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Figuring it out

Configurations of high-performing entrepreneurial ecosystems in Europe

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

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Abstract
Entrepreneurship is an important driver of economic development, but its success depends on a large set of interdependent factors and actors: an ecosystem for entrepreneurship. Is there one way to a successful entrepreneurial ecosystem or are there different paths? This paper applies Qualitative Comparative Analysis to identify and analyze configurations of successful regional entrepreneurial ecosystems in Europe. We test two rivalling causal logics: one stating that all entrepreneurial ecosystem elements need to be present and the weakest link is the most important constraint, and the other arguing that elements are substitutable. High entrepreneurship outputs can be realized with a small variety of entrepreneurial ecosystem configurations. But the higher the entrepreneurship output, the more convergence there is to an all-round entrepreneurial ecosystem.

Keywords: Entrepreneurship, entrepreneurial ecosystem, regional diversity, QCA

JEL classification: L26, M13, R12

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1. Introduction

Regions differ greatly in their ability to enable entrepreneurship, which is an important driver of economic development (Haltiwanger, Jarmin, and Miranda 2013; Stam et al. 2011; Fritsch and Wyrwich 2017; Fritsch and Schindele 2011). Entrepreneurship is predominantly a local event (Feldman 2001) and its prevalence is highly uneven across space (Bosma and Sternberg 2014; Dahl and Sorenson 2012; Stam 2007). This variation tends to persist over time because of the strong path dependence in entrepreneurship, which means that regions with a high rate of entrepreneurship are likely to continue this trend (Fotopoulos 2014; Andersson and Koster 2011; Fritsch and Wyrwich 2014). Various studies have sought to explain these persistent regional differences by investigating geographically bounded factors that matter for entrepreneurs (e.g., Delgado, Porter, and Stern 2010; Huggins and Thompson 2016; Qian, Acs, and Stough 2013).

Previous studies investigating spatial factors important for entrepreneurship have assumed that each factor affects entrepreneurship independently and in a linear way. However, the relationship between geographic factors and entrepreneurship is likely to be more complex, as various factors interact in different ways to enable entrepreneurship. The entrepreneurial ecosystem concept is a recent attempt to think in a complex system way about the regional environment enabling entrepreneurship (see e.g., Malecki 2018). 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 (Stam and Spigel 2018; Stam 2015). An ecosystem thus encompasses an interdependent set of actors and factors which can exist in different configurations. Productive entrepreneurship occurs when incentive structures are designed in such a way that, overall, entrepreneurship activity contributes positively to aggregate economic value creation (Baumol 1990). In the same vein, a successful entrepreneurial ecosystem enables productive entrepreneurship by enabling ambitious, innovative and growth-oriented entrepreneurship while discouraging types of entrepreneurship that may induce negative overall welfare effects (unproductive and destructive types of entrepreneurship in Baumol's terminology).

Adopting an entrepreneurial ecosystem approach holds the promise of facilitating the analysis of the strengths and weaknesses of the economic system at large, while taking into account the interdependencies between the elements of the system. 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 logic states that all elements need to be present and the weakest link is the most important constraint (Ács, Autio, and Szerb 2014). The second logic argues that elements are substitutable and there are many different possible pathways to a high-performing entrepreneurial ecosystem (Spigel 2017). This paper contributes to the literature by making a key step towards resolving this issue. We analyze the entrepreneurial ecosystems of 273 regions in Europe with a harmonized dataset that includes values of all entrepreneurial ecosystem elements and outputs in these regions, retrieved by combining various statistical sources. Focusing on regions is necessary to analyze the relevant local level of the entrepreneurial ecosystem (Brown and Mason 2017), while the use of 28 countries guarantees enough variety in the sample. The main question the paper addresses is: How do entrepreneurial ecosystem elements combine to enable productive entrepreneurship? The answer to this question reveals the importance of the two causal logics on entrepreneurial ecosystem performance: the complete entrepreneurial ecosystem logic and the equifinality entrepreneurial ecosystem logic, suggesting that there are multiple configurations that lead to entrepreneurial ecosystem success. To measure the different elements that constitute an ecosystem, the entrepreneurial ecosystem framework of Stam and Van de Ven (2019) is further developed. This study thus uses a clear theoretical framework validated by earlier research to choose the elements to include in the analysis.

To trace how the interdependencies between entrepreneurial ecosystem elements affect the levels of productive entrepreneurship in regions, we use Qualitative Comparative Analysis (QCA). QCA is a research method which explicitly allows for causal complexity and is applied to derive configurations of ecosystem elements (Schneider and Wagemann 2012). This method provides a mixture of a case-based (more qualitative) approach and a more general statistical approach. The types of causal complexity QCA incorporates are multiple conjunctural causation (elements that have to be combined to cause the outcome), equifinality (multiple ways to reach the same outcome) and causal asymmetry (presence and absence of an outcome can have different explanations), which are all relevant mechanisms in understanding entrepreneurial ecosystems. The set-theoretic basis of this method means that elements are analyzed 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 and Spigel 2018; Stam and van de Ven 2019). 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 startups and unicorn firms).

The findings indicate that different configurations of successful entrepreneurial ecosystems exist. High entrepreneurship outputs can be realized 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 very high levels of entrepreneurship output, there is more convergence to an all-round entrepreneurial ecosystem with all ecosystem elements strongly developed. However, there are still various ecosystem configurations in this group that lack some strong 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 enough to become one of the top entrepreneurial regions in Europe.

