Leendertse, Jip; Schrijvers, Mirella T.; Stam, Erik

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# Measure twice, cut once: entrepreneurial ecosystem metrics

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Utrecht University

School of Economics

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Kriekenpitplein 21-22, 3584 EC Utrecht, The Netherlands Tel: +31 30 253 9800, e-mail: use.ri@uu.nl www.uu.nl/use/research

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# Measure Twice, Cut Once
# Entrepreneurial Ecosystem Metrics

Jip Leendertse[1], Mirella T. Schrijvers[2], Erik Stam[2]
1: Innovation Studies, Copernicus Institute of Sustainable Development
Utrecht University
2: Utrecht University School of Economics
Utrecht University

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

**Keywords:** entrepreneurial ecosystem; regional dynamics; entrepreneurship; economic development; economic policy; entrepreneurship policy

**JEL classification:** D2, E02, L26, M13, O43, P00, R1, R58

Comments welcomed to: e.stam@uu.nl

# Measure Twice, Cut Once
# Entrepreneurial Ecosystem Metrics

## 1. Introduction

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

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

However, the lack of sufficient metrics on entrepreneurial ecosystems makes it difficult to have adequate diagnosis and monitoring in the policy cycle. The lack of adequate diagnosis and monitoring is one of the reasons that economic policy often fails to achieve its objectives. In this paper we address the metrics gap by developing and applying entrepreneurial ecosystem metrics to analyse entrepreneurial economies. These metrics enable adequate diagnosis of entrepreneurial economies and allow for the monitoring of economic change generated by policy and other dynamics. This paper thus takes heed of the old carpenter's adage "measure twice, cut once", by reducing policy failures with better measurement tools.

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

Developing entrepreneurial ecosystem metrics encompasses quantification and qualification. Quantification involves measuring the key elements with a wide range of data sources (Credit et al., 2018). Qualification involves developing a methodology that provides insight into the extent to which these elements are interdependent, into the overall quality of the entrepreneurial economy, and how this relates to entrepreneurial outputs. We have three main research questions. First and foremost, how can we compose a harmonized data set with which the quality of key elements of entrepreneurial economies can be measured? We develop a universal set of constructs for each entrepreneurial ecosystem element and we source data from a large variety of datasets to compose credible, accurate, and especially comparable metrics of entrepreneurial ecosystems. We measure entrepreneurial ecosystems with a harmonized dataset in the context of 273 regions in 28 European countries. Europe provides an excellent laboratory for analysing entrepreneurial economies because it contains a large number of regions that exhibit striking variation in socio-economic conditions, entrepreneurial activity, and economic growth.

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

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

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

## 2. Entrepreneurship and economic development

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

### *2.1 Entrepreneurship and economic growth*

The role of entrepreneurship in economic development has been studied for a long time, going back to Schumpeter (Schumpeter, 1934), Leibenstein (1968) and Baumol (1990). The

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

### *2.2 The geography of entrepreneurship*

The geography of entrepreneurship literature has provided numerous insights into the role of different factors enhancing the prevalence of entrepreneurship in regions (Bosma et al., 2011; Stam, 2010; Stam and Spigel, 2018; Sternberg, 2009). We summarize the empirical geography of entrepreneurship literature with ten elements affecting the prevalence of entrepreneurship (cf. Stam, 2015; Stam and Van de Ven, 2019). The first element, formal institutions, provides the fundamental preconditions for economic action (Granovetter, 1992) and for resources to be used productively (Acemoglu et al., 2005). Formal institutions are not only a precondition for economic action to take place, they also affect the way entrepreneurship is pursued and the welfare consequences of entrepreneurship (Baumol, 1990). Informal institutions in particular the entrepreneurship culture, which reflects on the degree to which entrepreneurship is valued in society, also have strong effects on the prevalence of entrepreneurship, (Fritsch and Wyrwich, 2014). Networks of entrepreneurs provide an information flow, enabling an effective distribution of knowledge, labour and capital (Malecki, 1997). A highly developed physical infrastructure (including both traditional transportation infrastructure and digital infrastructure) is a key element

of the context to enable economic interaction and entrepreneurship in particular (Audretsch et al., 2015). Access to finance—preferably provided by investors with entrepreneurial knowledge—is crucial for investments in uncertain entrepreneurial projects with a long-term horizon (see e.g. Kerr and Nanda, 2009). Leadership provides direction for the entrepreneurial ecosystem. This leadership is critical in building and maintaining a healthy ecosystem (Feldman, 2014) and involves a set of 'visible' entrepreneurial leaders who are committed to the region (Feldman and Zoller, 2012). The high levels of commitment and public spirit of regional leaders might be a reflection of underlying norms dominant in a region (Olberding, 2002). Perhaps the most important condition for entrepreneurship is the presence of a diverse and skilled group of workers ('talent': see e.g. Acs and Armington, 2004; Glaeser et al., 2010; Lee et al., 2004; Qian et al., 2013). An important source of opportunities for entrepreneurship can be found in knowledge, from both public and private organizations (see e.g. Audretsch and Lehmann, 2005). In addition, the presence of financial means in the population to purchase goods and services—preferably locally, but possibly also on a further distance—is essential for entrepreneurship to occur at all. The presence of demand thus is an important element of the entrepreneurial ecosystem. Income and purchasing power in a region is both a cause and an effect of entrepreneurship in a region (Berkowitz and DeJong, 2005), hinting at the role of feedback effects in the evolution of entrepreneurial ecosystems. Finally, the supply of support services by a variety of intermediaries can substantially lower entry barriers for new entrepreneurial projects, and reduce the time to market of innovations (see e.g. Clayton et al., 2018; Howells, 2006; Zhang and Li, 2010).

