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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 273 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.

Plain English Summary Sustainable start-ups are more dependent on the characteristics of a region that promotes entrepreneurship in general than on factors specific to sustainability. The characteristics that promote entrepreneurship in a region are called entrepreneurial ecosystems. Examples of generic ecosystem characteristics are investment capital and human capital, while strong environmental regulations or

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knowledge about sustainability are specific characteristics. Until now, it was unknown whether the generic ecosystem or the specific sustainability elements are more important for the founding of sustainable start-ups in a region. Our analyses show that sustainable start-ups are more dependent on the generic elements than on the sustainability-specific elements of entrepreneurial ecosystems. We also show that the quality of the generic ecosystem is more important for sustainable start-ups than for regular start-ups. Sustainable start-ups can play an important role in solving major environmental challenges. Policymakers can use our results to develop policies aimed at building ecosystems for sustainable entrepreneurship in their region. We advise them to initially focus on building a strong generic entrepreneurial ecosystem.

Keywords Sustainable entrepreneurship · Sustainable entrepreneurial ecosystems · Entrepreneurial ecosystems · Innovation systems · Sustainable start-ups · Environmental entrepreneurship

JEL Classification L26 · M13 · O03 · Q01 · Q55 · Q56 · R11 · R12

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 & Ellingsen, 2014; Cohen & 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 & 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 (Acs & Audretsch, 2005; Ács et al., 2014; Alvedalen & Boschma, 2017; Stam, 2015) on which the occurrence of entrepreneurship depends (Shane & Venkataraman, 2000). These factors are widely studied and have been summarized in the entrepreneurial ecosystem framework (Alvedalen & Boschma, 2017; Andersson & 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 & Spigel, 2018).

The EE framework initially focused on productive entrepreneurship independent of sector or type of entrepreneurship (Stam and van de Ven, 2021). However, recently, there have been 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 & 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 & 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, 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 & 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 273 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 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.

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.

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 & McMullen, 2007; van Rijnsoever, 2022). There is much heterogeneity among SSUs (Schaltegger & 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 from investing in SSUs (De Lange, 2017; Giudici et al., 2019; Mansouri & Momtaz, 2022; Martin & 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, particularly in Europe (Lin, 2022); as a result, there is an increasing availability of capital for SSUs (Mansouri & Momtaz, 2022). This might reduce the impact of this constraint.

The second constraint faced by SSUs is that they operate in imperfect or failing markets (Hoogendoorn et al., 2019; Pinkse & Groot, 2015). SSUs offer solutions that reduce the negative externalities of existing products or services (Cohen & Winn, 2007). Reducing negative externalities creates public value that is often insufficiently accounted for in the prices of goods or services (Cohen & Winn, 2007; Dean & 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 & 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 with 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 & Warnick, 2016; Munoz & 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 & Winn, 2007; Dean & 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 & 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).

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 framework, the focus is placed on the entrepreneurial actor, who is influenced by his environment, and 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 influence the outputs, productive entrepreneurship. The outputs in turn influence the EE through downward causation, and they also influence the outcomes and 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; Van Dijk et al., 2025). However, recently, several studies have started addressing EEs in specific sectors, such as digital (Bejjani et al., 2023), biotech (Auerswald & 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). These studies identify specific characteristics of 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 & 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, 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 (2) an institutional regime and (3) an infrastructure (Carlsson &

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 into two layers: *resource endowments* and *institutional arrangements.* The institutional arrangements cover both the informal (culture) and formal institutions that makeup 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 of 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 & 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 systems because innovation systems approaches have already been used extensively to understand sustainability (Carlsson & Stankiewicz, 1991; Hekkert et al., 2007).

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 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 on the EE framework by Spigel (2017). However, a systematic evaluation of how the combination of generic and specific sustainability EE elements influences the presence of SSUs is lacking (DiVito & Ingen-Housz, 2021; Volkmann et al., 2021). As a result, additional factors that are important for SSUs could be missing from the SEE literature (DiVito & Ingen-Housz, 2021; Giudici et al., 2019; Tiba et al., 2021). In this paper, we do provide such a systematic evaluation. For this purpose, we build on the shared conceptual basis between the EE and innovation systems approaches. This enables the identification of additional elements that differentiate a specific from a generic EE.

Rather than adapting every element of existing frameworks, we take a step back. To conceptualize SEEs, we combine the entrepreneurial ecosystem and the innovation system frameworks using (1) actors and resources and (2) institutional regime layers (Carlsson & Stankiewicz, 1991; van Rijnsoever et al., 2015). We argue that the sustainable entrepreneurial ecosystem can be found at the nexus between an entrepreneurial ecosystem and an innovation system for sustainability.

This allows us to derive factors that promote SSUs from outside the extant EE-literature that can be categorized into the two layers of the EE. We present our conceptual framework for SEEs (Fig. 1) 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 that 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 & 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.