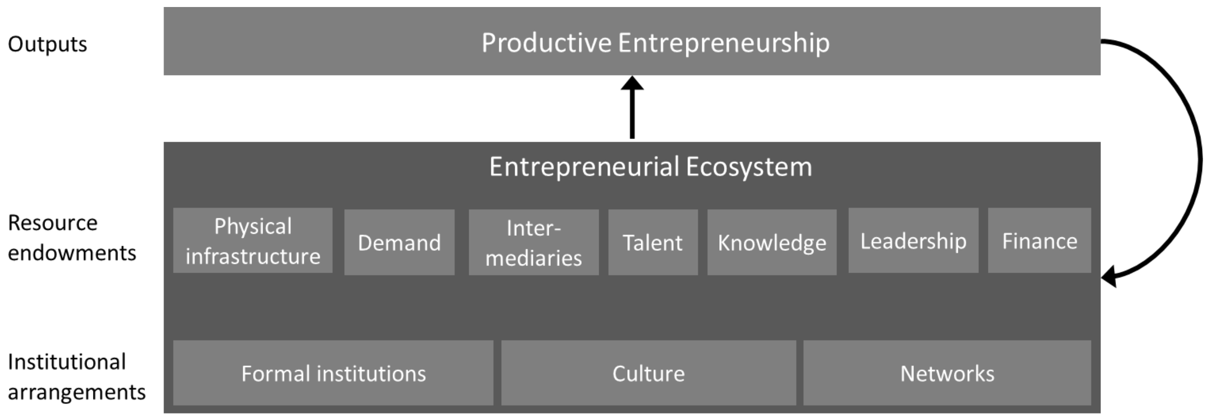
The outline of the paper is as follows. First, the entrepreneurial ecosystem concept is introduced and the existing literature on entrepreneurial ecosystem configurations is shortly discussed. Second, the dataset used in this study is described and the QCA research method is discussed in more detail. Third, the main findings of the QCA are presented. Finally, in the last section 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 (Malecki 2018; Wurth, Stam, and Spigel 2020). This concept is grounded in the economic geography literature and takes as its main starting point the idea that businesses do not exist in isolation of the environment. While this is a very old idea at least going back to Marshall (1890), who proposed the benefits of agglomeration for firms, the entrepreneurial ecosystem concept is different from the theory of agglomeration and related concepts such as industrial clusters and regional innovation systems. Several important distinctions are the central role of the entrepreneur in the entrepreneurial ecosystem and it being industry agnostic. In addition, governments are not seen as a leader of the ecosystem but as more of a facilitator (for a more extensive discussion of the differences see Spigel and Harrison 2018; Stam and Spigel 2018; Stam 2015).

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 and Spigel 2018; Stam 2015). Stam and Van de Ven (2019) visualize the entrepreneurial ecosystem framework with ten different ecosystem elements, divided into resource endowments and institutional arrangements that enable productive entrepreneurship (see Figure 1).

Figure 1. Elements and outputs of the entrepreneurial ecosystem (adapted from Stam and Van de Ven (2019)).



A distinctive characteristic of the entrepreneurial ecosystem concept is the systemic view it takes of entrepreneurship (Fredin and Lidén 2020). One of the systemic aspects is the interaction between elements; elements can reinforce each other or equally inhibit other elements to develop. Nevertheless, while the elements that compose the ecosystem have received much research attention, quite little is still known about the interaction of these elements (Alvedalen and Boschma 2017). To advance the theory 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.

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. (2014). They calculate an index to capture the quality of the entrepreneurial ecosystem at a national level. This index is composed of fifteen pillars which 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. 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. (2014) thus implicitly assume that all these fifteen conditions are necessary for high levels of entrepreneurship and equally important.

While Ács et al. (2014) essentially propose a one-size-fits-all prescription for the perfect entrepreneurial ecosystem, 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. He 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 the Stam and Van de Ven (2019) 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 entrepreneurship. 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 present and the weakest link is the most important constraint, and the other that argues that elements can be substitutable and there are different possible pathways to create a high-performing entrepreneurial ecosystem.

A research method well-suited to shed some light on this debate is Qualitative Comparative Analysis (QCA) (Ragin and Rihoux 2009). This 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 and 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 great 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. At the same time this method avoids problems, such as multicollinearity, of more traditional statistical methods. A disadvantage of the QCA method is that while a distinction is made between the presence and absence of an element, no precise numerical estimates are presented that measure the strength of the relation. It is thus not well suited to quantify the importance of the different elements in a very precise manner.

Recently, there has been some research that applied QCA to study entrepreneurial ecosystems. Vedula and Fitza (2019) study metropolitan areas in the US to find which specific combinations of elements are needed to support early-stage startups and late-stage ventures. Another study by Alves et al. (2019) looks at city ecosystems in the region of Sao Paulo in Brazil. While Muñoz, Kibler, Mandakovic, and Amorós (2020) study regional ecosystems in Chile with the use of Global Entrepreneurship Monitor data. The results of these studies indicate that there are multiple recipes for a high-performing entrepreneurial ecosystem, although some elements may be essential. This suggests a compromise between the two opposing ideas from the literature discussed above; some ecosystem elements may be substitutable, but others are essential and need to be well developed. The difference in importance of ecosystem elements links to the idea that elements in the entrepreneurial ecosystem should be given different weights (Corrente et al. 2019). However, the weighting of elements does not allow for possible substitutability. This paper aims at exploring the validity of such a compromise by revealing ecosystem configurations in a highly varied sample of successful entrepreneurial regions. To obtain a detailed understanding of the mechanisms, different definitions of entrepreneurial performance 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 50km or 100km 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 United Kingdom, 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.

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[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).

3.2 Conditions

The entrepreneurial ecosystem model of Stam and Van de Ven (2019) consists of ten elements. All of these elements are measured by statistical indicators, as described in Table A1 in the Appendix (see also Leendertse et al. (2020) for a detailed description of the construction of the database). 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.

Each element is treated as an input variable in the QCA, yielding a QCA with ten conditions. Even though this number of conditions is higher than usual and makes the solution space relatively complex, it still falls within the methodologically sound range (see Marx, Cambre and Rihoux 2013). All ten elements of the framework are included as conceptually they are all important for explaining entrepreneurial outcomes. Moreover, the systemic nature of the entrepreneurial ecosystem necessitates to analyze these elements together to capture the interdependencies that have so far not been uncovered. While all of these elements are positively correlated, there are no clear higher order constructs which can be used to reduce the number of conditions.