### *2.3 An entrepreneurial ecosystem framework*

To understand the long-term development of (regional) economies and the role of entrepreneurship, the approaches of economic growth and geography of entrepreneurship need to be combined. Entrepreneurship plays a double role: it is the output variable in the geography of entrepreneurship approach, and it is the input variable in the economic growth approach. To complicate matters even more, entrepreneurship and economic growth also affect the inputs of the geography of entrepreneurship approach, for example with serial entrepreneurs becoming venture capitalists and creating networks; and with economic growth leading to growth in demand, investments in knowledge, and congestion effects in the physical environment. One solution to these conceptual complications is to build on complex systems approaches (Arthur, 2013; Hidalgo and Hausmann,

2009; Ostrom, 2010; Simon, 1962) to develop and use a complex systems perspective on the evolution of entrepreneurial economies (Feld and Hathaway, 2020; Roundy et al., 2018; Stam and Van de Ven, 2019). A complex systems perspective is able to integrate the geography of entrepreneurship and the entrepreneurship and economic growth literature. We build on the integrative model of entrepreneurial ecosystems by Stam and Van de Ven (2019), which includes institutional arrangements and resource endowment elements (see Fig. 1). The model includes three key mechanisms: interdependence and coevolution of elements, upward causation of the ecosystem on entrepreneurship, and downward causation of entrepreneurial outputs on the quality of the ecosystem (Stam and Van de Ven, 2019).

The empirical literatures on the geography of entrepreneurship and economic growth reveal several factors to be of relevance in explaining the spatial heterogeneity in entrepreneurship. This suggests that there is a limited set of factors that affects the prevalence of entrepreneurship in a region. The insights from the empirical literature on the geography of entrepreneurship and economic growth can be integrated into one figure (see Fig. 1), reflecting an entrepreneurial ecosystem framework with ten elements (cf. Stam, 2015; Stam and Spigel, 2018; Stam and Van de Ven, 2019). This framework with ten elements provides a compromise between other frameworks with five (Vedula and Kim, 2019), six (Isenberg and Onyemah, 2016), seven (Radosevic and Yoruk, 2013) and 14 elements (Ács et al., 2014). We build on these frameworks and develop them further by separating inputs and outputs of the system, providing an academically grounded set of elements, and using empirical indicators more closely reflecting productive entrepreneurship (Baumol, 1990; Schumpeter, 1934).

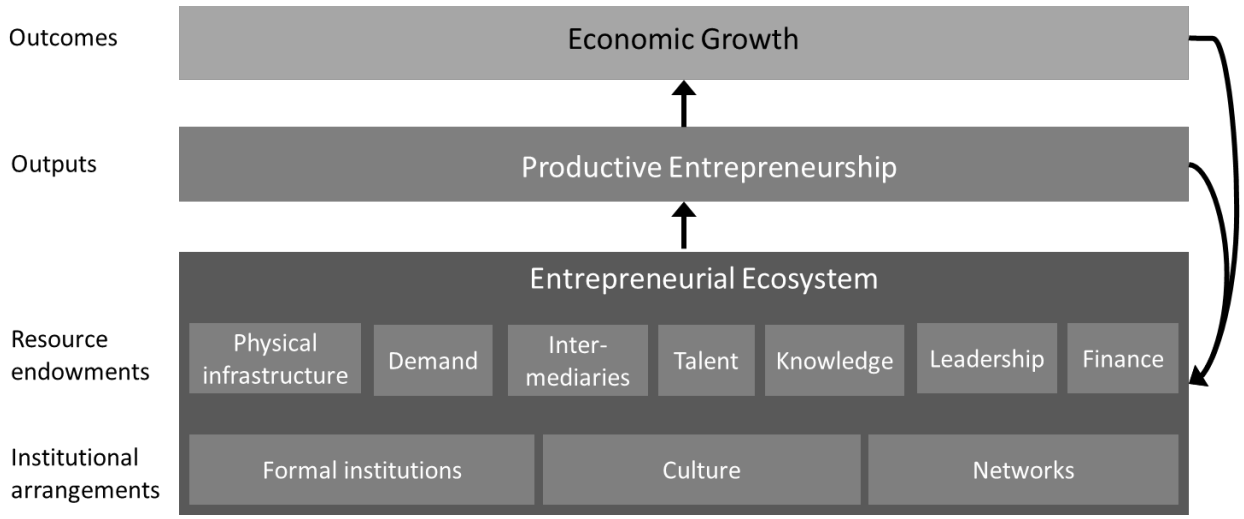



**Fig. 1.** Elements and outputs of the entrepreneurial ecosystem (adapted from Stam, 2015; Stam and Van de Ven, 2019).

## 3. Measuring entrepreneurial ecosystems

The ecosystem framework discussed above identifies ten key elements of an entrepreneurial ecosystem. While we do not claim to be exhaustive, ten ecosystem elements should be able to capture the most essential conditions for entrepreneurship to flourish. In this section, we discuss how we source data from a large variety of datasets to compose credible, accurate and especially comparable metrics of entrepreneurial ecosystems. Since there is no perfect dataset available for measuring entrepreneurial ecosystems, we have to compose one, with imperfections that we will discuss. This is also an invitation for follow-up research to improve our metrics when new data becomes available.

