Sustainability Formal institutions	0.116***
	(1.029)
Population	0.004***
	(0.000)
GRP	0.006**
	(0.002)
Constant	-1.386***
	(0.370)
Observations	272
Conditional R^2	0.690
Log Likelihood	-705.672
Note:	[a] p<0.1; *p<0.05; **p<0.01; ***p<0.001

Table F4. Multilevel negative binomial regression results.

	Dependent variable:						
	Sustainable start-up presence						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Random effects (variances)							
Country (Intercept)	0.362	0.142	0.118	0.140	0.112	0.120	0.028
Fixed effects							
Entrepreneurial Ecosystem index		0.115^{***}	0.090^{***}	0.112^{***}	0.117^{***}	0.139^{***}	0.108^{***}
		(0.013)	(0.015)	(0.015)	(0.013)	(0.014)	(0.016)
Fellow start-ups			0.038^{*}				0.031^{*}
			(0.015)				(0.013)
Sustainability Resource Endowments				0.025			0.032
				(0.055)			(0.048)
Sustainability Formal institutions					0.100^{a}		0.149^{*}
					(0.055)		(0.062)
Sustainability Informal institutions						0.007	0.039
						(0.025)	(0.027)
Population (per 10,000 inhabitants)	0.006^{***}	0.004^{***}	0.004^{***}	0.004^{***}	0.004^{***}	0.004^{***}	0.003^{***}
	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
GRP	0.020^{***}	0.006^{**}	0.007^{**}	0.006^{**}	-0.007^{**}	-0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Constant	-1.488^{***}	-0.967^{***}	-0.756^{***}	-0.895^{***}	-1.729^{***}	-0.483	-1.127^{*}
	(0.259)	(0.212)	(0.212)	(0.266)	(0.478)	(0.250)	(0.501)
Observations	268	267	267	267	267	209	209
Marginal R^2	0.549	0.673	0.676	0.673	0.678	0.669	0.710
Conditional R^2	0.695	0.741	0.737	0.740	0.733	0.734	0.726
Log Likelihood	-717.426	-680.677	-675.614	-680.575	-679.160	-564.248	-557.659

Note: ^{a} p<0.1; *p<0.05; **p<0.01; ***p<0.001

We use the r.squaredGLMM function of the MuMIn package (Bartoń, 2023) to calculate the conditional R^2. This measure includes a penalty for the number of fixed effects included in the model. The start-ups variable is divided by 100 in order to address scaling issues that occurred while running the model.

Summary

Sustainable entrepreneurship entails starting novel ventures that combine developing a business (profit) with sustaining the social (people) and natural (planet) environment. These novel ventures are so called sustainable start-ups. In this dissertation I focus on those sustainable start-ups that address environmental sustainability. Environmental sustainability is important because society faces several grand environmental challenges.
Sustainable entrepreneurs play an important role in solving these challenges by introducing new sustainable technologies and business models. This potential role of entrepreneurs is widely acknowledged, but to fulfil their potential two conditions must be met. First, sustainable start-ups need to be present, they need to exist. Second, for sustainable start-ups to significantly contribute to solving societal challenges they need to grow, they need to maintain a healthy business performance.

However, sustainable start-ups are constrained in several ways, and this causes them to encounter additional challenges in founding their business and in maintaining their business performance compared to regular start-ups. I identify four constraints. First, many technology-based sustainable start-ups are constrained because they require more investment capital than other types of start-ups. Second, sustainable start-ups create public value that is often insufficiently accounted for in the prices of goods or services. Third, sustainable start-ups are often institutionally constrained; their products or services do not always comply to market regulations, standards, norms, habits, or cognitive frames. Fourth, sustainable start-ups are often hybrid organizations founded with a combination of economic and environmental aspirations.