3.3 Output

The output of entrepreneurial ecosystems is productive entrepreneurship. There is not (yet) a perfect measure for the prevalence of regional productive entrepreneurship. For example, a measure such as total new firm formation includes many types of self-employment which are not likely to create much value beyond income for the business owner. Other measures, such as opportunity-based entrepreneurship (of the Global Entrepreneurship Monitor) are only available on the national level. In this study we operationalize productive entrepreneurship with two measures: innovative startups (less than 5 years old) and unicorn firms (young private firms with a valuation of more than $1 billion). 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 (see Guzman and Stern 2020; Leppänen, McKenny, and Short 2019).

Data on innovative startups was 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 is collected from investors and a community of contributors, it is moreover 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 OECD data, which shows very similar patterns and thus confirms the validity (Dalle, Den Besten, and Menon 2017). However, Crunchbase mainly includes companies which 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 startups and several studies have previously used Crunchbase to collect data on innovative companies (see 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 2015-2019, and corrects the number of firms for population size.

[2] In Leendertse et al. (2020) the Crunchbase data is compared with new firm data. The percentage of new firms included in Crunchbase ranges from 0.003% to 1.5%. These differences seem substantial but could very well correspond to a real difference in the percentage of new firms that aim for high growth.

Data on the presence of unicorn firms was 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 C.

4. Methodology

The research method used to explore the configurations of entrepreneurial ecosystems in Europe is Qualitative Comparative Analysis (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 analyzing the membership of cases in various conditions and the outcome (respectively the condition sets and outcome set). In this study, the conditions are the ten elements of the Stam and Van de Ven (2019) 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. The analysis was done with the software R using the packages QCA (Dusa 2019) and SetMethods (Oana et al. 2020). The R script is available upon request.

Calibrating membership scores requires setting an exclusion threshold, crossover point and inclusion threshold. These thresholds should ideally be chosen based on theoretical arguments or empirical findings in previous studies. However, the existing literature does not provide clear cutoff points based on either theory or empirics for what should be considered high and low scores of an element. As the data is mostly taken from studies conducted by the European Union, such as the Regional Ecosystem Scoreboard (Léon et al. 2016), which have only been recently initiated, it is also difficult to compare the data with historical averages or other countries. Therefore, in line with previous studies (Fiss 2011; Vedula and Fitza 2019; Alves et al. 2019), sample statistics are used to determine the thresholds. More specifically, the 25th, 50th and 75th percentile of the sample distribution are respectively the exclusion, crossover and inclusion threshold.[3] These thresholds are used for both the outcome and conditions. The use of sample statistics to calculate the thresholds means that regions are assessed relative to each other. A region is thus only considered a member of a condition if it scores good on this element compared to the other regions in the sample. For an overview of the thresholds and other descriptive statistics of the data, see Table B1 in the Appendix. A visual inspection of the calculated membership scores reveals that most scores are actually concentrated around 0 and 1. This has to do with the large variation in the data, which means that a lot of regions are actually quite far below or above the 25th/75th percentile. However, there is still a substantial group with scores between 0 and 1, which means the fuzzy calibration procedure does add meaningful information.

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

[3] Another common method to determine the thresholds is to use the median and standard deviations. However, this is not feasible in this dataset. As explained in Leendertse et al. (2020), the variation in the data is very large, mainly because the data distribution has a long right tail. This causes very high standard deviations and would thus translate into very low exclusion and high inclusion thresholds.

ten percent 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 and 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. This has to do with the fact that a combination of conditions is more likely to be sufficient for the outcome than a condition on its own. To exhaust this supply of possible sufficient conditions or combinations which are sufficient is therefore quite complex. On the contrary, necessary conditions can be tested for more easily because a single condition is more likely to be necessary than a combination. This is why the test of necessary conditions is often done at the beginning of the analysis for all single conditions separately (Schneider and Wagemann 2012). In the following paragraphs, the process of testing for sufficiency is described in more detail.

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. 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 analyzed 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 and Wagemann 2012). To make sure the results do not depend on the choice of this specific threshold, a sensitivity analysis is conducted in which different threshold values are applied (see Appendix D).

As the sample consists of 273 regions, the vast majority of theoretically possible configurations are not empirically observed. These 'empty rows' are considered logical remainders. The focus of this research is to find common configurations in Europe and not to study every regional peculiarity. For this reason, the frequency threshold is set to four. This implies that every configuration with fewer than four regions is considered an empty row for which the outcome is not observed. The truth tables showing all configurations with at least four regions are presented in the Appendix (Table B2 and B3).

The logical minimization of the truth table results in one or more solutions that are sufficient for the outcome. To summarize and present the solutions the format proposed by Fiss (2011) is employed, which distinguishes between core and peripheral conditions in a solution. Core conditions are those conditions that are present in the solution irrespective of the assumptions made about the logical remainders (this is also called the 'parsimonious solution'). Peripheral conditions are part of the solution when only logical remainders that are in line with theory (easy counterfactuals) are used for the logical minimization process (also called the 'intermediate solution'). However, peripheral conditions disappear from the solution when also logical remainders that do not support current theoretical knowledge (difficult counterfactuals) are allowed. So the core conditions are those for which there is very strong evidence of a causal relation with the outcome, while for peripheral conditions this evidence is weaker (Fiss 2011).

Two parameters of fit are calculated, the consistency and coverage. The consistency measure was briefly mentioned before 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 Necessary conditions

The results of the analysis of necessary conditions for both high-performing (top 25% Crunchbase firms) and very high-performing (top 10% Crunchbase firms) ecosystems are shown in Table 1. The conventional consistency threshold for necessary conditions is 0.9 (Schneider and Wagemann 2012). There are two necessary conditions that pass the threshold for the very high-performing ecosystems (shown in bold): leadership and intermediate services. So whenever regions exhibit very high levels of entrepreneurship output they almost always (as consistency is not exactly 1) have a strong presence of leadership and intermediate services. The coverage, which measures the empirical relevance of the conditions, of these two elements is just above 0.5, showing it covers more than half of the outcome set. In general, all elements have high consistency scores which already provides some evidence that these elements are important, although not strictly necessary, for entrepreneurship. A similar analysis with the absence of conditions as input and another to find necessary conditions for the absence of (very) high levels of entrepreneurship output did not show any conditions that passed the 0.9 consistency threshold.

