Regional Studies

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/cres20

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To cite this article: Mirella Schrijvers, Erik Stam & Niels Bosma (2024) Figuring it out: configurations of high-performing entrepreneurial ecosystems in Europe, Regional Studies, 58:5, 1096-1110, DOI: 10.1080/00343404.2023.2226727

To link to this article: https://doi.org/10.1080/00343404.2023.2226727

REGIONAL STUDIES
2024, VOL. 58, NO. 5, 1096–1110
https://doi.org/10.1080/00343404.2023.2226727

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Figuring it out: configurations of high-performing entrepreneurial ecosystems in Europe

Mirella Schrijvers[a], Erik Stam[a,b] and Niels Bosma[a]

ABSTRACT
Is there only one type of successful entrepreneurial ecosystem? This paper applies qualitative comparative analysis to identify and analyse configurations of regional entrepreneurial ecosystems in Europe. We test two rivalling causal logics: a completeness logic stating that all entrepreneurial ecosystem elements need to be present and the weakest link is the most important constraint, and a substitutability logic arguing that elements are substitutable. High entrepreneurship outputs can be realised with different entrepreneurial ecosystem configurations. However, focusing on regions with the highest entrepreneurship outputs, our results point at the importance of a complete entrepreneurial ecosystem.

KEYWORDS
entrepreneurship; entrepreneurial ecosystem; regional configurations; qualitative comparative analysis

JEL L26, M13, R12
HISTORY Received 3 December 2021; in revised form 1 June 2023

1. INTRODUCTION

Regions differ greatly in their ability to enable entrepreneurship, which is an important driver of economic development (Fritsch & Schindele, 2011; Fritsch & Wyrwich, 2017; Haltiwanger et al., 2013; Stam et al., 2011). Entrepreneurship is predominantly a local event (Feldman, 2001) and its prevalence is highly uneven across space (Bosma & Sternberg, 2014; Dahl & Sorenson, 2012; Stam, 2007). In previous decades, most geography of entrepreneurship studies investigating spatial factors important for entrepreneurship assumed that each factor affects entrepreneurship independently and in a linear way (e.g., Armington & Acs, 2002; Bosma & Sternberg, 2014; Delgado et al., 2010). However, the relationship between geographical factors and entrepreneurship is likely to be more complex, as various factors interact in different ways to enable entrepreneurship. The emergence of the entrepreneurial ecosystem concept can be seen as a response to incorporate non-linear mechanisms, since it offers a complex systems way of thinking about the regional environment enabling entrepreneurship (e.g., Cavallo et al., 2019; Malecki, 2018; Roundy et al., 2018; Stam & Van de Ven, 2021; Wurth et al., 2022).

An entrepreneurial ecosystem is defined as a set of interdependent factors and actors that are governed in such a way that they enable productive entrepreneurship in a particular territory (Nicotra et al., 2018; Stam, 2015; Stam & Spigel, 2018). An ecosystem thus encompasses an interdependent set of actors and factors that can exist in different configurations. Entrepreneurial ecosystems enable productive entrepreneurship to emerge (Leendertse et al., 2022; Stam & Van de Ven, 2021) and can also moderate the effect of entrepreneurship on regional economic development (Audretsch & Belitski, 2021; Content et al., 2020; Szerb et al., 2019).

Adopting an entrepreneurial ecosystem approach holds the promise of facilitating the analysis of the strengths and weaknesses of economic systems at large, while taking into account the interdependencies between the elements of systems. To advance the academic debate and policy relevance of the entrepreneurial ecosystem approach, we test two rivalling causal logics that are currently dominant in the entrepreneurial ecosystem literature. The first *completeness* logic states that all relevant actors and factors (or elements) need to be present and the weakest link is the most important constraint (cf. Ács et al., 2014a). The second *substitutability* logic argues that elements are to some extent substitutable and hence there can be multiple

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/00343404.2023.2226727

configurations that lead to a high-performing entrepreneurial ecosystem (cf. Spigel, 2017).

This paper contributes to the literature by making a key step towards resolving this issue. We analyse entrepreneurial ecosystems of 273 regions across 28 countries in Europe with a harmonised dataset capturing all relevant entrepreneurial ecosystem elements and different measures of entrepreneurial outputs. The main question the paper addresses is: Which entrepreneurial ecosystem configurations enable productive entrepreneurship? The answer reveals the importance of the two causal logics on entrepreneurial ecosystem performance: the completeness logic and the substitutability (or equifinality) logic. To measure the different elements that constitute an ecosystem, we build upon the entrepreneurial ecosystem framework of Stam and Van de Ven (2021). This framework integrates prior studies on the geography of entrepreneurship and economic growth and provides a complex systems approach to understanding the entrepreneurial economy (Stam & Van de Ven, 2021; Wurth et al., 2022).

To trace how the interdependencies between entrepreneurial ecosystem elements affect the levels of productive entrepreneurship in regions, we use qualitative comparative analysis (QCA), which is a research method that explicitly allows for causal complexity and can be applied to derive configurations of elements that lead to a certain outcome (Schneider & Wagemann, 2012). The set-theoretic basis of this method means that elements are analysed in groups (or configurations) instead of in isolation, thus taking into account the interaction between elements that is posited to be a key aspect of the entrepreneurial ecosystem concept (Stam & Spigel, 2018; Stam & Van de Ven, 2021). A few previous studies have applied this method to study entrepreneurial ecosystems (e.g., Vedula & Fitza, 2019). We build on these studies by taking a broader view of the entrepreneurial ecosystem as proposed by Stam and Van de Ven (2021) and by considering cross-national variation with a sample of 273 regions across 28 European countries. Two separate analyses are performed to study differences in the configurations of high-performing ecosystems and very high-performing ecosystems, defined as regions being either in the top 25% or top 10% of entrepreneurship output in Europe. The performance of entrepreneurial ecosystems is measured with proxies for productive entrepreneurship (innovative start-ups and unicorn firms).