2.3.1 Generic entrepreneurial 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

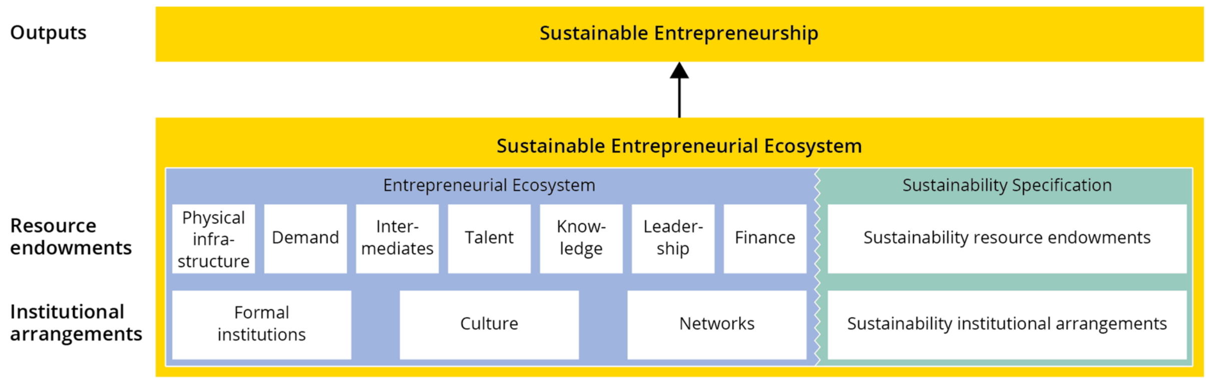


Fig. 1 Conceptual framework for sustainable entrepreneurial ecosystems

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 & 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 regular start-ups, partially help SSUs overcome these constraints. We thus expect that SSUs benefit from a supportive EE and hypothesize that:

> **Hypothesis 1**: (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 the presence of regular start-ups.

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 fulfill 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:

> **Hypothesis 2**: The number of start-ups in a region has a positive influence on the presence of SSUs in a region.

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 & 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 & 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:

Hypothesis 3: The presence of sustainability-oriented actors and resources has a positive influence on the presence of SSUs in a region.

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 & Schot, 2007). In line with the innovation systems literature, we make the distinction between formal and informal institutions (Edquist & Johnson, 1997; North, 1990; 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 with 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 toward 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 favorable norms and values about sustainability in a region mean 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 & Ingen-Housz, 2021). This demand can also serve as a driver for entrepreneurs to establish SSUs (Boluk & 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:

Hypothesis 4: The presence of favorable (a) formal and (b) informal institutions regarding sustainability has a positive influence on the presence of SSUs in a region.

3 Methodology

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 levels. 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 the seven 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.

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 from 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 and 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 members 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 and 2017 (CORDIS, 2022; European Commission, 2022). From the PATSTAT database, we selected patents with priority years 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 environmental tax revenues. This data contains the share of the total taxes that come from environmental taxes between 2013 and 2017. Sixth, for our informal institutions variable, we use data from the European Social Survey 8, conducted in 2016. There is micro-data available on the NUTS-2 level but only for 211 instead of 273 regions as several countries did not 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.

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 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 web pages 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 and 2021. We were thus able 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 a variety of 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 identifying a thesaurus, we manually coded a sample of 100 start-ups on whether they could be considered 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 in publications (Romero Goyeneche et al., 2021, 2022) 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 and insulation”, or a combination of both, e.g., “life cycle and 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 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 addresses 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

[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

reflected SSUs for which environmental sustainability was a central component of 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 a robustness check using both harsher and more lenient cut-off values. With a cut-off value of 1 match per 50 words, we identified 4.4% of start-ups as SSUs, and with a more lenient cut-off value of 1 match per 200 words, we identified 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 are 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 which 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 and 2021.

3.4 Independent variables

A full overview of the independent variables and their empirical indicators is shown in Table 1. We record most of the independent variables between 2013 and 2017, creating a time lag with our dependent variable, which is recorded from 2017 to 2021.

3.4.1 Generic entrepreneurial ecosystems operationalization

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 A.

Table 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 of 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 that 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

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 identified 48,681 start-ups founded from 2015 to 2017. The start-ups founded in this period can thus support SSUs founded in the future, between 2017 and 2021.

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 Sect. 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 of 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 & 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 toward 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.

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 and 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 B. We use all responses of citizens in a region to calculate the average regional score for the answer to 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.

3.4.5 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 and 2017 per 10,000 inhabitants. Second, we control for the wealth of each

Table 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

region through the Gross Regional Product (GRP) per capita, for which we use the standardized average between 2015 and 2017 as present in the RCI.

3.4.6 Analysis

Table 2 shows the mean, standard deviation, and 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 modeling dependent variables with a value between 0 and 1 (Ferrari & Cribari-Neto, 2004). We tested Hypotheses 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 are 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.