The ability of sustainable start-ups to contribute to solving societal challenges depends on the extent to which they are influenced by these constraints. Given the importance of the surrounding environment in these constraints I draw on the entrepreneurial ecosystem framework. I aim to better understand how these constraints influence sustainable start-ups and what can be done to help sustainable start-ups overcome their constraints. As such the research question of my dissertation is:

How do entrepreneurial ecosystems influence the presence of sustainable start-ups?

I conclude that an entrepreneurial ecosystem for sustainable start-ups consists of generic and specific sustainability elements that together form the sustainable entrepreneurial ecosystem. I find that the quality of the generic entrepreneurial ecosystem has a strong positive influence on the presence and prevalence of sustainable start-ups. The quality of a generic entrepreneurial ecosystem is important for the presence of sustainable start-ups, even more so than for their regular counterparts. Furthermore, I find that the presence of sustainable start-ups is positively influenced by the presence of fellow (regular) start-ups, the presence of sustainability-oriented

formal institutions, and to some extend sustainability-oriented resource endowments and sustainability-oriented informal institutions. Policy makers can use my results to develop policies that help build ecosystems for sustainable entrepreneurship in their region. In line with my results, policy makers with this aim could strive to improve both the generic entrepreneurial ecosystem and a sustainability specification. I argue that a first step is to focus on building a strong generic entrepreneurial ecosystem. As the quality of entrepreneurial ecosystems is more important for SSUs than their regular counterparts.

There were five research gaps that needed to be addressed before I could study the main research question. I summarize these research gaps and the main findings regarding each gap. First, at the time of writing there was no large-scale operationalization of the entrepreneurial ecosystem framework. I created a harmonized dataset to measure entrepreneurial ecosystems at the regional level in a large number of countries. I then showed that the inputs of the entrepreneurial ecosystem framework have a strong relation with the outputs. Furthermore, I find that the relation between inputs and outputs is stronger in high-quality entrepreneurial ecosystems.

Second, there was a lack of research on the persistence of high-growth firms over time. The lack of evidence regarding persistence caused Coad & Srhoj (2023) to question the validity of the entrepreneurial ecosystem framework. I address this research gap and their criticism and further articulate the entrepreneurial ecosystem framework based on an extension of their analyses. I introduce three hypotheses on the mechanism between entrepreneurial ecosystems and their outputs and provide empirical evidence for these hypotheses. I explain differential persistence in the prevalence of productive entrepreneurship based on the quality and size of entrepreneurial ecosystems. I conclude that only high-quality entrepreneurial ecosystems and entrepreneurial ecosystems of sufficient size consistently produce high-growth firms.

Third, I engage with another recent debate in the entrepreneurial ecosystem literature, which is the lack of research on interactions across entrepreneurial ecosystem boundaries. I study what factors drive and hinder interactions across the boundaries of a focal entrepreneurial ecosystem. This research aims to understand how start-ups can get access to resources from outside their entrepreneurial ecosystem and thus helps to better understand how start-ups can overcome the resource constraints they face. I find that the ability of actors to engage in cross-entrepreneurial ecosystem interactions is influenced by two logics. The start-up development logic, which does allow for interactions, and the regional development logic that often prevents interactions as it causes actors to transform administrative boundaries into entrepreneurial ecosystem boundaries.

Fourth, there are no studies that specifically address how start-ups can overcome institutional constraints. These institutional constraints could be reduced by actors who engage in institutional entrepreneurship, the process of creating new or changing existing institutions. However, start-ups are not the ideal actor to engage in institutional entrepreneurship due to their limited legitimacy. I discuss how entrepreneurial support organizations can change the institutions in an entrepreneurial ecosystem to help start-ups overcome institutional constraints. I find that entrepreneurial support organizations act as institutional entrepreneurs to change the institutions of the entrepreneurial ecosystem. Public entrepreneurial support organizations in so-called transparent ecosystems are most active as institutional entrepreneurs, highlighting a special role for this type of entrepreneurial support organization.