The findings indicate that different configurations of successful entrepreneurial ecosystems exist. High entrepreneurship outputs can be realised with a small variety of entrepreneurial ecosystem configurations. These varieties can be grouped into entrepreneurial ecosystems with strong human capital or knowledge combined with either strong leadership or strong formal institutions. When focusing on the highest levels of entrepreneurship output (top 10% of the regions), there is more convergence to a complete entrepreneurial ecosystem with all ecosystem elements strongly developed. However, also here we still find different ecosystem configurations that produce strong entrepreneurial output while lacking strength in some of the elements. This finding is supported by the analysis of configurations of regions with unicorn firms. There is thus not one perfect configuration that all successful ecosystems exhibit. Nevertheless, the analysis of very high-performing ecosystems shows that just having a few ecosystem elements on a high level is not sufficient for becoming one of the top performing entrepreneurial regions in Europe.

The outline of the paper is as follows. First, the entrepreneurial ecosystem concept is introduced and the existing literature on entrepreneurial ecosystem configurations is shortly discussed. Second, the dataset used in this study is described and the QCA research method is discussed in more detail. Third, the main findings of the QCA are presented. Finally, the main findings are discussed, policy implications highlighted and some suggestions for further research are given.

2. LITERATURE

A recent attempt to explain the emergence and persistence of productive entrepreneurship is the development of the entrepreneurial ecosystem approach. The concept of entrepreneurial ecosystems has been known since the 2000s but has become increasingly popular in recent years (Ács et al., 2017; Cavallo et al., 2019; Malecki, 2018; Wurth et al., 2022). The definition of the entrepreneurial ecosystem used in this paper is the following: a set of interdependent factors and actors that are governed in such a way that they enable productive entrepreneurship in a particular territory (Stam, 2015; Stam & Spigel, 2018). Stam and Van de Ven (2021) visualise the entrepreneurial ecosystem framework with 10 different ecosystem elements, divided into resource endowments and institutional arrangements that enable productive entrepreneurship (Figure 1).

A distinctive characteristic of the entrepreneurial ecosystem concept is the systemic view it takes of entrepreneurship (Fredin & Lidén, 2020; Roundy et al., 2018). For example, it incorporates feedback effects that can be caused by phenomena such as entrepreneurial recycling (Mason & Harrison, 2006). Another systemic aspect is the interaction between elements; elements can reinforce each other or equally inhibit other elements to develop. Although the elements that make up the ecosystem have received a lot of research attention, relatively little is still known about how these elements interact (Alvedalen & Boschma, 2017). To advance our understanding of entrepreneurial economies it is essential to know how connections between elements are formed and develop over time, and what might be the impact on the performance of the ecosystem when one or several elements are underdeveloped. Currently, it is still quite common to give all elements an equal weight and assume these are equally important, however Corrente et al. (2019) show that this assumption is not supported by empirical evidence in their sample of 24 European countries. Using expert evaluations of various ecosystem elements from the Global Entrepreneurship Monitor (GEM) database, they find

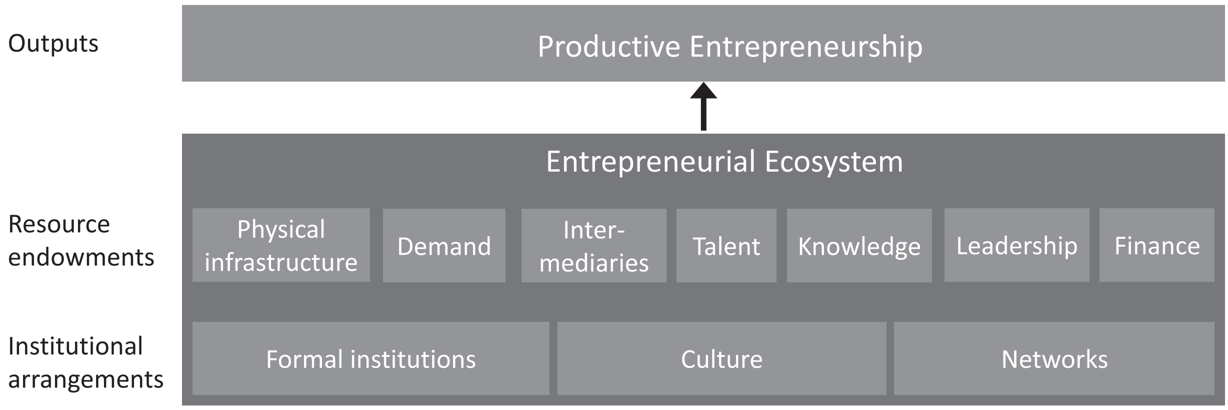

Figure 1. Elements and outputs of the entrepreneurial ecosystem.
Source: Adapted from Stam and Van de Ven (2021). Reproduced with permission from the authors.

that entrepreneurship culture, government programs to support businesses and market dynamism are the most important elements to explain differences in the number of high-growth start-ups.

There have been some attempts to take the interdependencies within an entrepreneurial ecosystem into account. One approach to do this is the penalty for bottleneck approach used by Ács et al. (2014a). They calculate an index to capture the quality of the entrepreneurial ecosystem at a national level (see Ács et al., 2014b, for a regional application). This index is composed of 14 pillars that combine both individual level variables and institutional variables. The way they incorporate the interaction of elements in their index is by including a penalty for the weakest component. The penalty does not only depend on the score of the weakest component but also on the difference between the score of the weakest component and the scores of all the other components in the ecosystem. The assumption underlying this method is that components in an ecosystem are not substitutable and all components should reach a certain minimum value before an entrepreneurial ecosystem can be successful. The weakest link postulate does not deny partial substitutability amongst the different ecosystem components but holds that the elements should be balanced for efficient operation. This means that to achieve a high index score an ecosystem needs to have all elements at more or less the same level and above a minimum threshold. In fact, Ács et al. (2014a) thus implicitly assume that all these 14 conditions are necessary for high levels of entrepreneurship and equally important; we refer to this as the *completeness* logic. It should be noted that whereas the completeness logic is a driving force behind this approach, the policy implications resulting from these analyses may still differ widely for countries or regions, contingent on the strength of the elements and in particular the bottleneck element(s). This is indeed one of the main outcomes of Lafuente et al. (2022).