4 Results

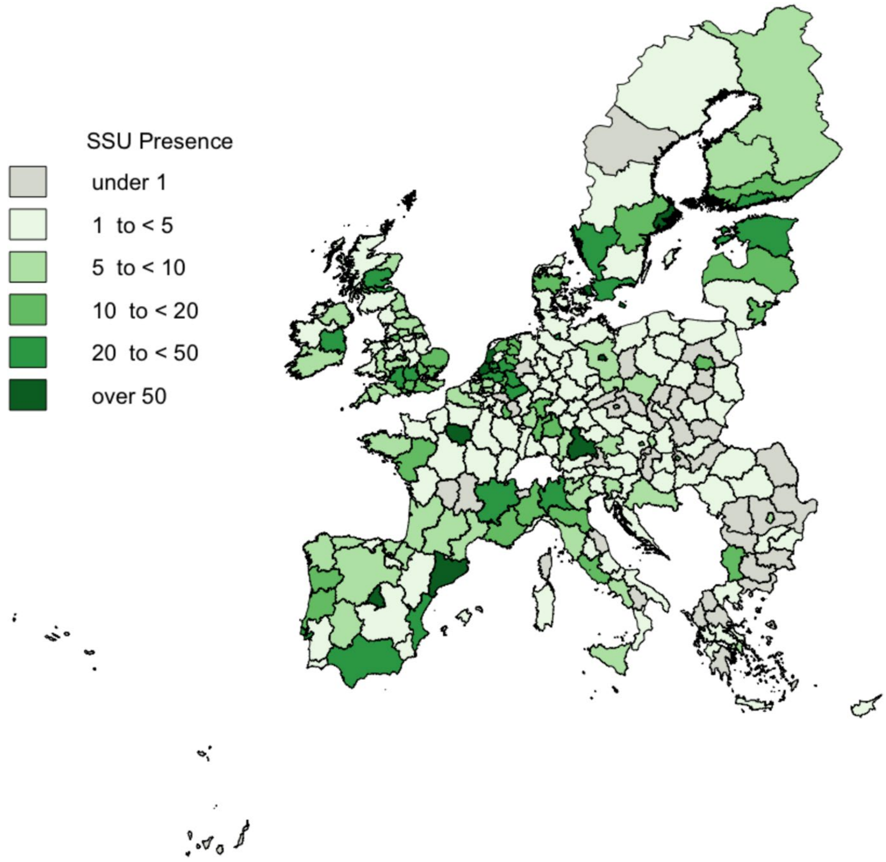
4.1 Descriptive results

Figure 2 shows a map with the presence of SSUs per region, and Fig. 3 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 of the top 10 we see that most regions are in Northwestern Europe, while there are two Southern European regions, the Spanish regions Madrid and Cataluña among the top 10. In general, we find relatively few Eastern European regions with a large SSU presence. Estonia, which ranks 14th, is the lone Eastern European region among the top 30.

4.2 Regression analyses

Table 3 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

Fig. 2 The presence of sustainable start-ups per region in Europe



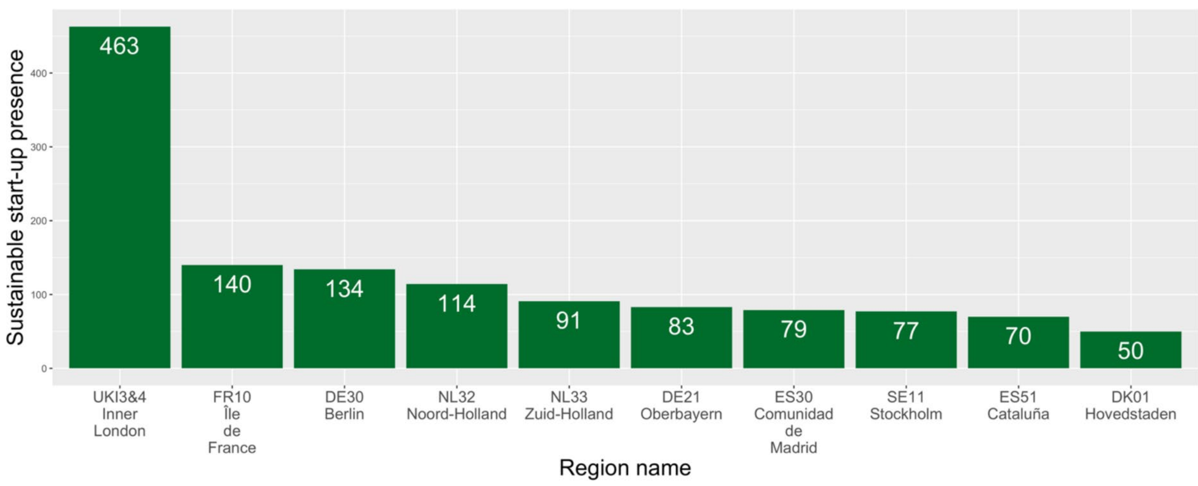


Fig. 3 The ten European regions with the highest number of sustainable start-ups

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 Hypothesis 1a, 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 Hypothesis 1b (Table 4), 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 Hypothesis 2. This indicates that SSUs benefit from peer effects. In line with Hypothesis 3, 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. In line with Hypothesis 4a, we find that sustainability formal institutions (Model 5) have a positive significant effect on the presence of SSUs in a region.

The effects of Hypotheses 1a, 2, 3, and 4a remain significant in the full model that includes all independent and control variables (Model 7), this adds to

Table 3 Negative binomial regression results

	Dependent variable						
	Sustainable start-up presence						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Entrepreneurial ecosystem index		0.118***	0.081***	0.109***	0.116***	0.141***	0.095***
		(0.011)	(0.012)	(0.012)	(0.011)	(0.013)	(0.014)
Fellow start-ups			0.001***				0.000***
			(0.000)				(0.000)
Sustainability resource endowments				0.087*			0.072^{a}
				(0.042)			(0.040)
Sustainability formal institutions					0.152***		0.175***
					(0.035)		(0.051)
Sustainability informal institutions						−0.005	0.035^{a}
						(0.019)	(0.020)
Population (per 10,000 inhabitants)	0.005***	0.004***	0.003***	0.004***	0.004***	0.004***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GRP	0.022***	0.004^{a}	0.005*	0.003	−0.006**	−0.003	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Constant	−1.289***	−0.653***	−0.370*	−0.433	−1.974***	−0.207	−1.034*
	(0.214)	(0.182)	(0.177)	(0.229)	(0.350)	(0.233)	(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