Fifth, I address the research gap that there is limited evidence on how sustainable start-ups balance their environmental and business performance. Balancing these types of performances is a crucial part of combining the environmental and economic goals with which they are founded. I find that achieving climate performance and business performance simultaneously is not straightforward as both require different strategies. This creates a paradox. I find that start-ups using novel and hardware-based technologies may partly escape the paradox and that having high climate ambitions partly alleviates the negative impact of hardware technologies on business performance.

Samenvatting

Duurzaam ondernemerschap omvat het starten van nieuwe ondernemingen waarin het ontwikkelen van een bedrijf (winst) gecombineerd wordt met het preserveren van de sociale (mensen) en natuurlijke (planeet) omgeving. Deze nieuwe ondernemingen worden duurzame start-ups genoemd. In dit proefschrift focus ik me op duurzame start-ups die zich richten op de milieucomponent van duurzaamheid. Dit is belangrijk vanwege de grote milieu gerelateerde uitdagingen die de samenleving bedreigen.

Duurzame ondernemers spelen een belangrijke rol bij het oplossen van deze uitdagingen omdat ze nieuwe duurzame technologieën en bedrijfsmodellen introduceren. Deze potentiële rol van ondernemers wordt algemeen erkend, maar om hun potentieel te vervullen, moet aan twee voorwaarden worden voldaan. Ten eerste moeten er daadwerkelijk duurzame start-ups zijn. Ten tweede moeten duurzame start-ups groeien en gezonde bedrijfsprestatie behalen. Alleen dan kunnen ze daadwerkelijk bijdragen aan het oplossen van deze maatschappelijke uitdagingen.

Duurzame start-ups hebben echter te maken met verschillende beperkingen. Dit leidt ertoe dat duurzame ondernemers, in vergelijking met reguliere start-ups, extra uitdagingen tegenkomen bij het oprichten van hun bedrijf en bij het handhaven van hun bedrijfsprestaties. Ik constateer vier beperkingen. Ten eerste hebben veel technologie gebaseerde duurzame start-ups meer investeringskapitaal nodig dan andere soorten start-ups. Ten tweede creëren duurzame start-ups publieke waarde en deze is vaak moeilijk te vangen in de prijzen van goederen of diensten. Ten derde hebben duurzame start-ups vaak te maken met institutionele beperkingen; hun producten of diensten voldoen niet altijd aan regelgeving, normen, gewoonten of cognitieve kaders. Ten vierde zijn duurzame start-ups vaak hybride organisaties waar de oprichters economische en milieudoelen moeten balanceren.

De potentie van duurzame start-ups om bij te dragen aan het oplossen van maatschappelijke uitdagingen hangt af van de mate waarin deze beperkingen de start-up beïnvloeden. Gezien de omringende omgeving een cruciale rol speelt bij deze beperkingen, baseer ik me op de literatuur over ondernemende ecosystemen. Het doel van mijn proefschrift is om te begrijpen hoe de genoemde beperkingen duurzame start-ups beïnvloeden en wat er gedaan kan worden om duurzame start-ups te helpen deze beperkingen te overwinnen. De onderzoeksvraag van mijn proefscrift is daarom:

Hoe beïnvloeden ondernemende ecosystemen de aanwezigheid van duurzame start-ups?

Ik concludeer dat een ondernemend ecosysteem voor duurzame start-ups bestaat uit generieke elementen en duurzaamheidsspecificatie elementen. Deze vormen samen het duurzame ondernemend ecosysteem. Ik vind dat de kwaliteit van het generieke