While Ács et al. (2014a) essentially propose the perfect entrepreneurial ecosystem to be one based on completeness, a qualitative case study by Spigel (2017) shows that entrepreneurial ecosystems can be successful with different types of configurations. According to Spigel (2017), depending on regional or even local idiosyncrasies, different elements may be more or less important to enable productive entrepreneurship. There is thus not necessarily one perfect entrepreneurial ecosystem, as the most productive configuration depends on specific local characteristics. Spigel compares the regions of Waterloo and Calgary in Canada to show two successful ecosystems with very different attributes. While Waterloo has very strong cultural, social and material attributes that are all densely connected, it misses a strong local market (corresponding to 'Demand' in Stam and Van de Ven's, 2021, framework). Calgary's ecosystem, on the other hand, mostly thrives on its strong local market, while it lacks strongly developed networks between entrepreneurs. Spigel (2017) thus proposes that different combinations of elements can be sufficient to enable high levels of technology entrepreneurship and that, for instance, one, two or three elements might be weak without incurring a high cost for entrepreneurial output; we refer to this as the *substitutability* logic. Hence, two logics – based on very distinct methodologies – present themselves when it comes to explaining and predicting the performance of entrepreneurial ecosystems: one that assumes that all elements need to be strongly present (completeness logic) and the weakest link is the most important constraint, and the other that argues that elements can be highly substitutable (substitutability logic) and there are different possible pathways to create a high-performing entrepreneurial ecosystem.

A research method well-suited to solve this debate is qualitative comparative analysis (QCA) (Ragin & Rihoux, 2009). The QCA method is based on set theory and Boolean algebra, and specifically designed to look for different configurations that can produce a specific outcome, in this case productive entrepreneurship. It is particularly useful to study systems because it allows for causal complexity. QCA understands causality as configurational and identifies mechanisms rather than net effects, which answers how-questions better than statistical methods do (Rutten, 2019). Unlike results of conventional statistical methods, QCA results can exhibit multiple conjunctural causation, equifinality and causal asymmetry (Schneider &

Wagemann, 2012). Multiple conjunctural causation means that several elements can combine to cause an outcome but may not produce it on its own. This takes into account how components within a system might interact to produce a certain outcome, referred to as interdependencies in the entrepreneurial ecosystem literature. Equifinality is based on the idea that there might be different 'paths' towards a final state, such as a successful ecosystem. So there can be more than one pathway (ecosystem configuration) to reach a certain outcome. Finally, causal asymmetry refers to the fact that the presence of an element or an outcome does not have to be the exact opposite of its absence. Although a bit abstract, this could mean in practice that when one has found a combination of elements (e.g., high levels of human capital and advanced physical infrastructure) that creates a successful ecosystem, it is not guaranteed that the exact opposite of this combination (low levels of human capital and very bad physical infrastructure) leads to a malfunctioning ecosystem. All these characteristics make QCA a very appropriate approach to study entrepreneurial ecosystems.

Recently, there has been some research that applied QCA to study entrepreneurial ecosystems. Vedula and Fitza (2019) study metropolitan areas in the United States to find which specific combinations of elements are needed to support early-stage start-ups and late-stage ventures. In their analysis they include five different ecosystem elements, corresponding to talent, knowledge, finance and culture in Stam and Van de Ven's (2021) framework. Even with this relatively low number of conditions, they find four configurations leading to early-stage start-up success and even five configurations for late-stage ventures, with a key position for technical knowledge. Another study by Alves et al. (2021) looks at city ecosystems in the region of Sao Paulo in Brazil. This study considers a more extensive set of entrepreneurial ecosystem elements more similar to those used in our paper. However, the outcome they study is the success in getting support from a government programme for innovative small enterprises, which is arguably not a direct measure of productive entrepreneurship. The authors find four different ecosystem configurations that lead to a large number of grants from the government. Muñoz et al. (2020) study regional ecosystems in Chile with the use of GEM data. They use evaluations of local experts to look at combinations of narrated attributes (in contrast to measured attributes) that enable entrepreneurship. While they find multiple combinations that result in high entrepreneurial activity, there are only two configurations leading to entrepreneurship with high growth ambitions which both include market dynamism as a key condition.

The results of these studies suggest that there are multiple recipes for a high-performing entrepreneurial ecosystem in these contexts, with some elements appearing as more critical in these configurations. A recent study by Lafuente et al. (2022) using a linear programming method to analyse country level data from the global entrepreneurship index (GEI) also supports this idea by showing that the best way to improve an ecosystem differs by country and specifically that the importance of elements may differ. This suggests a compromise between the two opposing logics from the literature discussed above; some ecosystem elements may be substitutable, but others are essential and need to be well developed. This paper aims at exploring the validity of such a compromise by revealing ecosystem configurations in a large and highly varied sample of successful entrepreneurial regions with a broad set of conditions covering the essential aspects of the entrepreneurial ecosystem. To obtain a detailed understanding of the mechanisms, different definitions of entrepreneurial outputs are used.

3. DATA

3.1. Sample

The entrepreneurial ecosystem literature does not define clear boundaries of an ecosystem. As Malecki (2018) notes some plausible possibilities are to take an area with a 50 or 100 km radius, as this would, for example, cover the area in which workers can commute. In most countries this would basically overlap with a region or a very big city. Such a regional level of analysis takes into account the local nature of entrepreneurship. The geographical unit in Europe that most closely resembles the regional demarcation just discussed is the NUTS-2 classification. NUTS-2 regions are defined based on existing administrative boundaries in a country and population size, which in a NUTS-2 region varies between 800,000 and 3 million people (European Commission, 2018). While within some countries better regional units may be available, it is important to choose a spatial unit that can reasonably and consistently be compared across different countries. Therefore, the NUTS-2 level is the best option given the current data availability.

Within Europe 281 NUTS-2 regions are defined within the 27 member states and the UK, of which 273 regions are used in this study.[1] Two inner London regions (UKI3 and UKI4) are merged because these are located next to each other and were not discerned in the firm data. The total sample thus consists of 272 observations across 28 countries, covering almost the whole population of interest. Since not all regions are of the same size, all variables are corrected for population size.