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

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

Table 4 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*	0.000a
	(0.000)	(0.000)
GRP	0.007***	0.004a
	(0.001)	(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

[a]$p<0.1$; [*]$p<0.05$; [**]$p<0.01$; [***]$p<0.001$

the robustness of our findings regarding these hypotheses. However, the sustainability-oriented resource endowments are 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 has over 60 fewer observations than previous models. This is due to missing values for our sustainability informal institutions variable. To exclude this explanation, we run an additional model that includes all variables except for informal institutions (Appendix: Table C1). This analysis gives similar results, except for the sustainability-oriented resource endowments variable that is not significant in this robustness test. This alternative explanation, therefore, does not explain our findings.

Regarding sustainability informal institutions (Hypothesis 4b), 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 & 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 & 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 (Hypothesis 3) and informal institutions variables (Hypothesis 4a) are not significant in the multilevel models (Appendix: Table C2). 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.

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 Hypotheses 1a, 1b, 2, and 4a. We find partial support for Hypotheses 3 and 4b. A clear evaluation of the combined influence of sustainability-oriented resource endowments and institutions on the presence of SSUs in regions requires further research.

5 Discussion

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 a 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 & 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 & 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 & 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). This is particularly relevant as several recent studies have started a debate on how the EE literature can be used to understand the dynamics in specific sectors, such as digital (Bejjani et al., 2023), biotech (Auerswald & 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). These studies often take a sub-ecosystem approach in which the specific EE is considered fully nested within the generic EE (Loots et al., 2021; Theodoraki & Messeghem, 2017). Our paper extends this sub-ecosystem perspective as we show that, while a specific EE is indeed nested in the generic EE, it also extends beyond it to the innovation system of a sector. Our conceptualization, of a specific EE as located at the nexus between the generic EE and a specific innovation system, does provide a bridge to better align the concept of specific EEs with the generic EE framework of Stam (2015).

We recommend that future researchers also study other sectors, such as biotech, fintech, deeptech, or agrifood in the same manner. Such studies will help to gain insights into whether our findings only apply the sustainability context, or are also applicable to other sectors. This gives more conclusive insights into the generic-specific ecosystem debate.

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 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, was 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.

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 of 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 keeping 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 to 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 toward the various technological and sector fields that SEEs are active in. Of particular interest could be the effect of different types of formal institutions. We argued that formal institutions can consist of favorable and unfavorable policies that stimulate or hinder (non-)sustainability. Future research could analyze the effect of these types of policies in more depth by studying whether it is more effective to implement regulations that reward sustainability or regulations that punish non-sustainability.

Finally, we only explained the presence of SSUs in a region. Future research could study how the SEE elements influence the success of SSUs.

5.3 Practical implications

Policy makers can use our results to develop policies that help build ecosystems for sustainable entrepreneurship in their region. We provide detailed information on the number of SSUs 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. They can identify best practices from regions with high numbers of SSUs and implement these in their own region.

Furthermore, we show that building ecosystems for sustainable entrepreneurship requires a dual perspective, SSUs can benefit from both a generic entrepreneurial ecosystem and an innovation system specific to sustainability. 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 the first step is to focus on building a strong generic entrepreneurial ecosystem. There are two reasons for this. First, the generic entrepreneurial ecosystem is a stronger predictor of the presence of SSUs than the sustainability specifications. Second, the quality of entrepreneurial ecosystems is more important for SSUs than their regular (non-SSU) counterparts, a better generic entrepreneurial ecosystem does not just lead to more SSUs, it also means that a higher percentage of start-ups is sustainable.

The metrics on the quality of generic entrepreneurial ecosystems, as presented in the works by Leendertse et al. (2022) and Schrijvers et al. (2023) can help policy makers to identify which elements can be improved in their region. For example, should they look to improve the availability of investment capital, or regulations for general companies, or to increase the available talent through education?

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 and resources and thereby help them overcome the constraints they face, but we need more evidence for this relationship.

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References

Ács, Z. J., Autio, E., & Szerb, L. (2014). National systems of entrepreneurship: Measurement issues and policy implications. *Research Policy, 43*, 476–494. https://doi.org/10.1016/j.respol.2013.08.016

Acs, Z. J., & Audretsch, D. B. (2005). Entrepreneurship, innovation, and technological Change. *Foundations and Trends in Entrepreneurship, 1*, 149–195.

Ainsworth, S. G., AlSum, A., Salah Eldeen, H., Weigle, M., Nelson, M. (2011). How much of the web is archived. Association for computing machinery. In *Proceedings of the 11th annual international ACM/IEEE joint conference on Digital libraries* (pp. 133–136).