There are several existing metrics studies on the regional level that focus on themes closely related to entrepreneurship, especially in the European Union. For example the regional competitiveness index (RCI) (Annoni and Dijkstra, 2019), which measures the general competitiveness of a region including factors such as human capital and infrastructure. While the RCI and other studies such as the Regional Innovation Scoreboard (RIS) include several key indicators related to entrepreneurship, none of these explicitly focus on entrepreneurship. This is why a study starting

from a clearly defined framework and explicitly focusing on productive entrepreneurship provides a novel and valuable contribution to the understanding of entrepreneurial conditions in a region. We thus set out to operationalize the entrepreneurial ecosystem elements into measurable variables at the appropriate geographical level. First, we discuss the boundaries of an ecosystem to determine the relevant level of analysis. Then we shortly illustrate the main data sources and describe the operational measures of each ecosystem element (for an overview see Table 1).

*3.1 Level of analysis*

The outputs and outcomes of entrepreneurial ecosystems are the result of a complex set of actors and factors that occur in a temporal and varying regional setting. As Feldman and Lowe (2015, p. 1785) rightly state there is often a disconnect "between the theoretical definition of a region as integrated contiguous space and the political and census geography for which data are readily available". In addition, since ecosystems are continuously evolving and are not limited to a specific sector, it is hard to precisely determine their boundaries (Stam and Van de Ven, 2019). The primary demarcation criterium should be the spatial reach of the causal mechanisms involved. This does not lead to one straightforward unit or spatial level of analysis. First, given the multiplicity of causal mechanisms involved in nurturing entrepreneurship, there will be different spatial reaches: for talent it may be the daily urban system (within a 50 mile radius), while for credit it may be the local bank, and for venture capital a two hour drive radius (which may overlap with the regional level in large countries, but may be beyond the national level for small countries). Second, there is a spatial nestedness of contexts: formal institutions at the municipal, regional, national and supranational level may be important context conditions. These first two considerations make it difficult to delineate the spatial boundary of entrepreneurial ecosystems from a causal mechanism point of view.

From a practitioners' point of view, the stakeholders of entrepreneurial ecosystems, the relevant boundaries will again be different depending on their role in the ecosystem. For civil servants it will be a particular jurisdiction, while for entrepreneurs it may be a multiplicity of layered (regional, national) or connected ecosystems (different city-regions). To determine the spatial level of analysis (although almost always imperfect) we therefore search for a common spatial denominator in combination with data availability (to allow for comparisons). It should be kept in

mind that even though we choose a spatial unit to represent the entrepreneurial ecosystem, entrepreneurial ecosystems are not closed containers, but open systems.

In the European context, the most relevant spatial level of analysis is between the municipal and national level, since the spatial reaches of the different elements are most likely to overlap with regional boundaries (e.g. the 50 mile radius for talent). The regional level in Europe is best defined through the NUTS 2 classification, which identifies 281 geographical regions[1] over the 27 member states and the United Kingdom. The boundaries of NUTS 2 regions are based on existing administrative boundaries and population thresholds. The population of a NUTS 2 unit is roughly between 800,000 and 3 million people (European Commission, 2018).

While for some countries and/or indicators data is available on the more fine-grained NUTS 3 level, this was not the case for most countries or indicators we are interested in. We therefore decided to keep the unit of analysis at NUTS 2 as this would enable us to cover a larger set of regions all over Europe. Including a large set of regions is important because it enables comparison, one of the main goals of this paper. This is a first step and future studies could dive deeper into certain topics or countries and use more detailed data to do so. By defining entrepreneurial ecosystems at the NUTS 2 level we use the same region size as the recent study by Stam and Van de Ven (2019) but instead of one country we include all countries in the European Union and the United Kingdom.

A disadvantage of looking at regions is that data on a regional level is, for most countries, scarcer than national data. However, the European Union performs several large data collection exercises on regional level to inform regional policy, which results in the availability of a fairly large amount of regional data. Furthermore, we use web scraping to create new metrics at the NUTS 2 level. Finally, we use several national measures to account for the aforementioned spatial nestedness of for example institutions. This combination of data on different geographical levels is discussed in detail for each element below and summarized in Table A1 in the appendix.

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

*3.2 Data sources and element construction*

To measure the entrepreneurial ecosystem elements we combine data from various sources and complement this with data obtained by web scraping. For most elements we use very specific datasets, e.g. for finance we use the regional venture capital data of Invest Europe and for formal institutions the Quality of Government Survey. While for other elements we use specific indicators from existing datasets on related topics, e.g. the accessibility of a region from the Regional Competitiveness Index (RCI) for physical infrastructure or the percentage of innovative SME's that collaborate from the Regional Innovation Scoreboard (RIS) for networks. The data sources used for each element are described in detail below and in Table A1 in the appendix.