Table 1. Necessary conditions Crunchbase firms

	Top 25%		Top 10%	
Element	*Consistency*	*Coverage*	*Consistency*	*Coverage*
Formal institutions	0.699	0.681	0.744	0.399
Culture	0.666	0.671	0.720	0.400
Networks	0.690	0.710	0.739	0.419
Physical infrastructure	0.685	0.698	0.794	0.446
Finance	0.719	0.696	0.797	0.426
Leadership	0.788	0.800	**0.940**	**0.526**
Talent	0.770	0.737	0.822	0.433
Knowledge	0.679	0.685	0.781	0.435
Demand	0.643	0.648	0.709	0.394
Intermediate services	0.809	0.818	**0.964**	**0.537**

Note: conditions that pass the 0.9 consistency threshold are shown in bold.

5.2 Configurations for high levels of entrepreneurship output

Having completed the analysis of necessity, we now turn to the ecosystem configurations that are sufficient for high levels of entrepreneurship output, operationalized as regions in the top 25% of Crunchbase firms in Europe. Table 2 summarizes the configurations according to the method proposed 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.[4] 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 on a map 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). Since there are several regions with high membership in most or even all ecosystem elements, there are various regions which are a member of multiple configurations. Especially the regions in different variations of the same solution (1a & 1b, 2a & 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 knowledge-intensive business services) for the second – and whether they depend on Leadership or Institutions (formal institutions, culture and networks combined).

[4] 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 and Wagemann 2012).

Table 2. Solutions for top 25% Crunchbase firms

	Talent-Leadership	**Talent-Institutions**	**Knowledge-Leadership**	**Knowledge-Institutions**
	1a	1b	2a	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			

Notes: 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.

Talent and knowledge are important drivers of entrepreneurship since new knowledge creates entrepreneurial opportunities which can be taken up by individuals with the required human capital (Qian, Acs, and Stough 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 and 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 specialized 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, Johnson, and Robinson 2006). However, it is important to realize 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 and 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 of these regions do have a well-educated labor 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.

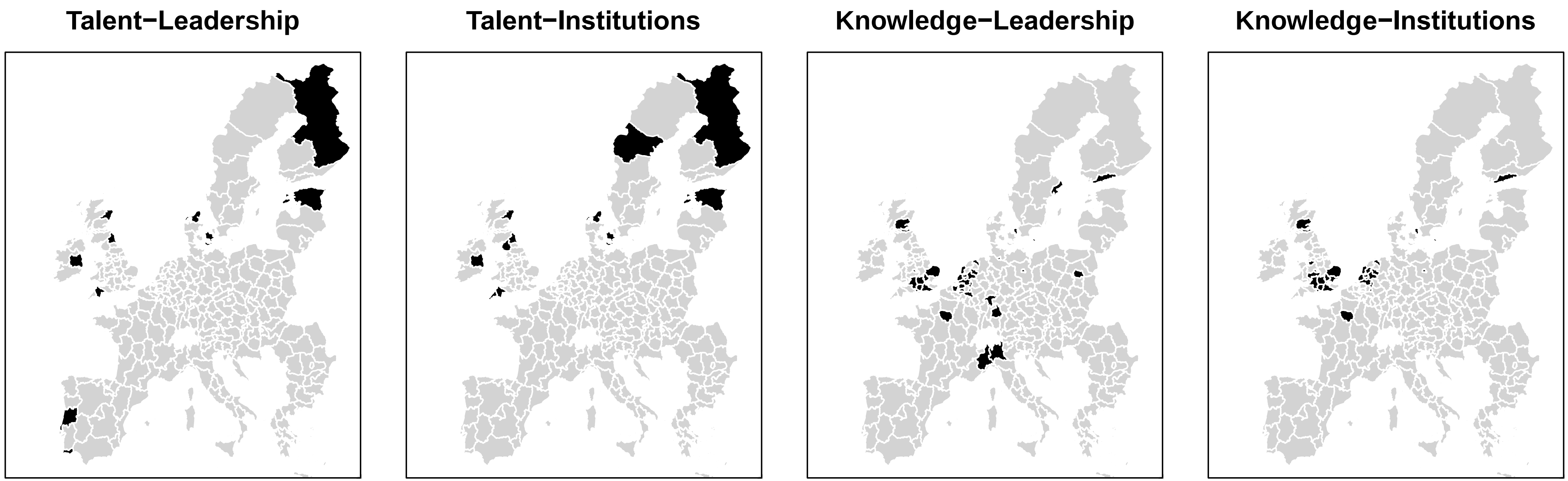
The second, Talent-Institutions, configuration is quite similar but combines strong talent with well-developed institutional arrangements, finance and intermediate services. The regions in this configuration are all located in the northern part of Europe and include northern Sweden and south-west England. 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 neighboring regions.

The third, Knowledge-Leadership, configuration 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, Knowledge-Institutions, configuration 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 ten 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 regions surrounding Amsterdam. Most of the regions in this configuration are also part of the Knowledge-Leadership configuration, as evidenced by the low unique coverage.

The overall solution consistency and coverage is high, showing the strength of the model. The four different configurations 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 ten elements. The explicit absence of demand in the two Talent configurations even seems to directly contradict the penalty for bottleneck theory (Ács, Autio, and Szerb 2014). 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.

Figure 2. Map of high-performing entrepreneurial ecosystem configurations in Europe



Notes: Regions in black are member of a particular configuration and member of the outcome set (top 25% Crunchbase firms).

5.3 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 ten percent in Europe. There is only one sufficient configuration with all elements present and most of these elements are core conditions. This can thus be characterized as an all-round ecosystem. However, the frequency threshold of four regions is quite high, because the number of regions in the outcome set is now lower with this more restrictive definition of success. When studying the truth table (Table B3) 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 there are several other configurations which consistently show the outcome. Table B4 shows the solutions for the analysis with a frequency threshold of three.