3.2. Conditions

The entrepreneurial ecosystem model of Stam and Van de Ven (2021) consists of 10 elements. All these elements are measured by statistical indicators, as shown in Table 1 and described in detail in Table A1 in Appendix A in the supplemental data online (see also Leendertse et al., 2022, for a detailed description of the construction of the database). The measures are constructed by combining data from existing statistical sources and obtaining new data using web scraping techniques. Most measures of the entrepreneurial ecosystem data are based on indicators from specialised datasets, such as the Quality of Government survey. Other elements are measured using specific indicators of more general datasets, to measure infrastructure

Table 1. Operationalisation 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 small and medium-sized enterprises (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 the 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 are 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 in terms of both formal education and skills	Four components: the percentage of the population with a tertiary education, the percentage of the working population engaged in lifelong learning, the percentage of the population with an entrepreneurship education, and the percentage of the population with e-skills	Eurostat and GEM
New knowledge	Investments in new knowledge	Intramural research and development (R&D) expenditure as a percentage of gross regional product (GRP)	Eurostat
Demand	Potential market demand	Three components: disposable income per capita, potential market size expressed in GRP and potential market size in population. All relative to the European Union average	RCI

(*Continued*)

Table 1. Continued.

Elements	Description	Empirical indicators	Data source
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 10 years	CB Insights and Dealroom

we, for example, rely on the accessibility indicator from the regional competitiveness index (RCI) (Leendertse et al., 2022).

Several criteria were considered when creating measures for the entrepreneurial ecosystem elements. These were accuracy, credibility and comparability of data sources (Leendertse et al., 2022). In short, the indicator should accurately capture what we are trying to measure, be from a reliable data source and be available for all European regions. These criteria occasionally conflicted with each other as in some cases it was optimal to use multiple indicators from an accuracy perspective, but these were not available from reliable sources (credibility) or not available for all regions (comparability). In addition, our aim was to create a measure with the lowest number of indicators to prevent unnecessary complexity.

Several of these indicators combine a general measure, such as percentage of population that received tertiary education, with a measure that is entrepreneurship specific, such as entrepreneurial skills training. In addition, several times national and regional data are combined to create a more robust measure, although every element contains at least one regional-level indicator. The data collection and choices regarding indicators are more extensively described by Leendertse et al. (2022). Each element is treated as an input variable in the QCA, yielding a QCA with 10 conditions (see Appendix B in the supplemental data online for a discussion of the methodological implications).

Most of the entrepreneurial ecosystem data we use is from the 2013–18 period. Even though this means we only perform QCA for this specific period, the available evidence suggests that these values only change slowly, and our findings are thus likely to be robust over a longer period of time. Several studies have reported a large persistence in entrepreneurial performance (Andersson & Koster, 2011; Fritsch & Wyrwich, 2014) and most ecosystem elements, such as institutions and education, are likely to change relatively little in the short run. Nevertheless, we acknowledge that by adopting a comparative static approach to the analysis of entrepreneurial ecosystems, we may miss out on intertemporal effects.

3.3. Output

The output of entrepreneurial ecosystems is productive entrepreneurship. In this study we operationalise productive entrepreneurship with two measures: 31,236 innovative start-ups (registered in Crunchbase, less than five years old) and 49 unicorn firms (young private firms with a valuation of more than US$1 billion, registered in CB Insights). While these proxies do not perfectly measure the productive entrepreneurship concept, we consider these the best measures currently available. It is also similar to measures used in previous studies which have tried to capture closely related concepts, such as Schumpeterian or high-quality entrepreneurship (Guzman & Stern, 2020; Leppänen et al., 2019).

Data on innovative start-ups were scraped from Crunchbase, an online database that collects information on all promising new firms, mainly with the goal of informing potential investors who pay to access the data. The data are collected from investors and a community of contributors; moreover, the data are checked with the use of artificial intelligence (Crunchbase, 2020). The investment data of Crunchbase (i.e., firm funding) has also been compared with other data sources, including Organisation for Economic Co-operation and Development (OECD) data, which show very similar patterns and thus confirm their validity as a measure of innovative start-ups (Dalle et al., 2017). Crunchbase mainly includes companies that are venture capital-oriented and it is difficult to conclusively confirm that it covers new firms equally across countries.[2] Nevertheless, it is currently the most comprehensive database for innovative start-ups and several studies have previously used Crunchbase to collect data on innovative companies (e.g., Block et al., 2015). The firms in Crunchbase were matched to NUTS-2 regions with geocoding using the location of the company headquarters (Crunchbase, 2019). The analysis only includes firms founded in the last five years, covering the period 2015–19, and corrects the number of firms for population size.[3]

Data on the presence of unicorn firms were also collected for all NUTS-2 regions. This was used as an alternative output measure. The results of the analysis with unicorn firms support the main findings and are reported in Appendix G in the supplemental data online.

4. METHODOLOGY

The research method used to explore the configurations of entrepreneurial ecosystems in Europe is QCA. As discussed in section 2, this method is well-suited to capture the causal complexity inherent to entrepreneurial ecosystems. Performing a QCA involves various steps and decisions by the researcher which are described below (for a more detailed overview, see Leppänen et al., 2019).

4.1. Calibration

As QCA is a set-theoretic method, it is based on analysing the membership of cases in various conditions and the outcome (respectively, the condition sets and outcome set). In this study, the conditions are the 10 elements of Stam and Van de Ven's (2021) framework and the outcome is productive entrepreneurship. For each region one needs to assess whether it is a member of each of the conditions and the outcome, and to what degree. A fuzzy-set QCA is applied to allow for differences in the degree of membership instead of using a dichotomy of 0 and 1 membership. To calibrate the membership scores, we used quartiles as thresholds (for a detailed explanation of the calibration, see Appendix B in the supplemental data online). The analysis was performed with the software R using the packages QCA (Dusa, 2019) and SetMethods (Oana et al., 2020). The R script is available from the authors upon request.

The aim of the QCA analysis is to find out what determines membership in the highest quartile of the distribution of Crunchbase firms. However, this outcome category is still quite broad (almost 70 regions) and is not limited to the absolute top performers among the European regions. Therefore, a second analysis is conducted with a different calibration of membership in the outcome set. Specifically, the thresholds used are as follows: 50th percentile for exclusion, 75th for crossover and 90th for inclusion. This allows us to study the set of very high-performing ecosystems, as only regions with a number of Crunchbase firms in the top 10% of the distribution in Europe are considered full members of the outcome set.

In summary, the main analysis consists of two parts. First, an analysis of the solutions for high levels of entrepreneurship output, defined as membership in the top 25% of Crunchbase firm output. Second, an analysis of the solutions for very high levels of entrepreneurship output, defined as being a member of the top 10% of the Crunchbase firm distribution.