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

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

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

To measure four of our variables, high-growth firms, unicorns, leadership, and the number of incubators, we use the location of individual organizations to calculate a regional aggregate measure. The methodology of geocoding and region allocation for these measures is as follows. First, we use the nominatim package in R to geocode the given locations using OpenStreetMap (OpenStreetMap, 2019; Rudis, 2019). This is an online map which allows users to pass a list of locations into the software and obtain their coordinates. For the few regions without a match in this procedure we manually search and add its coordinates. Subsequently, we used Eurostat shapefiles to determine in which NUTS 2 region these coordinates are located. These shapefiles contain an exact overview of the NUTS 2 boundaries (Eurostat, 2019). We then use the rgdal package in R to assign the coordinates to the corresponding NUTS 2 region (Bivand et al., 2019; Eurostat, 2019). With this procedure we are able to assign all except for about 0.1% of the organizations to a region. We manually searched the remaining organizations and located the remaining geocodes through the browser tool of OpenStreetMap. After this we were able to assign all organizations for all four variables to a region. For each of the four variables we then count the number of organizations/firms in each NUTS 2 region and divide this by the population of the region to obtain our final measure.

For a few indicators, in some countries, data is only available at the NUTS 1 level. In those cases we follow the approach of previous measurement studies and impute the NUTS 1 values for the NUTS 2 regions (Annoni and Dijkstra, 2019; Hollanders et al., 2019; Léon et al., 2016). Table 1 provides an overview of the empirical indicators and data source for each element while Table A1 in the appendix provides a more detailed description for each measure.

**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 SMEs that engage in innovative collaborations as a percentage of all SMEs in the business population | Regional Innovation Scoreboard (RIS) |
| Physical Infrastructure | Transportation infrastructure and digital infrastructure | Four components in which the transportation infrastructure is measured as the accessibility by road, accessibility by railway and number of passenger flights and digital infrastructure is measured by the percentage of households with access to internet | Regional Competitiveness Index (RCI) |
| Finance | The availability of venture capital and access to finance | Two components: The average amount of venture capital per capita and the percentage of SMEs that is credit constrained | Invest Europe and European Investment Bank (EIB) |
| Leadership | The presence of actors taking a leadership role in the ecosystem | The number of coordinators on H2020 innovation projects per capita | CORDIS (Community Research and Development Information Service) |
| Talent | The prevalence of individuals with high levels of | Four components: The percentage of the population with tertiary education, the percentage of the working population | Eurostat and the Global |

| | | | |
|---|---|---|---|
| | human capital, both in terms of formal education and skills | engaged in lifelong learning, the percentage of the population with an entrepreneurship education, the percentage of the population with e-skills | Entrepreneurship Monitor (GEM) |
| New Knowledge | Investments in new knowledge | Intramural R&D expenditure as percentage of Gross Regional Product | Eurostat |
| Demand | Potential market demand | Three components: disposable income per capita, potential market size expressed in GRP, potential market size in population. All relative to EU average. | Regional Competitiveness Index (RCI) |
| Intermediate services | The supply and accessibility of intermediate business services | Two components: the percentage of employment in knowledge-intensive market services and the number of incubators/accelerators per capita | Eurostat and Crunchbase |
| Output | Entrepreneurial output | The number of Crunchbase firms founded in the past 5 years per capita | Crunchbase |
| | Unicorn output | The absolute number of unicorns in the region founded in the last ten years | CB Insights and Dealroom |

*3.4 Formal institutions*

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

To operationalize the quality of government we use the Quality of Government study (QOG), which is the largest sub national governance study that has been performed (Charron et al., 2019). The Quality of Governance study has been used in numerous other studies and is a reliable measure of institutional quality (Charron et al., 2015). The quality of government indicator consists of three

components: corruption, accountability and impartiality. These are each measured by a large, regional, citizen survey and complemented by the World Governance Indicators on a national level. The survey questions measure both experiences and perceptions of citizens with institutions in the particular region of the respondent (Charron et al., 2019). This measure thus accounts for the nestedness of the regional variation in quality of governance within national institutions.

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

*3.5 Entrepreneurship culture*

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

To measure entrepreneurship culture we use four indicators: entrepreneurial motivation and cultural and social norms encouraging new business activity from the Global Entrepreneurship Monitor (GEM) measured at the country level (Bosma and Kelley, 2019), and the perceived importance of being innovative and creative, and trust in others from the European Social Survey[2] measured at the NUTS 2 level (Norwegian Center for Research Data, 2014)[3]. Again, we combine

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

[3] Stam and Van de Ven (2019) use the number of new firms per 1,000 inhabitants as an alternative measure of culture. We initially aimed to combine our current indicator with this data. However, there is (not yet) a harmonized dataset on this variable for all European NUTS 2 regions and we thus had to use a combination of OECD, Eurostat, and national statistics offices to construct this variable (see Table A1). These data sources were not consistent in their

entrepreneurship specific measures with a more general measure of the regional culture (trust). This general indicator is important because in societies where people trust others it is for example easier to have economic interaction and invest in the first place (Zak and Knack, 2001).