ondernemende ecosysteem een sterke positieve invloed heeft op de aanwezigheid en prevalentie van duurzame start-ups. De kwaliteit van een generiek ondernemend ecosysteem is belangrijk voor de aanwezigheid van duurzame start-ups, dit effect is sterker dan voor reguliere start-ups. Verder vind ik dat de aanwezigheid van duurzame start-ups positief wordt beïnvloed door de aanwezigheid van andere (reguliere) start-ups, de aanwezigheid van duurzaamheid gerelateerde formele instituties, en in zekere mate door duurzaamheid gerelateerde informele instituties en op duurzaamheid gerichte actoren en middelen. Beleidsmakers kunnen mijn resultaten gebruiken bij het ontwikkelen van beleid gericht op het opbouwen van ecosystemen voor duurzaam ondernemerschap in hun regio. Overeenkomstig met mijn resultaten kunnen deze beleidsmakers zich inspannen om zowel het generieke ondernemend ecosysteem als de duurzaamheidsspecificatie te verbeteren. Ik raad aan om eerst te focussen op het opbouwen van een sterk generiek ondernemerschapsecosysteem omdat de kwaliteit van ondernemerschapsecosystemen belangrijker is voor duurzame dan voor reguliere start-ups.

Voordat ik deze hoofdvraag kon bestuderen waren er nog vijf hiaten in de literatuur die eerst onderzocht moesten worden. Hieronder vat ik deze samen en geef ik de belangrijkste bevindingen per onderzoek weer. Ten eerste was er op het moment van schrijven geen grootschalige operationalisatie van ondernemende ecosystemen. Ik maakte een geharmoniseerde dataset waarmee ik de kwaliteit van ondernemende ecosystemen meet. Dit doe ik op regionaal niveau voor een groot aantal landen. Vervolgens toon ik aan dat de elementen van ondernemende ecosystemen een sterke relatie met de ondernemerschapsuitkomsten. Ik vind dat deze relatie tussen sterker is in hoogwaardige ondernemende ecosystemen.

Ten tweede was er een gebrek aan onderzoek naar de persistentie van snelgroeiende bedrijven over de tijd. Dit zorgde ervoor dat Coad & Srhoj (2023) vraagtekens stellen aan de bruikbaarheid van het concept ondernemende ecosystemen. Ik onderzoek dit thema en hun kritiek. Ik stel drie hypothesen op waarin ik het mechanisme tussen de elementen en de uitkomsten van ondernemende ecosystemen herdefinieer. Vervolgens lever ik empirisch bewijs voor deze hypotheses. Ik gebruik de kwaliteit en omvang van ondernemende ecosystemen om verschillen in hoe persistent de prevalentie van productief ondernemerschap is te verklaren. Ik concludeer dat alleen hoogwaardige ondernemende ecosystemen en ondernemende ecosystemen van voldoende omvang consequent snelgroeiende bedrijven produceren.

Ten derde ga ik in op een andere recente discussie in de literatuur over ondernemende ecosystemen, namelijk het gebrek aan onderzoek naar interacties tussen ondernemende ecosystemen. Ik onderzoek welke factoren interacties over de grenzen van een bepaald ondernemend ecosysteem stimuleren of belemmeren. Dit onderzoek heeft als doel om te begrijpen hoe start-ups toegang krijgen tot hulpbronnen van buiten hun ondernemende ecosysteem. Hiermee help ik om beter te begrijpen hoe start-ups de uitdagingen als gevolg van beperkte middelen kunnen overwinnen. Ik vind dat het vermogen van actoren om deel te nemen aan grensoverschrijdende interacties tussen ondernemende ecosystemen beïnvloed wordt door twee logica's. De start-upontwikkelingslogica, die interacties mogelijk maakt, en de regionale ontwikkelingslogica die interacties vaak voorkomt, omdat het actoren stimuleert om administratieve grenzen om te vormen tot de grenzen van het ondernemende ecosysteem.

Ten vierde zijn er geen studies die specifiek ingaan op hoe start-ups institutionele beperkingen kunnen overwinnen. Deze institutionele beperkingen kunnen worden verminderd door actoren die optreden als institutionele ondernemers. Actoren die dit doen creëren nieuwe instituties of veranderen bestaande instituties. De beperkte legitimiteit van start-ups maakt het echter moeilijk voor ze om effectief op te treden als institutionele ondernemers. Ik beschrijf hoe incubatoren en andere ondersteunende organisatie de instituties in een ondernemend ecosysteem kunnen veranderen en daarmee start-ups kunnen helpen om institutionele beperkingen te overwinnen. Ik vind dat ondernemerschapsorganisaties inderdaad optreden als institutionele ondernemers om de instituties in ondernemende ecosystemen te veranderen. Publieke incubatoren en andere publieke ondersteunende organisatie, in zogenaamde transparante ecosystemen, zijn het meest actief als institutionele ondernemers. Dit laat zien dat deze organisaties een speciale rol vervullen rondom institutionele veranderingen.