4.2. Necessary and sufficient conditions

The main aim of QCA is to find necessary and sufficient relationships between the conditions and the outcome (Schneider & Wagemann, 2012). A *sufficient* relationship means that whenever the condition is present the outcome will also be present. In other words, the condition implies the outcome. A *necessary* relationship is the mirror image: whenever the outcome is present the condition will also be present, hence the outcome implies the condition. Finding sufficient conditions is often seen as the key part of the QCA and involves several steps. In the next section, the process of testing for sufficiency is described in more detail. The results of the necessary condition analysis are presented in Appendix C in the supplemental data online.

4.3. Solutions

With 10 conditions there are 1024 possible configurations (2^{10}), in which every configuration combines the presence and absence of conditions in a unique way.[4] The so-called truth table lists all these possible configurations and creates an overview of the regions that fit each particular configuration. For every region in a configuration the outcome is analysed, and if the presence of the outcome is consistent with at least 80% of the regions, the configuration is considered to be a sufficient condition for the outcome. This consistency threshold of 0.8 is the one that is commonly used in the literature (Schneider & Wagemann, 2012). We only consider configurations with at least four regions because we are interested in studying general patterns. To make sure the results do not depend on the choice of these thresholds, a sensitivity analysis is conducted in which different threshold values are applied (see Appendix H in the supplemental data online). The truth tables showing all configurations with at least four regions are presented in Tables D1 and D2 in Appendix D online.

The logical minimisation of the truth table results in one or more solutions that are sufficient for the outcome. To summarise and present the solutions, the format proposed by Fiss (2011) is employed, which distinguishes between core and peripheral conditions in a solution. Two parameters of fit are calculated: consistency and coverage. The consistency measure was briefly mentioned above and captures how much of the cases actually exhibit a specific subset relation such as sufficiency. The coverage is a measure of how much of the outcome is explained by a specific condition or solution. It thus conveys how many of the regions, which are members of the outcome set, are covered by that condition or solution. In addition to the consistency and coverage, the unique coverage can be calculated for each solution, which is the part of the outcome set covered by that particular solution while not being covered by any of the other solutions.

5. RESULTS

5.1. Configurations for high levels of entrepreneurship output

Which entrepreneurial ecosystem configurations enable productive entrepreneurship? To answer this question, we empirically trace the importance of the two causal logics on entrepreneurial ecosystem performance: the completeness logic and the substitutability logic (equifinality). Table 2 summarises the configurations sufficient for high levels of entrepreneurship output (top 25% innovative start-up regions), according to the method proposed

Table 2. Solutions for the top 25% innovative start-up regions.

	Talent–Leadership 1a	Talent–Institutions 1b	Knowledge–Leadership 2a	Knowledge–Institutions 2b
Formal institutions		●		●
Culture		●		●
Networks		●		●
Physical infrastructure			●	●
Finance		●		●
Leadership	●		●	
Talent	⬤	⬤		●
Knowledge			⬤	⬤
Demand	⊗	⊗	●	
Intermediate services		●	⬤	⬤
Consistency	0.899	0.924	0.938	0.948
PRI	0.854	0.880	0.922	0.930
Raw coverage	0.290	0.180	0.394	0.285
Unique coverage	0.124	0.025	0.150	0.027
Number of regions	12	12	35	29
Overall solution consistency		0.904		
Overall solution coverage		0.648		

Note: Black circles (●) are present conditions, white circles with a cross (⊗) are absent conditions. Large circles indicate core conditions and small circles peripheral conditions. The absence of a circle indicates indifference for that condition. Solutions are grouped by their core conditions. All parameters are calculated with the intermediate solution term. PRI, proportional reduction in inconsistency.

by Fiss (2011). There is both first-order (across type) and second-order (within type) equifinality (i.e., different possible paths to reach the outcome), as shown by the presence of two overall solutions and the different variations (also called neutral permutations) of these solutions. Solution 1a and 1b, and 2a and 2b are variations of the same type because the core conditions, indicated by the large circles, are the same. The high consistency scores and proportional reduction in inconsistency (PRI) show the strength of the evidence for the sufficient relation.[5] The high raw and unique coverage indicate that the solutions are also empirically relevant and cover quite some part of the regions in the outcome set.

The membership of specific regions in each configuration is plotted in Figure 2. Note that this map only includes those regions that fit one of the configurations. Regions that have high entrepreneurship output and a different combination of ecosystem elements are not shown (e.g., Catalonia in Spain). For an overview of all regions with high entrepreneurship output and their membership in configurations, see Table E1 in Appendix E in the supplemental data online. Since there are several regions with high membership in most or even all ecosystem elements, various regions are a member of multiple configurations. Especially the regions in different variations of the same solution (1a and 1b, 2a and 2b) overlap to some extent.

When studying the elements which constitute the different configurations, one can identify four types of entrepreneurial ecosystems grouped in two main solutions. These four types can be identified based on their main driver – Talent for the first solution, and Knowledge (new knowledge production and intermediate (knowledge-intensive) services) for the second – and whether they depend on Leadership or Institutions (formal institutions, culture and networks combined).

Talent and knowledge are important drivers of entrepreneurship since new knowledge can be a source of entrepreneurial opportunities only to be recognised by individuals with the required human capital (Qian et al., 2013). Perhaps surprisingly knowledge and talent are not observed together in most of the configurations, even though some research suggests they are complementary (e.g., Abel & Deitz, 2012). This could be related to the relatively free flow of knowledge, which would mean that knowledge is less place bound than some of the other ecosystem elements and regions can benefit from knowledge produced elsewhere. The absence of talent in the Knowledge–Leadership configuration is similarly somewhat counterintuitive. However, the combination of high knowledge production and strong knowledge-intensive business services might mean that entrepreneurs in these ecosystems outsource tasks which require high levels of human capital to a few specialised firms.