*3.6 Networks*

When actors in a region are well connected in networks this allows information, labour and knowledge to flow to firms which can use it most effectively (Malecki, 1997). Networks are essential for entrants as it helps new firms to build social capital, which firms can leverage to get access to resources, information and knowledge (Eveleens et al., 2017; van Rijnsoever, 2020). The connections between firms can be measured through their cooperation projects. Our focus on entrepreneurship entails that we specifically want to measure cooperation on innovative projects. Therefore, we measure networks as the number of Small and Medium Enterprises (SMEs) that collaborate on innovation projects as percentage of all SMEs in a specific region. These SMEs will not all necessarily be entrepreneurial firms, but the focus on innovation projects means this measure captures the kind of productive collaboration that is likely to contribute to entrepreneurial output. We therefore believe that this is the best data currently available. In addition, the size of SMEs (enterprises with between 10 and 250 employees) matches with our focus on entrepreneurial growth since it does not include micro firms (less than 10 employees) or large firms, both of which are less relevant for our research goal. We use the data from the RIS, complemented with the European Innovation Scoreboard (EIS) for countries with only one NUTS 2 region. The RIS and EIS base their data on the Community Innovation Survey, a large survey on innovation activity including thousands of enterprises in every country in the European Union (Arundel and Smith, 2013).

*3.7 Physical infrastructure*

Physical infrastructure is essential for economic interaction between actors and thus essential for entrepreneurship as well (Audretsch et al., 2015). In this highly digital world not only physical infrastructure enables this interaction but also digital infrastructure. Digital infrastructure provides

definitions and data demarcations. Hence, we deemed the validity of this alternative measure to be questionable and we excluded this measure from our analyses. We did perform a robustness test in which we combined the birth rate of new firms with our current culture measure. The results of our analyses remained largely identical.

the opportunity to meet other actors, even if they are not in close physical proximity. Therefore, it is important to include this when creating an empirical measure of infrastructure. For our indicator we follow the approach of the RCI which uses the accessibility by road, accessibility by railway and number of passenger flights to measure the physical (transportation) infrastructure of a region (for details see Table A1). To this we add a measure for the digital infrastructure of a region, which is the percentage of households with access to internet and also available from the RCI (Annoni and Dijkstra, 2019).

*3.8 Finance*

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

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

*3.9 Leadership*

Leadership in an entrepreneurial ecosystem is necessary to provide the actors in the ecosystem a certain direction or vision to work towards and to make the ecosystem function more effectively (Normann, 2013). Leadership can be provided by individual leaders but also by collaborative

efforts that try to guide the system in a certain direction. Since leadership is an intangible concept it is quite hard to measure and remains understudied (Sotarauta et al., 2017). In our study we operationalize leadership as the number of project coordinators of Horizon2020 innovation projects in a region.[4] We thus follow the approach of Stam and Van de Ven (2019) who use the number of innovation project leaders as their operationalization for leadership. Although this measure is not limited to entrepreneurial leaders, it does capture whether there are organizations in a region that are willing to initiate new and innovative projects. These organizations, either public or private, are likely to create collective action in entrepreneurial ecosystems. To construct this variable we use the CORDIS database which contains data on 23,693 innovation projects that are subsidized as part of the Horizon 2020 program of the European Union (CORDIS, 2019; European Commission, 2019). We then use the geocoding approach outlined in section 3.3 to create our leadership indicator, the number of innovation leaders per capita.

*3.10 Talent*

Human capital (or talent) encompasses the skills, knowledge and experience possessed by individuals (Stam and Van de Ven, 2019). Human capital is a critical input for entrepreneurship and has been shown to be linked to new firm formation (see e.g. Acs and Armington, 2004; Glaeser et al., 2010). It is clearly a broad concept which asks for several empirical measures to properly cover its different facets. We break human capital down into two different components, general human capital and entrepreneurship-specific human capital (Becker, 1964; Rauch and Rijsdijk, 2013). We use two measures for the general human capital component, both from Eurostat (Eurostat, 2020). The first measure is the percentage of population having completed tertiary education and the second measure is the percentage of population aged 25-64 that participates in education or training (lifelong learning).

Entrepreneurship specific human capital is directly related to start-up activities (Brüderl et al., 1992; Rauch & Rijsdijk, 2013). We include two measures, the quality of entrepreneurship and business education from the GEM (Bosma and Kelley, 2019), and the percentage of population

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

with high level e-skills from Eurostat (Eurostat, 2020). The inclusion of digital skills is important because digital literacy is essential for working in any type of enterprise in the current digital society. In addition, a lot of productive entrepreneurship nowadays involves some digital aspect.

### *3.11 Knowledge*

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

### *3.12 Demand*

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

### *3.13 Intermediate services*

Intermediate services or producer services can help producers to start a new enterprise and market an innovation. This support can substantially lower entry barriers for new entrepreneurial projects and speed up the introduction of innovations (Howells, 2006; Zhang and Li, 2010). For this

element we again combine a general and an entrepreneurship specific measure. We operationalize the general measure as employment in knowledge intensive market services, which represents the general availability of intermediate services, such as legal, marketing, accountancy and consultancy services. The required data is available in Eurostat (Eurostat, 2020).