Ajzen, I., & Fishbein, M. (2000). Attitudes and the attitude-behavior relation: Reasoned and automatic processes. *European Review of Social Psychology, 11*, 1–33. https://doi.org/10.1080/14792779943000116

Alaassar, A., Mention, A.-L., & Aas, T. H. (2022). Ecosystem dynamics: Exploring the interplay within fintech entrepreneurial ecosystems. *Small Business Economics, 58*, 2157–2182. https://doi.org/10.1007/s11187-021-00505-5

Alkemade, F., Hekkert, M. P., & Negro, S. O. (2011). Transition policy and innovation policy: Friends or foes? *Environmental Innovation and Societal Transitions, 1*, 125–129. https://doi.org/10.1016/j.eist.2011.04.009

AlNoamany, Y., AlSum, A., Weigle, M. C., & Nelson, M. L. (2014). Who and what links to the internet archive. *International Journal on Digital Libraries, 14*, 101–115. https://doi.org/10.1007/s00799-014-0111-5

Alvedalen, J., & Boschma, R. (2017). A critical review of entrepreneurial ecosystems research: Towards a future research agenda. *European Planning Studies, 25*, 887–903. https://doi.org/10.1080/09654313.2017.1299694

Andersson, M., & Koster, S. (2011). Sources of persistence in regional start-up rates-evidence from Sweden. *Journal of Economic Geography, 11*, 179–201. https://doi.org/10.1093/jeg/lbp069

Auerswald, P. E., & Dani, L. (2017). The adaptive life cycle of entrepreneurial ecosystems: The biotechnology cluster.

Small Business Economics, 49, 97–117. https://doi.org/10.1007/s11187-017-9869-3
Austin, J., Stevenson, H., & Wei-Skillern, J. (2006). Social and commercial entrepreneurship: Same, different, or both? *Entrepreneurship Theory and Practice, 30*, 1–22. https://doi.org/10.1111/j.1540-6520.2006.00107.x
Bartoń, K., (2023). MuMIn: multi-model inference. *R package version. 48.4*. https://doi.org/10.32614/CRAN.package.MuMIn
Bejjani, M., Göcke, L., & Menter, M. (2023). Digital entrepreneurial ecosystems: A systematic literature review. *Technol Forecast Soc Change, 189*, 122372. https://doi.org/10.1016/j.techfore.2023.122372
Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy, 37*, 407–429. https://doi.org/10.1016/j.respol.2007.12.003
Bivand, R., Keitt, T., Rowlingson, B. (2019) rgdal: Bindings for the "geospatial" data abstraction library. *R package version 1.4–7*. http://cran.r-project.org/package=rgdal
Bjornali, E. S., & Ellingsen, A. (2014). Factors affecting the development of clean-tech start-ups: A literature review. *Energy Procedia, 58*, 43–50. https://doi.org/10.1016/j.egypro.2014.10.407
Bogers, M., Biermann, F., Kalfagianni, A., & Kim, R. E. (2022). Sustainable development goals fail to advance policy integration: A large-n text analysis of 159 international organizations. *Environmental Science & Policy, 138*, 134–145. https://doi.org/10.1016/j.envsci.2022.10.002
Boluk, K. A., & Mottiar, Z. (2014). Motivations of social entrepreneurs blurring the social contribution and profits dichotomy. *Social Enterprise Journal, 10*, 53–68. https://doi.org/10.1108/sej-01-2013-0001
Breschi, S., Lissoni, F. (2004). Knowledge networks from patent data: methodological issues and research targets. In Handbook of quantitative science and technology research: The use of publication and patent statistics in studies of SspsampspsT systems (pp. 613–643). Springer Netherlands.
Carlsson, B., & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics, 1*, 93–118.
Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy, 43*, 1164–1176. https://doi.org/10.1016/j.respol.2014.04.014
Coad, A., & Srhoj, S. (2023). Entrepreneurial ecosystems and regional persistence of high growth firms: A 'broken clock' critique. *Research Policy, 52*, 104762. https://doi.org/10.1016/j.respol.2023.104762
Cohen, B. (2006). Sustainable valley entrepreneurial ecosystems. *Business Strategy and the Environment, 15*, 1–14. https://doi.org/10.1002/bse.428
Cohen, B., & Winn, M. I. (2007). Market imperfections, opportunity and sustainable entrepreneurship. *Journal of Business Venturing, 22*, 29–49. https://doi.org/10.1016/j.jbusvent.2004.12.001
Cooke, P. (2002). Biotechnology clusters as regional, sectoral innovation systems. *International Regional Science Review, 25*, 8–37. https://doi.org/10.1177/016001760202500102
Cooke, P. (2007). Regional innovation, entrepreneurship and talent systems. *International Journal of Entrepreneurship and Innovation Management, 7*(2–5), 117–139. https://doi.org/10.1504/IJEIM.2007.012878
CORDIS, (2022). EU research projects under Horizon 2020 (2014-2022) - Datasets [WWW Document]. URL https://data.europa.eu/euodp/en/data/dataset/cordisH2020projects. Accessed 19 Dec 2019
De Lange, D. E. (2017). Start-up sustainability: An insurmountable cost or a life-giving investment ? *Journal of Cleaner Production, 156*, 838–854. https://doi.org/10.1016/j.jclepro.2017.04.108
Dean, T. J., & McMullen, J. S. (2007). Toward a theory of sustainable entrepreneurship: Reducing environmental degradation through entrepreneurial action. *Journal of Business Venturing, 22*, 50–76. https://doi.org/10.1016/j.jbusvent.2005.09.003
Dean, B. (2022). Google's 200 ranking factors: The complete list [WWW Document]. https://backlinko.com/google-ranking-factors. Accessed 22 Dec 2022
Debackere, K., Luwel, M., & Veugelers, R. (1999). Can technology lead to a competitive advantage? A case study of Flanders using European patent data. *Scientometrics, 44*, 379–400. https://doi.org/10.1007/BF02458486
DiVito, L., & Ingen-Housz, Z. (2021). From individual sustainability orientations to collective sustainability innovation and sustainable entrepreneurial ecosystems. *Small Business Economics, 56*, 1057–1072. https://doi.org/10.1007/s11187-019-00254-6
Edquist, C., Johnson, B. (1997). Chapter 2: Institutions and organisations in systems of innovation. In Systems of innovation: Technologies, institutions and organizations. Taylor & Francis
European Commission, (2018). Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May2003 on the establishment of a common classification of territorial units for statistics (NUTS).
European Commission. (2022). Horizon 2020 | The EU framework programme for research and innovation [WWW Document]. URL https://ec.europa.eu/programmes/horizon2020/en. Accessed 19 Dec 2019
Eurostat.(2022). Eurostat [WWW Document]. URL https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts. Accessed 26 Nov 2019
Evans, D. (2018). Hardware startups are only as successful as their cash flow management. Forbes.com. https://www.forbes.com/sites/daveevans/2018/11/14/hardware-startups-are-only-as-successful-as-their-cash-flow-management/
Ferrari, S., & Cribari-Neto, F. (2004). Beta regression for modelling rates and proportions. *Journal of Applied Statistics, 31*, 799–815.
Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional

theory. *Research Policy, 33*, 897–920. https://doi.org/10.1016/j.respol.2004.01.015
Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy, 36*, 399–417. https://doi.org/10.1016/j.respol.2007.01.003
Gibbs, D. C. (2006). Sustainability entrepreneurs, ecopreneurs and the development of a sustainable economy. *Greener Management International*. https://doi.org/10.9774/GLEAF.3062.2006.au.00007
Giudici, G., Guerini, M., & Rossi-Lamastra, C. (2019). The creation of Cleantech startups at the local level: The role of knowledge availability and environmental awareness. *Small Business Economics, 52*, 815–830. https://doi.org/10.1007/s11187-017-9936-9
Google. (2022). Search engine optimization (SEO) Starter Guide [WWW Document]. https://developers.google.com/search/docs/fundamentals/seo-starter-guide#navisimportant. Accessed 22 Dec 2022
Google Maps. (2022). Google Maps [WWW Document]. URL https://www.google.com/maps?hl=nl. Accessed 20 Dec 2022
Hart, J. (2006). The new capitalists: Is it possible to make money and really make a difference? *UTNE-MINNEAPOLIS, 135*, 39–43.
Hechavarría, D. M., Terjesen, S. A., Ingram, A. E., Renko, M., Justo, R., & Elam, A. (2017). Taking care of business: The impact of culture and gender on entrepreneurs' blended value creation goals. *Small Business Economics, 48*, 225–257. https://doi.org/10.1007/s11187-016-9747-4
Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change, 74*, 413–432. https://doi.org/10.1016/j.techfore.2006.03.002
Hille, E., Althammer, W., & Diederich, H. (2020). Environmental regulation and innovation in renewable energy technologies: Does the policy instrument matter? *Technol Forecast Soc Change, 153*, 119921. https://doi.org/10.1016/j.techfore.2020.119921
Hoogendoorn, B. (2016). The prevalence and determinants of social entrepreneurship at the macro level. *Journal of Small Business Management, 54*, 278–296. https://doi.org/10.1111/jsbm.12301
Hoogendoorn, B., van der Zwan, P., & Thurik, R. (2019). Sustainable entrepreneurship: The role of perceived barriers and risk. *Journal of Business Ethics, 157*, 1133–1154. https://doi.org/10.1007/s10551-017-3646-8
Hörisch, J., Kollat, J., & Brieger, S. A. (2017). What influences environmental entrepreneurship? A multilevel analysis of the determinants of entrepreneurs' environmental orientation. *Small Business Economics, 48*, 47–69. https://doi.org/10.1007/s11187-016-9765-2
Horne, J., Recker, M., Michelfelder, I., Jay, J., & Kratzer, J. (2020). Exploring entrepreneurship related to the sustainable development goals - Mapping new venture activities with semi-automated content analysis. *Journal of Cleaner Production, 242*, 118052. https://doi.org/10.1016/j.jclepro.2019.118052
Johnson, M. P., & Schaltegger, S. (2020). Entrepreneurship for sustainable development: A review and multilevel causal mechanism framework. *Entrepreneurship Theory and Practice, 44*, 1141–1173. https://doi.org/10.1177/1042258719885368
Jolink, A., & Niesten, E. (2015). Sustainable development and business models of entrepreneurs in the organic food industry. *Business Strategy and the Environment, 24*, 386–401. https://doi.org/10.1002/bse.1826
Kemp, R. R. (1994). Technology and the transition to environmental sustainability. *Futures, 26*, 1023–1046.
Leendertse, J., van Rijnsoever, F. J., & Eveleens, C. P. (2021). The sustainable start-up paradox: Predicting the business and climate performance of start-ups. *Business Strategy and the Environment, 30*, 1019–1036. https://doi.org/10.1002/bse.2667
Leendertse, J., Schrijvers, M., & Stam, E. (2022). Measure twice, cut once: Entrepreneurial ecosystem metrics. *Research Policy, 51*, 104336. https://doi.org/10.1016/j.respol.2021.104336
Lin, L. (2022). Venture capital in the rise of sustainable investment. *European Business Organization Law Review, 23*, 187–216. https://doi.org/10.1007/s40804-021-00238-8
Linnanen, L. (2002). An insider's experiences with environmental entrepreneurship. *Greener Management International, 2002*, 71–80. https://doi.org/10.9774/GLEAF.3062.2002.su.00008
Loots, E., Neiva, M., Carvalho, L., & Lavanga, M. (2021). The entrepreneurial ecosystem of cultural and creative industries in Porto: A sub-ecosystem approach. *Growth Change, 52*, 641–662. https://doi.org/10.1111/grow.12434
Mair, J., & Marti, I. (2006). Social entrepreneurship research: A source of explanation, prediction, and delight. *Journal of World Business, 41*, 36–44. https://doi.org/10.1016/j.jwb.2005.09.002
Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy, 31*, 247–264. https://doi.org/10.1016/S0048-7333(01)00139-1
Mansouri, S., & Momtaz, P. P. (2022). Financing sustainable entrepreneurship: ESG measurement, valuation, and performance. *Journal of Business Venturing, 37*, 106258. https://doi.org/10.1016/j.jbusvent.2022.106258
Martin, P. R., & Moser, D. V. (2016). Managers' green investment disclosures and investors' reaction. *Journal of Accounting and Economics, 61*, 239–254. https://doi.org/10.1016/j.jacceco.2015.08.004
McMullen, J. S., & Warnick, B. J. (2016). Should we require every new venture to be a hybrid organization? *Journal of Management Studies, 53*, 630–662. https://doi.org/10.1111/joms.12150
Munoz, P., & Cohen, B. (2018). Sustainable entrepreneurship research: Taking stock and looking ahead. *Bus Strategy Environ, 27*, 300–322. https://doi.org/10.1002/bse.2000
Neck, H. M. H., Meyer, G. D., Cohen, B., & Corbett, A. C. (2004). An entrepreneurial system view of new venture creation. *Journal of Small Business Management, 42*, 190–208. https://doi.org/10.1111/j.1540-627X.2004.00105.x
North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.