Strongly developed institutions are not required in all configurations, seemingly contradicting the work of Baumol (1990) and the economic growth literature (e.g., Acemoglu et al., 2006). However, it is important to realise

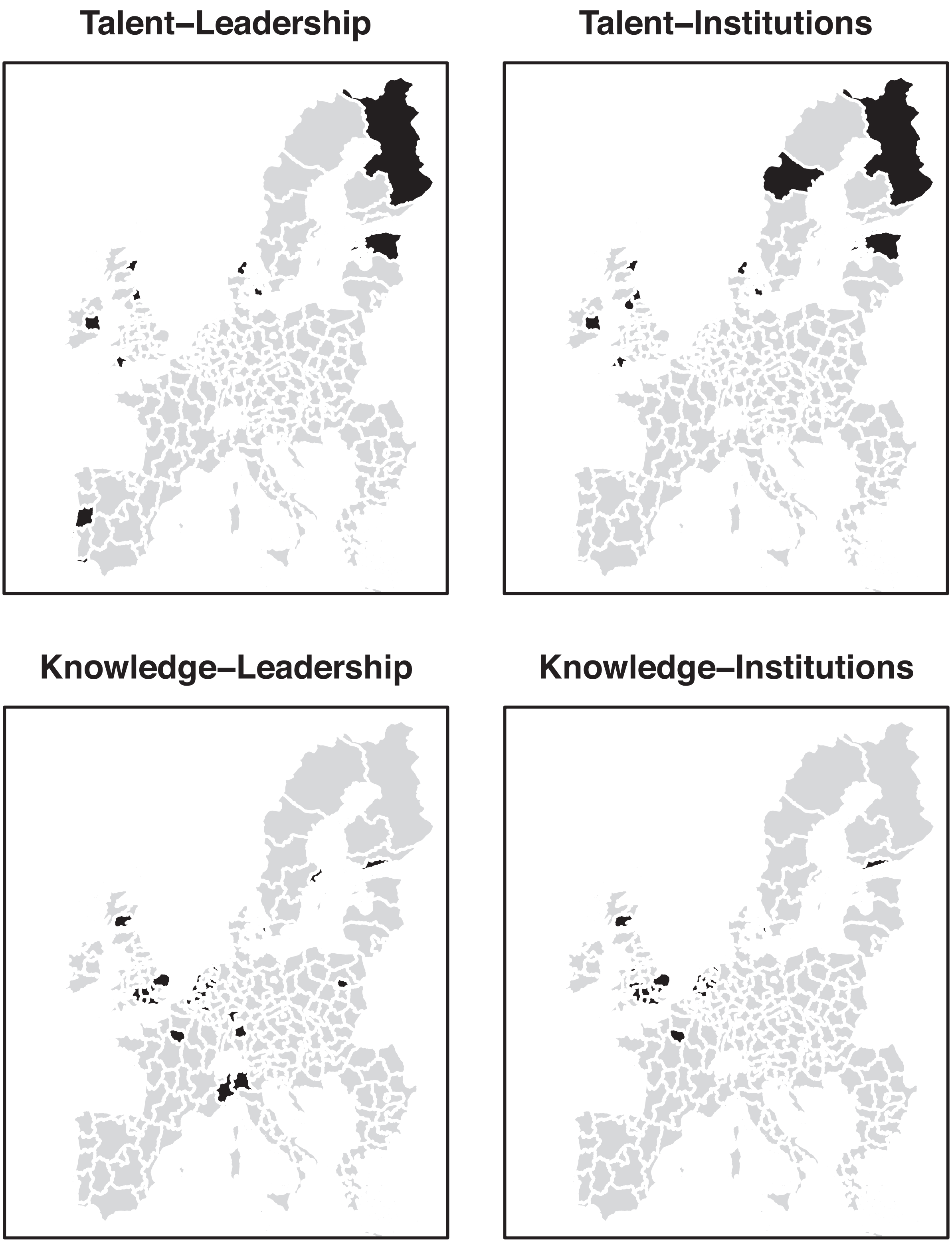

Figure 2. Maps of high-performing entrepreneurial ecosystem configurations in Europe.
Source: Eurostat/GISCO (n.d.) Administrative units/Statistical units, https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units

that European institutions are quite well developed in general and a region scoring below the European median might still possess the minimum level of institutions (e.g., basic property right protection) needed for productive entrepreneurship. Interestingly, in the configurations lacking the presence of strong institutional arrangements a high level of leadership is required, suggesting that strong leadership seems to substitute to some degree for institutions (cf., Porras-Paez & Schmutzler, 2019).

The first configuration, the Talent–Leadership ecosystem, is based on the presence of talent and the absence of demand, combined with strong leadership. Figure 2 shows that regions in this configuration are located a bit more in the periphery, such as Scotland and northern Finland. This explains why market demand in these regions is relatively low. While not having a very strong regional market, all these regions do have a well-educated labour force. Estonia as well as Finnish and Danish regions are members of this configuration, which matches well with their outstanding education system. The lack of regional demand is thus compensated by a well-developed human capital base combined with strong leadership.

The second configuration, Talent–Institutions, is quite similar but combines strong talent with well-developed institutional arrangements, finance and intermediate services. The regions in this configuration are all located in northern Europe and include northern Sweden and south-west England. These regions lack a strong regional market but have a lot of the other elements of a strong ecosystem which enable entrepreneurship. Businesses in these regions are likely to focus on producing for the global market or neighbouring regions.

The third configuration, Knowledge–Leadership, shows an ecosystem based on knowledge, demand and intermediate services combined with good infrastructure and leadership. The key distinction with the other configurations is the presence of high demand in the region. Many of the regions in this configuration are metropolitan areas that are well-known innovation hotspots, including London, Edinburgh, Paris, Stockholm, Helsinki and Hamburg.

Most elements are present in the fourth configuration, Knowledge–Institutions, with knowledge and intermediate services as core conditions. This is the only configuration in which demand does not have to be present or absent. The Knowledge–Institutions ecosystem configuration is the most well-rounded, with both strong institutional arrangements and resource endowments. Nevertheless, not all 10 elements need to be present in order for a region to be a member of this configuration. Members of this configuration include many capital cities and regions bordering capital cities, such as southern England and the Greater Amsterdam region. Most of the regions in this configuration are also part of the Knowledge–Leadership configuration, as evidenced by the low unique coverage.

When analysing some of the main characteristics of the regions in the different configurations a few things are remarkable (see Tables F1–F4 in Appendix F in the supplemental data online). The regions in the Talent–Institutions configurations have the smallest population and lowest population density, followed by the regions in the Talent–Leadership configuration. Both of these also show a gross domestic product (GDP) per capita close to the European average. The regions in the knowledge-driven configurations are, on the other hand, very densely populated, confirming the observation that these regions are often more urban areas. In addition, the GDP per capita in these regions is a lot higher than the European average.