Table 3. Solutions for top 10% Crunchbase firms

	All-round
	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

Notes: 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.

While the solution consistency is still above the commonly used threshold of 0.8 (Schneider and 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 which are a member of the all-round configuration are a subset of the regions in the Knowledge ecosystem configuration (2a & 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 upon request) reveal that some regions are able to become part of this group with a few elements underdeveloped. Thus, while a strong all-round ecosystem is the most common way to entrepreneurial success, it is not an absolute requirement and there are examples of several exceptions.

For a QCA analysis several parameters have to be set by the researcher. To make sure the results do not crucially depend on one particular decision, several sensitivity analyses have been conducted for both the analysis of top 10% and top 25% Crunchbase firms. The results of these are presented in Appendix D.

6. Discussion

This study analyzed 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 complete entrepreneurial ecosystem logic and the equifinality 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 ten elements of the Stam and Van de Ven (2019) framework combined with several output measures. 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 ecosystems find a way to function without all elements at a high level.

The results of the necessary condition analysis showed that leadership and intermediate services are central elements of successful entrepreneurial ecosystems. This provides a first indication that some elements may be more important than others and it may pay off to focus on developing these first. On the other hand, the analysis of very high-performing ecosystems established that just having a few ecosystem elements on a high level is not enough to become one of the top entrepreneurial regions in Europe. It is therefore important to take a systemic view and not focus solely on developing one element of the ecosystem. Further research should investigate whether some elements of the ecosystem, like leadership, are indeed more important than others and should be prioritized when developing an ecosystem.

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. For example, leadership is measured with Horizon 2020 projects, which are EU-funded public-private partnerships for innovation projects. While this might be a good measure of knowledge leadership, 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 emphasize place-based leadership for realizing collective action in and for the region (Stam 2020). To measure this, one would however have to collect network data in every regional ecosystem.

Another improvement would be to decompose the indicators into their constituent parts and examine which parts are really essential for productive entrepreneurship. The infrastructure indicator for example encompasses both physical and digital infrastructure, which one could argue are quite different elements. However, the decomposition of indicators is not possible without making the QCA overly complicated. The use of 10 conditions is already quite on the high end of what one normally sees in QCA studies and difficult enough to grasp when properly taking into account the causal complexity (Leppänen, McKenny, and Short 2019).

The use of sample statistics to determine the thresholds for the configuration of the QCA is not ideal, although quite common in current literature. It is preferable to base thresholds on previous empirical evidence or theoretical arguments, to ensure cases are not compared relative to each other but relative to some external threshold. When more rounds of data become available, it would be possible to determine thresholds based on historical data. This also links to an important aspect of the entrepreneurial ecosystem approach, which is the dynamic nature of such systems. Entrepreneurial ecosystems are constantly developing and there are important feedback effects, through for example entrepreneurial recycling (Mason and Brown 2014). With longitudinal data, one could look at the stability of the presence of elements in the entrepreneurial ecosystem. It is important to understand whether elements of an entrepreneurial ecosystem are dynamic and constantly changing or relatively stable over time.

Another aspect that should be addressed in future research is the effect of neighboring regions. Entrepreneurs living close to regions with highly developed entrepreneurial ecosystems might benefit from these, which is also known as the borrowed size effect (Phelps, Fallon, and Williams 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 analyze the possibility that regions may benefit from well-developed ecosystem elements in neighboring regions, as this could explain why regions are able to function well without having some elements on a very high level themselves.

To better understand the functioning of the different types of ecosystems the QCA identified, it would be interesting 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 which seem to contradict the current theory. In particular, as all elements of the framework are deemed to be important for entrepreneurship, we could learn from analyzing 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 capitalizing 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.

The findings of the present study showed that different types of ecosystems may co-exist 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 which 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.

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Appendix A

Data description

Table A1. Description of indicators and data sources

Element	Indicators	Measurement and description	Source	Geographical level	Year
Formal institutions	Quality of Governance indicators for Corruption, Impartiality, and Quality and accountability	Average of z-score for the three indicators (Corruption, Impartiality, and Quality and accountability) based on survey answers	Quality of Government Index	NUTS 2 NUTS 1 for BE, DE, EL, SE, and UK Country for IE and LT	2017
Formal institutions	Ease of doing business index	Index based on several dimensions: starting a business, dealing with permits, registering property, credit access, protecting investors, taxes, trade, contract enforcement and closing a business	World Bank Doing Business Report	Country	2015
Entrepreneurship culture	Entrepreneurial motivation	Percentage of early-stage entrepreneurs motivated by a desire to improve their income or a desire for independence	Global Entrepreneurship Monitor	Country	2014

Entrepreneurship culture	Cultural and social norms	The extent to which social and cultural norms encourage or allow actions leading to new business methods or activities that can potentially increase personal wealth and income. Rating: 1=highly insufficient, 5=highly sufficient	Global Entrepreneurship Monitor	Country	2014
Entrepreneurship culture	Innovative and creative	Survey question on scale 0-5: it is important to think of new ideas and be creative	European Social Survey	NUTS 2 NUTS 1 for DE, UK Missing for FRM0, ITF2, LU00, MT00, PT20, PT30	2008 - 2016
Entrepreneurship culture	Trust	Survey question on scale 0-10: Most people can be trusted	European Social Survey	NUTS 2 NUTS 1 for DE, UK Missing for FRM0, ITF2, LU00, MT00, PT20, PT30	2008 - 2016

Networks	Innovative SMEs collaborating with others	Percentage of innovative SMEs in SME business population collaborating with others	RIS & EIS (for countries which are a NUTS 2 region) (also available in RCI)	NUTS 2 NUTS 1 for BE, UK, FR, and AT	2016
Physical Infrastructure	Accessibility via road	Population accessible within 1h30 by road, as share of the population in a neighborhood of 120 km radius	DG Regio (RCI)	NUTS 2	2016
Physical Infrastructure	Accessibility via rail	Population accessible within 1h30 by rail (using optimal connections), as share of the population in a neighborhood of 120 km radius	DG Regio (RCI)	NUTS 2	2014
Physical Infrastructure	Number of passenger flights	Daily number of passenger flights accessible in 90 min drive	Eurostat / Eurogeographics / National Statistical Institutes (RCI)	NUTS 2	2016
Physical Infrastructure	Household access to internet	Percentage of households with access to internet	Eurostat (RCI)	NUTS 2	2018
Finance	Venture capital	The average amount of venture capital for the last five years per capita	Invest Europe	NUTS 2	2014 - 2019