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

### *3.14 Entrepreneurial Ecosystem Index*

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

does not rely on the assumption that all components are equally important, as alternative method of combining the elements. Subsequently, we also perform a series of robustness checks on the index. Finally, we present a future research agenda on ways to further improve the measurement of the quality of entrepreneurial ecosystems that includes giving weights to elements.

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

*3.15 Output*

The output of the entrepreneurial ecosystem is productive entrepreneurship (see Fig. 1). This kind of entrepreneurship contributes to the output of the economy and consequently leads to aggregate value creation, which is the outcome of the system (Baumol, 1990). Previous research has shown that proxies of productive entrepreneurship have strong positive effects on economic growth and job creation (Criscuolo et al., 2014; Haltiwanger et al., 2013; Stam et al., 2011; Wong et al., 2005). Productive entrepreneurship is a subset of total entrepreneurship and thus requires another measure than, for example, the total number of new firms.

In this study we take the number of new firms (i.e. founded less than 5 years ago) that are registered in Crunchbase as our measure for entrepreneurial output (Crunchbase, 2019; Dalle et al., 2017). Crunchbase predominantly captures venture capital oriented innovative entrepreneurial firms and largely ignores companies without a growth ambition and is thus a good source for data on productive entrepreneurship (Dalle et al., 2017). We choose the five year timeframe to ensure that we select firms who experience their growth phase during the same time period (2015-2019) as most of our indicators are measured (see Table A1). This time period also helps to limit our sample towards innovative new firms as Crunchbase also includes incumbent, long established innovative firms. The data on Crunchbase mostly comes from two channels, a community of contributors and a large investor network. This data is then validated with other data sources using AI and machine-learning algorithms.

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

[5] The data sources for the number of new firms in each country is outlined in table A1.

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

In addition to the Crunchbase output measure, we use a measure for extreme entrepreneurial output in the form of unicorns, which are young private firms valued above $1 billion. Data was collected from CB Insights which keeps a list of current unicorn companies all over the world (CB Insights, 2020). As these are so rare, all firms founded in the last ten years that acquired unicorn status were included. This was done by scraping data from historical web pages of the internet archive and cross-checking this with Dealroom data (Dealroom, 2020).[7] We then used the geocoding procedure to allocate these unicorns to a total of 20 NUTS 2 regions. As such, unicorns are a very rare and selective form of productive entrepreneurship that is only present in a small number of regions. Besides unicorns being a very rare type of organization, the value of unicorns as a measure of productive entrepreneurship has also been a topic of discussion (see for example Aldrich and Ruef, 2018; Economist, 2019), which is why we only use this as an additional output measure.

*3.16 Extreme values*

Since the European Union covers a large and diverse set of regions, the data show a lot of variety. In particular, for the measures of knowledge, intermediate services, leadership and entrepreneurial output there are a few regions that have very high values (up to 14 times the standard deviation). Even though this variation is plausible, these outliers do disproportionally influence the correlation results and regression results. Most importantly, for the regions that score extremely high on one particular indicator, the index for the quality of the entrepreneurial ecosystem is disproportionally influenced by that indicator. This does not reflect the systemic nature of entrepreneurial ecosystems as argued in the existing academic literature (Spigel, 2017; Stam, 2015). Therefore, we performed two transformations on the data to provide better interpretable results. First, before the standardization of the composite indicators we cap the maximum value at four standard deviations of the mean (for more information on the standardization procedure see section 3.14 on index calculation).[8] In practice this means that we change the values for UKI3&4 (Inner London) of the Crunchbase output, leadership, and intermediate services measures, for DE91 (Braunschweig) of knowledge (as a result of the high R&D intensity), and for DK01 (Hovedstaden)

[7] The data from Dealroom is similar but less extensive than the Crunchbase data. We used it for the unicorn variable because Dealroom keeps a list of all European unicorns.

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

of leadership. Without these transformations the high deviations of these values skew the outcomes of the normalization process in such a way that only a few regions achieve above average scores. Second, we set the maximum score for any single element to five in order to prevent a disproportionate influence of strong performing ecosystem elements on the overall index. We perform a number of robustness checks on the construction of our index which we discuss in appendix C.

## 4. Quantifying and qualifying entrepreneurial ecosystems in Europe

### *4.1 Descriptive statistics*

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

**Table 2**

Descriptive statistics

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

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

We see a large variation for several variables, from regions with less than 2 percent of the EU average to regions who have over 56 times the average value. These findings are nevertheless in line with our expectations since we study regions across different countries and levels of development. Looking at the three index values that we calculated using the methods of Stam and Van de Ven (2019), we find that the difference between the smallest and largest value for the multiplicate index is a factor $10^{15}$. This difference is disproportionately large in comparison with the actual variation in the data as a result of the multiplicative way of calculating the index. Hence, we deem the external validity of the multiplicative index to be insufficient and instead use the additive and the logarithmic indices in our further analyses. Throughout the remainder of this study we primarily focus on the additive index due to the intuitiveness of its interpretation.