Ten vijfde doe ik onderzoek om het beperkte bewijs over hoe duurzame start-ups hun milieuprestaties en bedrijfsprestaties in evenwicht houden aan te vullen. Het balanceren van deze twee soorten prestaties is een cruciaal onderdeel van het combineren van de milieu en economische motivaties waarmee ze zijn opgericht. Ik vind dat het tegelijkertijd behalen van klimaatprestaties en bedrijfsprestaties niet eenvoudig is omdat beide verschillende strategieën vereisen. Dit creëert een paradox. Wel kunnen start-ups die gebruik maken van nieuwe en op hardware gebaseerde technologieën deels aan deze paradox ontsnappen. Daarnaast vind ik dat het hebben van hoge klimaatambities de negatieve impact van hardware technologieën op bedrijfsprestaties deels verlicht.

Word of thanks

I started my dissertation with the story of how I discovered my passion for sustainable entrepreneurship at the ClimateLaunchpad finals in Tallinn, Estonia. However, reflecting on my PhD I think the actual story starts much earlier, in 1995. A two-year-old me walked around at the party that my parents threw together because they both successfully obtained their doctorates. To keep an eye on me my parents tied an inflatable balloon to my pants...

Lieve pappa en mamma, you taught me to see the world around me, which is one of the most special gifts I received. Looking back, it is no surprise that, as the child of two ecosystem biologists, I developed a love for nature. This love for nature laid the foundation for the sustainability focus of my working life, and particularly this dissertation. And although I didn't study the natural ecosystems (dunes and marches) that were central in your dissertations the fact that my dissertation is still about ecosystems really feels like coming full circle. Thank you for your love, support, care, encouragement, and inspiration.

Moving on to my academic inspirers. Frank, when you invited me to talk about doing a PhD I came well prepared with all the reasons why I did not want to become a researcher. In that meeting you systematically debunked, countered or found solutions for all my arguments, so to my surprise I started working on a PhD. And throughout my PhD you have continued to do all three of these things. You debunked incorrect assumptions, you provided counter arguments to underdeveloped ideas, and you were extremely creative in finding solutions. Thank you for the many opportunities to work together on research, teaching, and impact. You also tried hard to get me to be more concise and compact. But if you really succeeded there... Finally, I want to thank you for the many fun international trips and bike rides. Looking back, I have never been so happy to be wrong as during that initial talk. I loved doing my PhD.

Erik, from the first moment that we discussed my PhD you always reiterated that I was in the lead. Thank you for your continuous trust, for the (guided) freedom and many opportunities. Perhaps the most important lesson I learned is that doing research (at least for you and me) goes in waves. The fact that you also experienced and acknowledged that made it much easier for me to ride the waves rather than try to create my own. Looking back to the start of my PhD I also remember how I left the first 'official' meeting of my PhD feeling utterly confused. For an hour, I listened to conversations about people and concepts I had never heard of, and I found myself wondering what I was getting myself into working with economists. Looking back, I see some similarities to the coaching philosophy of basketball coach Ton Boot because since then, each visit to U.S.E became less confusing, and I have slowly started to also see myself as a bit of an 'undisciplined economist'.

Timon, I want to thank you for a lot of things, and at the time of writing your valiant efforts in helping protect the medals I earned during the 'Tour du Jip' seems like an obvious place to start. Furthermore, the many hours spend playing board games, talking, and during the 'The adventures of Timon and Jip abroad' come to mind. But I will restrain myself and just say that I have many fond memories of all these things with the 'Bullfighting' in Madrid as the undisputed highlight. Because most of all, I want to thank you for your friendship.