Finance	Credit constrained SMEs	Percentage of SMEs that is credit constrained because they either were rejected for loans or received less, or were discouraged to apply because it was too expensive or they expected to be turned down.	Investment Survey European Investment Bank	Country	2018
Leadership	The presence of actors taking a leadership role in the ecosystem	The number of coordinators on H2020 innovation projects per capita	CORDIS (Community Research and Development Information Service)	NUTS 2	2014 - 2019
Talent	Tertiary education	Percentage of total population that completed tertiary education	Eurostat	NUTS 2 NUTS 1 for BE, DE, and UK	2013
Talent	Lifelong learning	Percentage of population aged 25-64 participating in education and training	Eurostat	NUTS 2 NUTS 1 for BE, DE, and UK	2013
Talent	Business and entrepreneurship education	The extent to which training in creating or managing SMEs is incorporated within the education and training system. Rating: 1=highly insufficient, 5=highly sufficient	Global Entrepreneurship Monitor	Country	2014

Talent	E-skills	Percentage of individuals in active population with high levels of e-skills	Eurostat	Country	2014
New knowledge	R&D expenditure	Intramural R&D expenditure as percentage of Gross Regional Product	Eurostat	NUTS 2	2015
Demand	Disposable income per capita	Net adjusted disposable household income in PPCS per capita (index EU average=100)	Eurostat	NUTS 2	2014
Demand	Potential market size in GRP	Index GRP PPS (EU population-weighted average=100)	Eurostat	NUTS 2	2016
Demand	Potential market size in population	Index population (EU average=100)	Eurostat	NUTS 2	2018
Intermediate services	Incubators	Percentage of incubators in total business population	Own data	NUTS 2	2019
Intermediate services	Knowledge intensive services	Percentage employment in knowledge-intensive market services	Eurostat	NUTS 2	2018
Productive entrepreneurship	Innovative new firms	Number of new firms registered in Crunchbase in the last five years per capita	Crunchbase	NUTS 2	2019
Productive entrepreneurship	High-value new firms (unicorns)	Absolute number of entrepreneurial firms valued above $1 billion founded in the last ten years	CB Insights & Dealroom	NUTS 2	2019

Appendix B

Tables

Table B1. Descriptive statistics

Variable	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Formal institutions	272	0.992	0.803	0.098	0.311	1.680	3.497
Culture	272	0.985	1.070	0.026	0.321	1.170	5.000
Networks	272	0.984	1.147	0.117	0.262	1.213	5.000
Physical infrastructure	272	0.907	1.060	0.058	0.276	1.043	5.000
Finance	272	0.993	0.823	0.053	0.386	1.365	5.000
Leadership	272	0.704	1.112	0.181	0.207	0.534	5.000
Talent	272	0.960	0.958	0.072	0.241	1.322	5.000
Knowledge	272	0.724	1.032	0.109	0.220	0.644	5.000
Demand	272	1.003	0.932	0.032	0.334	1.430	4.761
Intermediate	272	0.682	0.984	0.082	0.205	0.597	5.000
Unicorn	272	0.180	1.052	0	0	0	15
Crunchbase output	272	0.852	1.020	0.014	0.287	0.920	5.000

Table B2. Truth table top 25% Crunchbase firms

Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate services	Crunchbase firms	N	Cons	PRI	Cases
1	1	1	1	1	1	1	1	1	1	1	22	0.969	0.958	DE30,DK01,FI1B,FR10,NL32,NL11,NL21,NL22,NL31,NL33,NL41,NL42,UKH2,UKI3&4,UKD7,UKG3,UKH1,UKJ1,UKJ2,UKJ3,UKK1,UKM7
1	1	1	1	1	1	1	0	0	1	1	4	0.958	0.914	DK02,IE06,UKC2,UKK4
1	1	1	0	1	1	1	1	0	1	1	4	0.957	0.925	DK05,EE00,FI1D,UKM5
0	0	1	1	1	1	0	1	1	1	1	5	0.932	0.871	BE24,BE31,BE21,BE23,BE33
1	1	0	1	1	1	1	1	1	1	1	4	0.927	0.864	DE11,DE60,DE71,SE11
1	1	1	0	1	0	1	0	0	1	1	4	0.880	0.691	SE31,SE32,UKD1,UKK3
1	1	1	1	1	0	1	1	1	1	1	7	0.877	0.744	NL23,UKH3,UKI5,UKI6,UKI7,UKD6,UKG1
0	0	0	1	0	1	0	1	1	1	1	4	0.856	0.684	ITC1,ITC3,ITI4,PL91
0	0	0	0	0	1	1	0	0	0	1	4	0.812	0.513	PT15,PT16,PT18,PT30
1	1	1	1	1	0	1	0	1	1	0	4	0.787	0.541	NL12,NL13,NL34,UKJ4
1	1	1	1	1	0	0	1	1	0	0	4	0.613	0.031	DE27,DEA5,DEB2,DED4
1	1	0	1	1	1	0	1	1	0	0	5	0.584	0.123	DE24,DE25,DE26,DEB3,DEG0

0	0	0	0	0	0	0	0	0	1	0	7	0.522	0.138	HR03,ITF1,ITF3,ITF4,ITG1,ITI3,PL63
0	0	0	0	0	0	0	1	0	0	0	4	0.481	0.094	CZ03,HU33,PL21,PL92
0	0	0	0	0	0	0	0	0	0	0	44	0.214	0.039	BG31,BG32,BG33,BG34,BG42,CZ04,CZ08,EL54,EL62,EL64,EL65,ES43,ES70,HR04,HU21,HU22,HU23,HU31,HU32,ITF2,ITF6,PL41,PL42,PL43,PL51,PL52,PL61,PL62,PL71,PL72,PL81,PL82,PL84,PT20,RO11,RO12,RO21,RO22,RO31,RO41,RO42,SK02,SK03,SK04