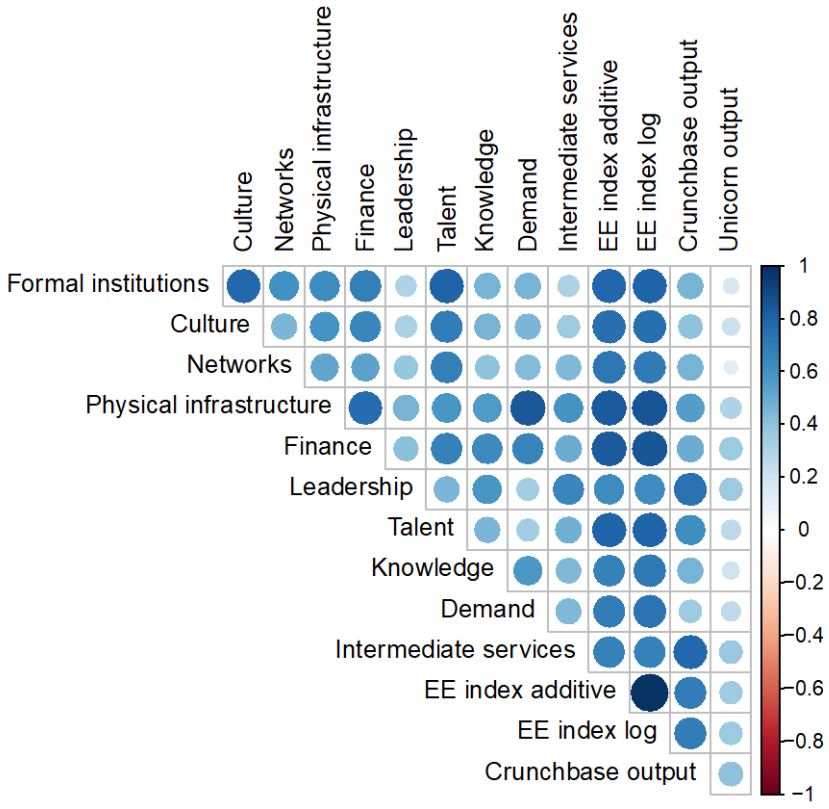
*4.2. Interdependence between entrepreneurial ecosystem elements*

Table 3 shows the correlations between the different elements of the entrepreneurial ecosystem, the index and the outputs. We see high, positive and significant correlations between all of the elements of the ecosystem.[9] The strong positive correlations illustrate the interdependencies in the entrepreneurial ecosystem. This corresponds to the results shown in Stam and Van de Ven (2019) and confirms the systemic nature of entrepreneurial ecosystems. Considering the entrepreneurial output measures, we see positive and significant correlations with all elements, and with the entrepreneurial ecosystem indices we constructed. These correlations provide some support for the proposition regarding upwards causation, stating that the ecosystem elements influence the occurrence of productive entrepreneurship.

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

**Table 3.**

Correlation matrix (correlation coefficient is indicated by colour and the significance level by size, only correlations that are significant at 5% level are shown)




We use a network methodology to show the interdependencies between the ten elements in Fig. 5. Physical infrastructure and finance take the most central position in the interdependence web. This central role is supported by the finding that physical infrastructure and finance have respectively eight and six interdependencies with a correlation above 0.5 (Fig. 6a), followed by formal institutions and talent which each have five. When looking at the interdependencies with correlations above 0.6, formal institutions and finance are the most central in the interdependence web with each five correlations above 0.6 (Fig. 6b). Physical infrastructure, culture, and talent also have central positions with four correlations above 0.6. Finally, formal institutions and physical infrastructure each have two interdependencies with correlations above 0.7 (see table A2). This provides an indication for a potential role of these elements as fundamental conditions of the entrepreneurial ecosystem.