The values for overall solution consistency (0.904 with a common threshold value of 0.8) and solution coverage (almost 65% of cases are explained) are high, showcasing the strength of the model. The four different configurations thus provide empirical support for the presence of different configurations of successful entrepreneurial ecosystems in Europe. These configurations are all sufficient for entrepreneurship output in the top 25% of Europe, showing that it is possible to have a well-functioning ecosystem without high performance on all 10 elements. The explicit absence of demand in the two Talent configurations even seems to directly contradict the completeness logic underlying the 'penalty for bottleneck' technique in Ács et al. (2014a). One might argue though that the group of high-performing ecosystems included in this analysis is too broad and that we can only learn from the exceptionally successful ecosystems, which is what we turn to next.

Table 3. Solutions for the top 10% innovative start-up regions.

	Complete 1
Formal institutions	●
Culture	●
Networks	●
Physical infrastructure	●
Finance	•
Leadership	●
Talent	●
Knowledge	●
Demand	●
Intermediate services	•
Consistency	0.819
PRI	0.687
Raw coverage	0.347
Unique coverage	0.347
Number of regions	22
Overall solution consistency	0.819
Overall solution coverage	0.347

Note: Black circles (●) are present conditions, white circles with a cross (⊗) are absent conditions. Large circles indicate core conditions and small circles peripheral conditions. The absence of a circle indicates indifference for that condition. Solutions are grouped by their core conditions. All parameters are calculated with the intermediate solution term. PRI, proportional reduction in inconsistency.

5.2. Configurations for very high entrepreneurship output levels

Table 3 shows the configurations that are sufficient for very high entrepreneurial performance measured as having a number of Crunchbase firms among the top 10% in Europe. There is only one sufficient configuration with all elements present and most of these elements are core conditions. This can thus be characterised as a complete ecosystem. However, the frequency threshold of four regions is quite high because the number of regions in the outcome set is now lower (28 regions) with this more restrictive definition of success. When studying the truth table (see Table D2 in Appendix D in the supplemental data online) it becomes clear that only one configuration passes this frequency threshold. When this threshold is lowered to, for example, three or two cases, more variety becomes visible as several other configurations consistently show the outcome. Table H1 in Appendix H online shows the solutions for the analysis with a frequency threshold of three.

While the solution consistency is still above the commonly used threshold of 0.8 (Schneider & Wagemann, 2012), it is lower than the solution consistency for top 25% Crunchbase firms. The PRI takes on a value around 0.7, which is again somewhat lower but still acceptable. The cause of this lower PRI is that some regions that are a member of this configuration are not a member of the outcome set (while they were before with the lower threshold). However, there is still convincing evidence that the set of members of configuration 1 is a non-simultaneous subset of regions in the top 10% of Crunchbase firms. The relatively low coverage indicates that this configuration only explains part of the outcome set, again indicating that there are various regions in the top 10% that do not fit this configuration.

The regions that are a member of the complete configuration are a subset of the regions in the Knowledge ecosystem configuration (2a and 2b) of the analysis of top 25% Crunchbase firms. The group of regions in the configurations lacking demand thus completely disappeared. This indicates that while it is possible to become quite successful with several elements lacking, it is very hard to get to the top of entrepreneurial ecosystems in Europe. However, the truth tables with lower frequency thresholds (available from the authors upon request) reveal that some regions are able to become part of this group with a few elements underdeveloped. Thus, while a strong complete ecosystem is the most common way to entrepreneurial success, it is not an absolute requirement and there are examples of several exceptions.

6. CONCLUSIONS

This study analysed the interdependence of entrepreneurial ecosystem elements in configurations of high-performing entrepreneurial ecosystems, answering the question of how entrepreneurial ecosystem elements combine to enable high levels of productive entrepreneurship. These analyses provided a test of two distinct causal logics on entrepreneurial ecosystem success: the completeness entrepreneurial ecosystem logic and the substitutability entrepreneurial ecosystem logic, suggesting that there are multiple configurations that lead to entrepreneurial ecosystem success. To perform this test a large dataset was used covering all 10 elements of Stam and Van de Ven's (2021) framework and several entrepreneurship output measures. Regions in all European countries were included in the sample to provide a large amount of variation in entrepreneurial ecosystem elements, both within and across countries. QCA was applied because this method specifically allows for interactions between elements (multiple conjunctural causation) and multiple pathways (in this case configurations) to reach the same outcome (equifinality).

The results of the QCA indicated that there are different types of successful entrepreneurial ecosystems in Europe. There were four different configurations for high levels of entrepreneurship output: two of these were based on strong talent combined with either strong leadership or institutions, the other two configurations combined strong knowledge and intermediate services with either leadership or institutions. When looking at the absolute top-performing ecosystems in Europe, the results indicated only one sufficient configuration, with all elements strongly developed. However, additional analyses showed there were several regions in this exclusive group that managed without having one or two elements at a high level. The analysis using unicorn firms supported this finding. There is thus not one perfect configuration that all successful entrepreneurial ecosystems exhibit, instead several entrepreneurial economies find a way to function without all entrepreneurial ecosystem elements at a high level.

Our findings support a more nuanced understanding of entrepreneurial ecosystems and propose a combination of the completeness logic and the substitutability (or equifinality) logic. The assumption that all elements are equally important and need to be present for any amount of entrepreneurial success was not strongly supported by the empirical evidence, although it was applicable to some extent for regions with the highest levels of entrepreneurial output. While the results of the QCA for the top 25% regions correspond with previous studies (Alves et al., 2021; Muñoz et al., 2020; Vedula & Fitza, 2019) finding multiple configurations that enable entrepreneurship (substitutability logic), we find evidence that the highest performing entrepreneurial ecosystems need to be quite well-rounded (completeness logic).