Table B3. Truth table top 10% Crunchbase firms

Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate services	Crunchbase firms	N	Cons	PRI	Cases
1	1	1	1	1	1	1	1	1	1	1	22	0.819	0.687	DE30,DK01,FI1B,FR10,NL32,NL11,NL21,NL22,NL31,NL33,NL41,NL42,UKH2,UKI3&4,UKD7,UKG3,UKH1,UKJ1,UKJ2,UKJ3,UKK1,UKM7
1	1	1	0	1	1	1	1	0	1	0	4	0.799	0.500	DK05,EE00,FI1D,UKM5
1	1	1	1	1	1	1	0	0	1	0	4	0.789	0.431	DK02,IE06,UKC2,UKK4
0	0	1	1	1	1	0	1	1	1	0	5	0.787	0.541	BE24,BE31,BE21,BE23,BE33
1	1	0	1	1	1	1	1	1	1	0	4	0.738	0.535	DE11,DE60,DE71,SE11
1	1	1	1	1	0	1	1	1	1	0	7	0.603	0.177	NL23,UKH3,UKI5,UKI6,UKI7,UKD6,UKG1
0	0	0	1	0	1	0	1	1	1	0	4	0.598	0.281	ITC1,ITC3,ITI4,PL91

1	1	1	0	1	0	1	0	0	1	0	4	0.529	0.005	SE31,SE32,UKD1,UKK3
1	1	1	1	1	0	1	0	1	1	0	4	0.505	0.05	NL12,NL13,NL34,UKJ4
0	0	0	0	0	1	1	0	0	0	0	4	0.43	0.07	PT15,PT16,PT18,PT30
1	1	1	1	1	0	0	1	1	0	0	4	0.314	0.000	DE27,DEA5,DEB2,DED4
1	1	0	1	1	1	0	1	1	0	0	5	0.304	0.001	DE24,DE25,DE26,DEB3,DEG0
0	0	0	0	0	0	0	0	0	1	0	7	0.258	0.045	HR03,ITF1,ITF3,ITF4,ITG1,ITI3,PL63
0	0	0	0	0	0	0	1	0	0	0	4	0.229	0.000	CZ03,HU33,PL21,PL92
0	0	0	0	0	0	0	0	0	0	0	44	0.068	0.001	BG31,BG32,BG33,BG34,BG42,CZ04,CZ08,EL54,EL62,EL64,EL65,ES43,ES70,HR04,HU21,HU22,HU23,HU31,HU32,ITF2,ITF6,PL41,PL42,

														PL43,PL51,PL52,PL61,PL62,PL71,PL72,PL81,PL82,PL84,PT20,RO11,RO12,RO21,RO22,RO31,RO41,RO42,SK02,SK03,SK04

Table B4. Solutions for top 10% Crunchbase firms (frequency cutoff 3)

	Knowledge	**Demand**
	1	2
Formal institutions	•	•
Culture	●	●
Networks	●	●
Physical infrastructure	●	●
Finance	•	•
Leadership	●	●
Talent	●	●
Knowledge	●	
Demand		●
Intermediate services	•	•
Consistency	0.819	0.822
PRI	0.687	0.698
Raw coverage	0.391	0.392
Unique coverage	0.044	0.046
Number of regions	25	25
Overall solution consistency	0.822	
Overall solution coverage	0.436	

Notes: 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

Appendix C

Unicorn Analysis

European unicorn firms are used as a second and slightly different measure of productive entrepreneurship. This provides a robustness tests for the results with Crunchbase firms as output measure. Unicorn firms are private (not stock listed) companies with a valuation of more than $1 billion. The emergence of unicorn firms is very rare but is a great example of Schumpeterian entrepreneurship (Henrekson and Sanandaji 2020). Moreover, a unicorn firm can be seen as a specific type of blockbuster entrepreneurship, which is important for an ecosystem as it can generate many positive externalities (Mason and Brown 2014). Nevertheless, the contribution of unicorns to economic output and growth has been debated (Aldrich and Ruef 2018), and is likely to differ per type of unicorn. For example, unicorn firms with widespread employee stock options are more likely to act as a catalyst of entrepreneurial ecosystem development, than unicorn firms with concentrated ownership, or foreign ownership. Data was collected from CB Insights which keeps a list of current unicorn firms globally (CB Insights 2020). As these are so rare, all firms that acquired unicorn status and were founded in the last ten years were included. The historical data was collected by scraping data from historical web pages of the internet archive and cross-checking this with Dealroom data (Dealroom 2020).[5] The unicorn firms were matched to the NUTS 2 region where the headquarters of the firm are located.

Since unicorn firms are only present in a handful of regions, it is not meaningful to use percentiles to calibrate membership in this outcome set. Nevertheless, there is a large range (0-15) in the number of unicorns per region, which needs to be reflected in the analysis. To allow for differences in

[5] The data from Dealroom is very similar to the Crunchbase data. It was used because Dealroom keeps a list of all European unicorns.

degree of membership, a fuzzy set QCA is applied with 0 as the exclusion, 0.1 as the crossover and 1.1 as the inclusion threshold. These thresholds are set like this to ensure that only regions with more than one unicorn are considered full members of the outcome set and regions with one unicorn are partial members of the outcome set. Even with these low membership thresholds, the membership in the outcome set is very skewed which leads to several analytical problems (Schneider and Wagemann 2012). While it is still possible to analyze necessary conditions for unicorn firms, it is not possible to find sufficient configurations (also called solutions). This is the case because almost every configuration with a unicorn region will also contain regions without a unicorn, therefore such a configuration does not pass the normally applied consistency threshold (see section 4.3 for further explanation of this measure). The simultaneous membership of regions with and without the outcome in a configuration also presents problems with simultaneous subset relations. Therefore, for the unicorn firms only the necessary condition analysis is conducted and a short discussion of the configurations of regions with unicorn firms is provided.