I also want to thank all my other co-authors. Chris, thank you for your enthusiasm in the early stages of my PhD. Your insistence on definitions as a requirement to understand phenomena has served me well along the way. Mirella, it has been a pleasure to simultaneously work on entrepreneurial ecosystems. I look forward to continuing our regular calls to address the challenges that remain with entrepreneurial ecosystem metrics. Jasper, I really enjoyed turning a shared frustration to into a paper. Yvette, your limitless enthusiasm about turning education in impact has been inspiring. Sharon, I learned a lot from (and enjoyed) our discussions about our paper but especially about life in academia during my visits to Eindhoven. Maral, I love how excited you could be about theoretical/conceptual papers where I had no clue what the authors were talking about. Hopefully, one day I will also understand those papers and share this excitement with you.

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A special thanks to the new PhDs Remi, Sanne, and Paula for adopting me after all of the other 7.30 PhDs had either completed their PhDs or decided to complete their PhD next to a new job. I had a blast sharing offices with you. Remi, thank you for our conversations about our futures including the thorough analyses of which PostDoc position I should choose. Sanne, thank you for the many discussions on ISFE and for all the (for me) completely random 'carnaval' related events that you brought to the office. Paula, thank you for thinking along about all the challenges with chapter orders (what about something random like '5,3,1,2,6'), structures, and lay-outs that I encountered.

While some of them were already named I want to say thank you to all my fellow teachers, Frank, Timon, Bart, Sanne, Abe, Vivian, Joost etc., for your inspiring ideas, enthusiasm and feedback. I really enjoyed sharing the joys (and misery) of teaching with you.

Furthermore, thanks to my other colleagues. Mark, for giving me an opportunity to work on the IRIS project and the critical discussions about science and ecosystems

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Moving back to friends and family. One of the challenges of a PhD is to stop thinking and let some lessons or thoughts simmer. So, thanks to all my friends, basketball teammates, fellow coaches, cycling buddies, or party animals (and those who fit in all categories) for this. Jim, Joeri, Yorrick, Sanne, Maarten, Anouk, Florian, Tijs, John, Tirso, Yoeri, and Biko to name a few.

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About the Author

Jip Leendertse was born in Amsterdam on June 15th, 1993. After completing high school at Niftarlake College he moved to Oklahoma, United States for a year abroad. Upon his return to the Netherlands, Jip obtained a Bachelor of Science degree in Science and Innovation Management (cum laude) from Utrecht University. This included a one semester visit to RMIT University in Melbourne, Australia. Jip then obtained his Master of Science degree in Innovation Sciences (cum laude) also from Utrecht University.

During his student years he started his own consultancy company 'Cocon Innovatie'. After completing his master thesis on the paradox between business and climate performance in 2018, he decided that studying entrepreneurs was a better fit than being an entrepreneur. Therefore, he started a PhD project on sustainable entrepreneurship with joined supervision by the Utrecht School of Economics and the Copernicus Institute of Sustainable Development.

His research has been shared at numerous international conferences and has been published in peer-reviewed journals. Furthermore, Jip contributed to writing several professional reports. As a result of his extensive teaching activities Jip obtained his University Teaching Qualification from Utrecht University.

Jip currently continues his academic career as a postdoctoral researcher working at the TU Delft where he studies the link between sustainable entrepreneurs and public clients as a member of the Faculty of Architecture and the Built Environment.

Peer reviewed publications

- Leendertse, J., Schrijvers, M., & Stam, E. (2022). Measure twice, cut once: Entrepreneurial ecosystem metrics. Research Policy, 51(9), 104336.
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- van Rijnsoever, F. J., & Leendertse, J. (2020). A practical tool for analyzing socio-technical transitions. Environmental Innovation and Societal Transitions, 37, 225-237.