6.1. Future research

Future research can improve on this study by creating or integrating more regional data. The drawback of doing regional analyses is the constraints it poses on data availability. For most measures this could be solved by combining multiple indicators or data sources, but sometimes national data had to be combined with regional data. This reduces the variability in the data and could hide some important patterns. Another possible concern is the choice of indicators for the ecosystem elements and if these indicators correctly capture the elements. Future research can improve the measurement of indicators for several elements, especially leadership and networks. Leadership is measured in this study with the prevalence of coordinators of Horizon 2020 projects, which are

European Union-funded public–private partnerships for innovation projects. While this might be a good measure of leadership of collective action for knowledge and innovation, it might not be a perfect measure of the leadership of an entrepreneurial ecosystem. Feldman and Zoller (2012) argue that leadership is provided by what they call dealmakers: experienced entrepreneurial actors who link other actors in an ecosystem and define entrepreneurial networks. Others emphasise place-based leadership for realising collective action in and for the region (Stam, 2020). To measure this, one would, however, have to collect network data in every regional ecosystem.

An entrepreneurial ecosystem is not a closed system, and future research should also take into account inter-ecosystem linkages. One example is the possible spillover effect of neighbouring regions. Entrepreneurs living close to regions with highly developed entrepreneurial ecosystems might benefit from these (Pijnenburg & Kholodilin, 2014), which is also known as the borrowed size effect (Phelps et al., 2001). For example, entrepreneurs might be able to use intermediate services and venture capital from an adjacent region. In the current analysis there were no strong indications of this; for example, it was not the case that all talent-based ecosystems are clearly clustered around a big city. However, it would be relevant to formally analyse the possibility that regions may benefit from well-developed ecosystem elements in neighbouring regions, as this could explain why regions are able to function well without having some elements on a very high level themselves. In contrast, better developed neighbouring or well-connected entrepreneurial ecosystems can also lure entrepreneurial talent away, and this may lead to relatively low levels of entrepreneurship output in the region of origin (Mazzoni et al., 2022). The entrepreneurial ecosystem approach emphasises intra-ecosystem connections (e.g., within entrepreneurial communities; Feld & Hathaway, 2020), but should also take into account inter-ecosystem connections. Inter-ecosystem linkages over longer distances ('pipelines') enable long-distance flows of knowledge, talent and capital that might explain the accumulation of these resources in a few places globally. This also necessitates more network data, and better ways to analyse this to uncover the effects on entrepreneurship outputs, and to inform policy interventions.

To better understand the functioning of the different types of ecosystems the QCA identified, it would be useful to perform in-depth case studies and compare regions in different ecosystem categories. The results of this study can be used to systematically select case studies and learn from those that confirm or contradict the current theory. As all elements of the framework are deemed to be important for entrepreneurship, we could learn from analysing regions which seem to be able to function without some of them and investigate potential substitution effects. For example, our results suggest that strong formal institutions is not a necessary condition for high entrepreneurship output and is not required in some of the configurations. Strong social norms or leadership may be able to substitute for well-developed formal institutions. In a similar vein, regions capitalising on the global economy may demonstrate high levels of entrepreneurial performance in a region without strong regional demand. Results of such studies could help to finetune the current theory of which elements are necessary for an entrepreneurial ecosystem and which elements may be helpful but less essential.

Finally, our comparative static approach to the analysis of entrepreneurial ecosystems also helps to pave the way for more dynamic approaches. Now that we observe initial evidence for multiple pathways in a cross-national setting, more longitudinal data collection would be needed to better explore changes over time and dynamic interplays between, for example, neighbouring regions and cross-border collaborations. This may be achieved by more traditional dynamic panel data techniques allowing for spatial autocorrelation, or by analysing specific targeted entrepreneurial ecosystem transitions over time. This allows us to trace the paths of entrepreneurial ecosystem development: how evolution from one configuration to another takes place, and virtuous and vicious cycles of development.

6.2. Policy implications

Our findings stress the need to adapt policy to local circumstances and encourages a holistic approach to entrepreneurship policy. The findings of the study showed that different types of ecosystems may coexist and that having all elements on a high level is not a precondition for high levels of productive entrepreneurship. This is good news for regions that lack elements that are particularly hard to change, such as institutions or local demand. Nevertheless, the analysis of very high-performing ecosystems indicated that almost all ecosystem elements need to be strongly developed to enable extremely high entrepreneurship output. Therefore, a holistic view is warranted to stimulate regional entrepreneurship, as developing only a few elements of the entrepreneurial ecosystem is unlikely to enable great entrepreneurial success.

Our analyses imply that there are multiple configurations to achieve high entrepreneurial output levels. This suggests that policies for improving entrepreneurial ecosystems should start with a diagnosis of the current strengths and especially weaknesses of the entrepreneurial ecosystem, benchmarking themselves to comparable regions (cf. Rodrik, 2010). It is important to use the entrepreneurial ecosystem framework to create tailor-made context-specific policies, instead of implementing a fashionable policy, to improve the regional entrepreneurial ecosystem. Using the entrepreneurial ecosystem approach along these lines can help every region to build a stronger entrepreneurial economy.

ACKNOWLEDGEMENTS

This article benefited from the advice and suggestions of Barbara Vis, Bart Cambré, Matthew Josefy and the participants of the 2020 IECER conference. An earlier version of this study was published as a working paper in the USE Working Paper Series (No. 21-05).

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

FUNDING

This research was partly funded by the TNO , The Netherlands Organisation for Applied Scientific Research.

NOTES

1. For an overview of the NUTS-2 regions, see https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:02003R1059-20180118&qid=1519136585935. We omit FRY1–5, PT20, PT30, ES63, ES64, ES70 (overseas regions not located near Europe) and FI20 (due to missing data).
2. Leendertse et al. (2022) compare the Crunchbase data with new firm data. The percentage of new firms included in Crunchbase ranges from 0.003% to 1.5% per region. These differences seem substantial but could very well correspond to a real difference in the percentage of new firms that aim for high growth.
3. A similar exercise was done with data from Dealroom (2021), which gave a similar number of innovative firms and a distribution across regions, which was highly correlated (0.841) with the Crunchbase firm distribution (Leendertse et al., 2022).
4. Based on our sample of 273 regions, only a small part of the possible configurations can be observed. This is known as limited diversity and further aggravated by the observation that elements tend to appear in certain patterns (Fiss, 2007). In other words, some combinations of elements may never be observed even in a very large sample. Since we are interested in understanding empirically relevant entrepreneurial ecosystems, this does not pose a problem for our analysis.
5. PRI measures to what extent the set X is a subset of the outcome set Y instead of the negated outcome set ~Y. When the PRI is low, this indicates a simultaneous subset relation which implies a logical contradiction (Schneider & Wagemann, 2012).

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