OpenStreetMap, 2022. OpenStreetMap [WWW Document]. URL https://www.openstreetmap.org/ (accessed 12.20.22).

Pinkse, J., & Groot, K. (2015). Sustainable entrepreneurship and corporate political activity: Overcoming market barriers in the clean energy sector. *Entrepreneurship Theory and Practice, 39*, 633–654. https://doi.org/10.1111/etap.12055

Polzin, F., & Sanders, M. (2020). How to finance the transition to low-carbon energy in Europe? *Energy Policy, 147*, 111863. https://doi.org/10.1016/j.enpol.2020.111863

R Core Team. (2023) R: A language and environment for statistical computing. *R Foundation for Statistical Computing*.

Romero Goyeneche, O. Y., Ramirez, M., Schot, J., & Arroyave, F. (2022). Mobilizing the transformative power of research for achieving the sustainable development goals. *Research Policy, 51*, 104589. https://doi.org/10.1016/j.respol.2022.104589

Romero Goyeneche, O. Y., Vis, J., Vila I de Villasante, E., Arroyave, F., Heimeriks, G., de Laat, J., Schot, J. (2021). Addressing the sustainable development goals at Utrecht University. https://doi.org/10.13140/RG.2.2.20833.84323

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: Categories and interactions. *Bus Strategy Environ, 20*, 222–237. https://doi.org/10.1002/bse.682

Schrijvers, M., Stam, E., & Bosma, N. (2023). Figuring it out: Configurations of high-performing entrepreneurial ecosystems in Europe. *Regional Studies*. https://doi.org/10.1080/00343404.2023.2226727

Scott, W. R. (2008). Approaching adulthood: The maturing of institutional theory. *Theory and Society, 37*, 427–442. https://doi.org/10.1007/s11186-008-9067-z

Shane, S., & Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *The Academy of Management Review, 25*, 217–226. https://doi.org/10.5465/amr.2000.2791611

Smink, M., Negro, S. O., Niesten, E., & Hekkert, M. P. (2015). How mismatching institutional logics hinder niche–regime interaction and how boundary spanners intervene. *Technol Forecast Soc Change, 100*, 225–237.

Spigel, B. (2017). The relational organization of entrepreneurial ecosystems. *Entrepreneurship Theory and Practice, 41*, 49–72. https://doi.org/10.1111/etap.12167

Spigel, B., & Harrison, R. (2018). Toward a process theory of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal, 12*, 151–168. https://doi.org/10.1002/sej.1268

Stam, E. (2015). Entrepreneurial ecosystems and regional policy: A sympathetic critique. *European Planning Studies, 23*, 1759–1769. https://doi.org/10.1080/09654313.2015.1061484

Stam, E., & Spigel, B. (2018). Entrepreneurial ecosystems. In R. Blackburn, C. De Clerq, & J. Heinonen (Eds.), *The SAGE handbook of small business and entrepreneurship* (pp. 407–422). SAGE.