Table C1 shows the analysis of necessary conditions. Four of the ten elements pass the consistency threshold of 0.9 (shown in bold) with some other elements, especially infrastructure, also being very close to 0.9. Almost all regions with one or more unicorns thus have a strong presence of finance, leadership, talent and intermediate services. The necessity of finance may not be surprising as this includes a measure of venture capital and unicorns are almost always backed by a venture capital investor. In the previous analyses, we saw that leadership and intermediate services are also elements necessary to produce a very high number of Crunchbase firms (see Table 1) and talent and intermediate services are core conditions in the sufficient configurations (see Table 2). These elements are thus characteristic for outstanding entrepreneurial ecosystems.

There are twenty regions in Europe with at least one unicorn, an excerpt from the truth table presented below (Table C2) shows that these regions are a member of ten different configurations in total. This variation in configurations supports the earlier results. While the largest group of regions (9) has all elements on a high level, there are many regions that lack at least one element. Some regions such as Oberbayern in Germany and Catalonia in Spain even have multiple elements (2 and 3 respectively) missing but still produced respectively 3 and 2 unicorns in the last ten years. In sum, the analysis of unicorns indicates the robustness of the earlier results to a change in the outcome measure of productive entrepreneurship.

Table C1. Necessary conditions unicorns

Element	*Consistency*	*Coverage*
Formal institutions	0.814	0.177
Culture	0.857	0.192
Networks	0.764	0.175
Physical infrastructure	0.889	0.201
Finance	**0.913**	**0.197**
Leadership	**0.928**	**0.210**
Talent	**0.905**	**0.193**
Knowledge	0.824	0.185
Demand	0.870	0.195
Intermediate services	**0.928**	**0.209**

Note: conditions that pass the 0.9 consistency threshold are shown in bold.

Table C2. Modified excerpt from truth table unicorns (only cases with unicorns included)

Formal institutions	Culture	Networks	Physical infrastructure	Finance	Leadership	Talent	Knowledge	Demand	Intermediate services	Unicorns	N	Cases
1	1	1	1	1	1	1	1	1	1	32	9	DE30 (Berlin), NL41 (Noord-Brabant), UKH1 (East Anglia), UKJ2 (Surrey, East and West Sussex), NL32 (Noord-Holland), UKI3&4 (Inner London), UKK1 (Gloucestershire, Wiltshire, Bristol/Bath), FR10 (Ile-de-France), NL31 (Utrecht)
1	0	1	1	1	1	1	1	1	1	2	1	AT13 (Vienna)
1	1	0	1	1	1	1	1	1	1	4	2	SE11 (Stockholm), DE60 (Hamburg)
1	1	0	1	1	1	0	1	1	1	3	1	DE21 (Oberbayern)
1	1	1	1	1	1	1	0	0	1	2	1	IE06 (Eastern and Midland)
0	0	0	1	1	1	1	1	1	1	2	1	ES51 (Catalonia)
0	1	0	1	1	1	1	1	1	1	1	1	ES30 (Madrid)
0	1	1	1	1	1	1	0	1	1	1	1	LU00 (Luxembourg)
1	1	1	0	1	1	1	1	0	1	1	1	EE00 (Estonia)
1	1	1	1	1	1	1	0	1	0	1	1	UKC1 (Tees Valley and Durham)

Appendix D

Sensitivity analysis

Decisions on specific parameters of the QCA analysis were based on theory or current best practice (Schneider and Wagemann 2012). To make sure the results do not crucially depend on one particular decision, several sensitivity analyses have been conducted. In particular, for these robustness checks the frequency threshold, the consistency threshold and the calibration of the membership scores were varied.

In the main analysis the frequency threshold was set at four regions to study common configurations among regions, while not examining every existing configuration in Europe in detail. When one lowers this threshold the number of solutions increases sharply, as almost every specific ecosystem configuration is included in the logical minimization process. The opposite occurs when one raises the threshold to five regions. Nevertheless, the main result is not affected by changing the frequency threshold as the results still show different possible configurations for top 25% Crunchbase firms, which largely overlap with those shown in Table 2. When the frequency threshold is lowered for the analysis of top 10% Crunchbase firms, the number of configurations increases as discussed previously and shown in Table B4.

Varying the consistency threshold from 0.8 to 0.7 or 0.9 does similarly not cause major changes in the results. While the number of solutions and the specific permutations vary somewhat, this does not change the interpretation of the results. However, the configuration in which demand is absent is not very robust and disappears when the consistency threshold is changed. On the other hand, configurations with explicit absence of formal institutions and culture appear with a low consistency threshold. Another interesting observation is that when the consistency threshold is set at 0.9 for top 10% Crunchbase firms, there is no configuration that passes this consistency level and can thus be said to be sufficient for very high entrepreneurship. This indicates that there are some regions with a strong presence of the elements but without the corresponding high levels of entrepreneurship output. While these are exceptional cases (including Gelderland and Limburg in the Netherlands and the Liverpool area in the UK), it would be interesting to study these regions and investigate what inhibits them from being successful.

The calibration that was used in the main analysis was based on the 25th, 50th and 75th percentile. Robustness analyses were performed with more and less strict thresholds for membership by varying the exclusion, crossover and inclusion thresholds, but the solutions remain qualitatively similar. The only remarkable change is that with thresholds at the 20th, 50th and 80th percentile the absence of formal institutions and culture appear while the absence of demand disappears from the solution. An interesting variation is to set the thresholds for membership in the conditions the same as those for the outcome of the very high-performing ecosystem analysis (exclusion 50th, cross-over 75th and inclusion 90th percentile). The membership sets of the conditions thus become very exclusive, while the thresholds for the outcome are kept at the quartile levels. This results in none of the regions being a member of all the elements anymore and five different configurations in the truth table for top 25% Crunchbase firms. The solution shows that the core elements are formal institutions, talent and intermediate services.