Stam, E., & van de Ven, A. (2021). Entrepreneurial ecosystem elements. *Small Business Economics, 56*, 809–832. https://doi.org/10.1007/s11187-019-00270-6

Steinz, H. J. H. J., van Rijnsoever, F. J., & Nauta, F. (2015). How to green the red dragon: A start-ups' little helper for sustainable development in China. *Business Strategy and the Environment, 25*, 593. https://doi.org/10.1002/bse.1899

Stubbs, W. (2017). Sustainable entrepreneurship and B corps. *Bus Strategy Environ, 26*, 331–344. https://doi.org/10.1002/bse.1920

Tennekes, M. (2018). tmap: Thematic maps in R. *Journal of Statistical Software, 84*, 1–39. https://doi.org/10.18637/JSS.V084.I06

Theodoraki, C., & Messeghem, K. (2017). Exploring the entrepreneurial ecosystem in the field of entrepreneurial support: A multi-level approach. *International Journal of Entrepreneurship and Small Business, 31*, 47–66. https://doi.org/10.1504/IJESB.2017.083847

Theodoraki, C., Messeghem, K., & Rice, M. P. (2018). A social capital approach to the development of sustainable entrepreneurial ecosystems: An explorative study. *Small Business Economics, 51*, 153–170. https://doi.org/10.1007/s11187-017-9924-0

Thompson, T. A., Purdy, J. M., & Ventresca, M. J. (2018). How entrepreneurial ecosystems take form: Evidence from social impact initiatives in Seattle. *Strategic Entrepreneurship Journal, 12*, 96–116. https://doi.org/10.1002/sej.1285

Tiba, S. (2020). *Sustainability startups and where to find them: How entrepreneurial ecosystems impact their sustainability startups*. Utrecht University.

Tiba, S., van Rijnsoever, F. J., & Hekkert, M. P. (2020). The lighthouse effect: How successful entrepreneurs influence the sustainability-orientation of entrepreneurial ecosystems. *Journal of Cleaner Production, 264*, 121616. https://doi.org/10.1016/j.jclepro.2020.121616

Tiba, S., van Rijnsoever, F. J., & Hekkert, M. P. (2021). Sustainability startups and where to find them: Investigating the share of sustainability startups across entrepreneurial ecosystems and the causal drivers of differences. *Journal of Cleaner Production, 306*, 127054. https://doi.org/10.1016/j.jclepro.2021.127054

Truffer, B., Murphy, J. T., & Raven, R. (2015). The geography of sustainability transitions: Contours of an emerging theme. *Environmental Innovation and Societal Transitions, 17*, 63–72. https://doi.org/10.1016/j.eist.2015.07.004

van Rijnsoever, F. J. (2020). Meeting, mating, and intermediating: How incubators can overcome weak network problems in entrepreneurial ecosystems. *Research Policy, 49*, 103884. https://doi.org/10.1016/j.respol.2019.103884

van Rijnsoever, F. J. (2022). Intermediaries for the greater good: How incubators can embed constrainedsustainable development startups in entrepreneurial ecosystems. *Research Policy*, *51*, 104438. https://doi.org/10.1016/j.respol.2021.104438

Van Dijk, J., Leendertse, J., Stam, E., & van Rijnsoever, F. (2025). The entrepreneurial ecosystem clock keeps on ticking – A replication and extension of Coad and Srhoj

(2023). *Research Policy, 54*, 105154. https://doi.org/10.1016/j.respol.2024.105154

van Rijnsoever, F. J., Van Den Berg, J., Koch, J., & Hekkert, M. P. (2015). Smart innovation policy: How network position and project composition affect the diversity of an emerging technology. *Research Policy, 44*, 1094–1107. https://doi.org/10.1016/j.respol.2014.12.004

van Weele, M. A., van Rijnsoever, F. J., Eveleens, C. P., Steinz, H., van Stijn, N., & Groen, M. (2018). Start-EU-up! Lessons from international incubation practices to address the challenges faced by Western European start-ups. *Journal of Technology Transfer, 43*, 1161–1189. https://doi.org/10.1007/s10961-016-9538-8

Vedula, S., Doblinger, C., Pacheco, D., York, J. G., Bacq, S., Russo, M. V., & Dean, T. J. (2022). Entrepreneurship for the public good: A review, critique, and path forward for social and environmental entrepreneurship research. *Academy of Management Annals, 16*, 391–425. https://doi.org/10.5465/annals.2019.0143

Veefkind, V., Hurtado-Albir, J., Angelucci, S., Karachalios, K., & Thumm, N. (2012). A new EPO classification scheme for climate change mitigation technologies. *World Patent Information, 34*, 106–111. https://doi.org/10.1016/j.wpi.2011.12.004

Verhoeven, D., Bakker, J., & Veugelers, R. (2016). Measuring technological novelty with patent-based indicators. *Research Policy, 45*, 707–723. https://doi.org/10.1016/j.respol.2015.11.010

Volkmann, C., Fichter, K., Klofsten, M., & Audretsch, D. B. (2021). Sustainable entrepreneurial ecosystems: An emerging field of research. *Small Business Economics, 56*, 1047–1055. https://doi.org/10.1007/s11187-019-00253-7

Wurth, B., Stam, E., & Spigel, B. (2022). Toward an entrepreneurial ecosystem research program. *Entrepreneurship Theory and Practice*. https://doi.org/10.1177/1042258721998948

Wurth, B., Stam, E., & Spigel, B. (2023). Entrepreneurial ecosystem mechanisms. *Foundations and Trends in Entrepreneurship, 19*, 224–339. https://doi.org/10.1561/0300000089