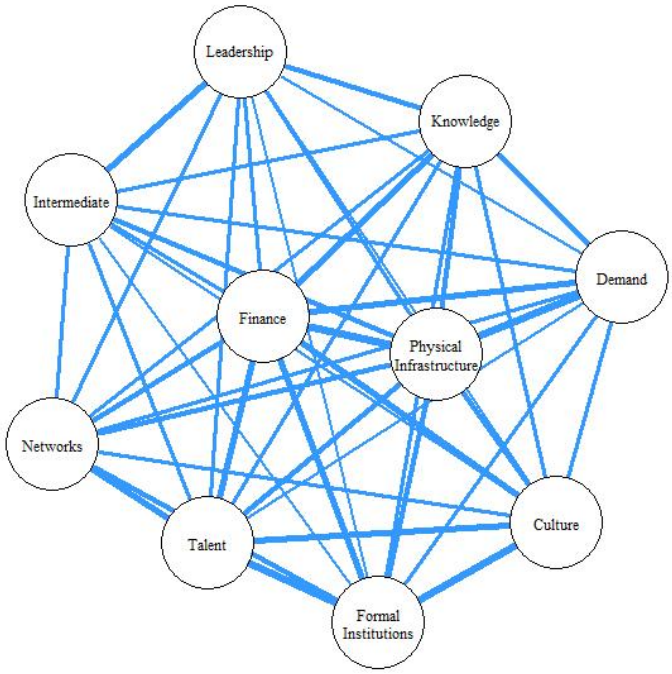



**Fig. 5.**

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

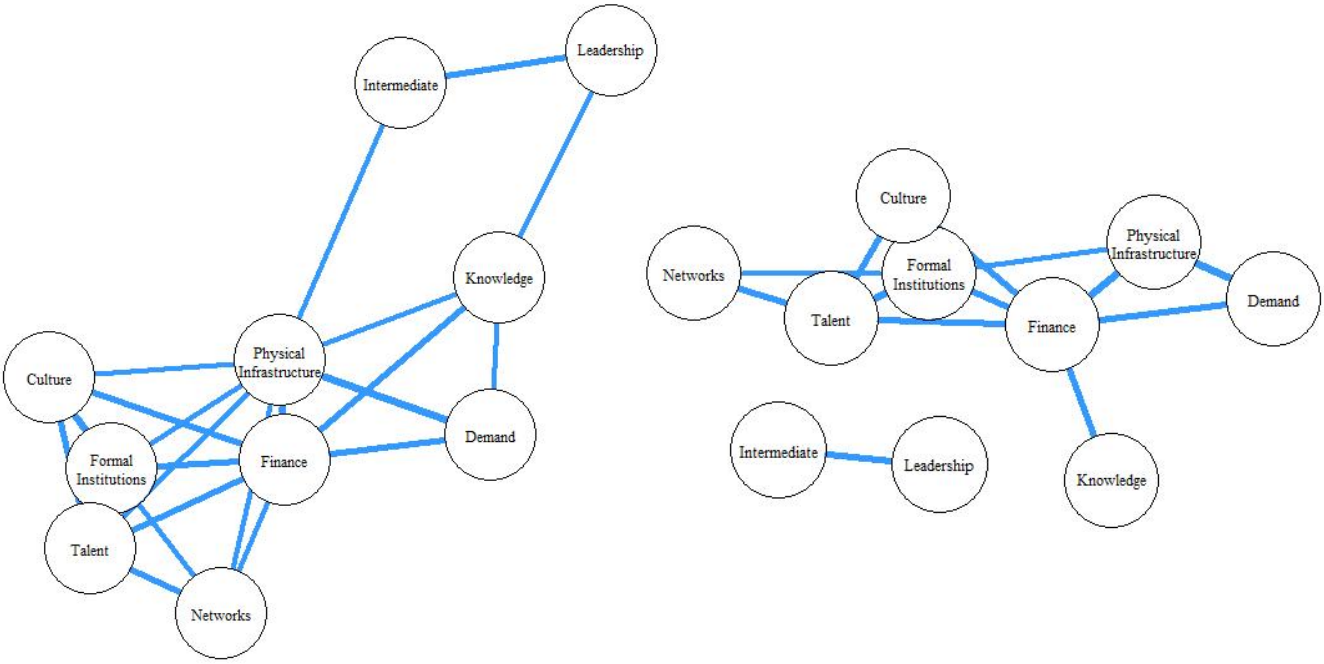



**Fig. 6a. and 6b.**

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

To further explore the interdependencies we performed principal component analysis (PCA) on the 10 individual elements. This method does not assume that all elements are equally important as the elements are assigned different loadings. The results are presented in Table 4, the first component explains 44.9% of the variance and has loadings of 0.21 or higher for all components. The three elements with the highest loadings are finance (0.40), physical infrastructure (0.38), talent (0.36), and formal institutions (0.35). This result confirms our findings from the interdependence graphs which show a strongly connected set of elements with a central role for these elements. The second component, which explains an additional 12.8% of the variation, has loadings of 0.21 or higher for six components. Similarly, the third component explains 12.4% of the variation and here six elements have loadings above 0.24. The results of the PCA thus confirm the strong interdependencies between the entrepreneurial ecosystem elements. The high loadings of all elements also show that all elements are related to the underlying dimensions of the data and are thus likely to be relevant to the entrepreneurial ecosystem.

**Table 4.**

Principal components analysis

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

*4.3. Entrepreneurial Ecosystem Index*

We now use the Entrepreneurial Ecosystem Index (EEI) to provide insight in the strongest and weakest entrepreneurial ecosystems in Europe. The scores for the ten highest (Fig. 2) and lowest ranking (Fig. 3) regions are shown in the bar graphs below. The highest scoring regions are, as expected, mainly Western European and densely populated, while the lowest scoring regions are mainly Bulgarian and Greek rural regions. To look at the different Entrepreneurial Ecosystems in more detail, Fig. 4 shows the map of Europe with all NUTS 2 regions coloured based on the value of the EEI. The highest index values can be found in European capital regions, such as London, Helsinki, and Stockholm. Many regions in Eastern Europe show very low index values as do some of the more rural areas in Spain. The map supports the claim that there is a substantial difference between urban and rural areas. Most of the high-scoring regions include large cities. In section 4.6 we will compare our index to existing variables and rankings (such as GDP and the RCI) to discuss the added value of the EEI.

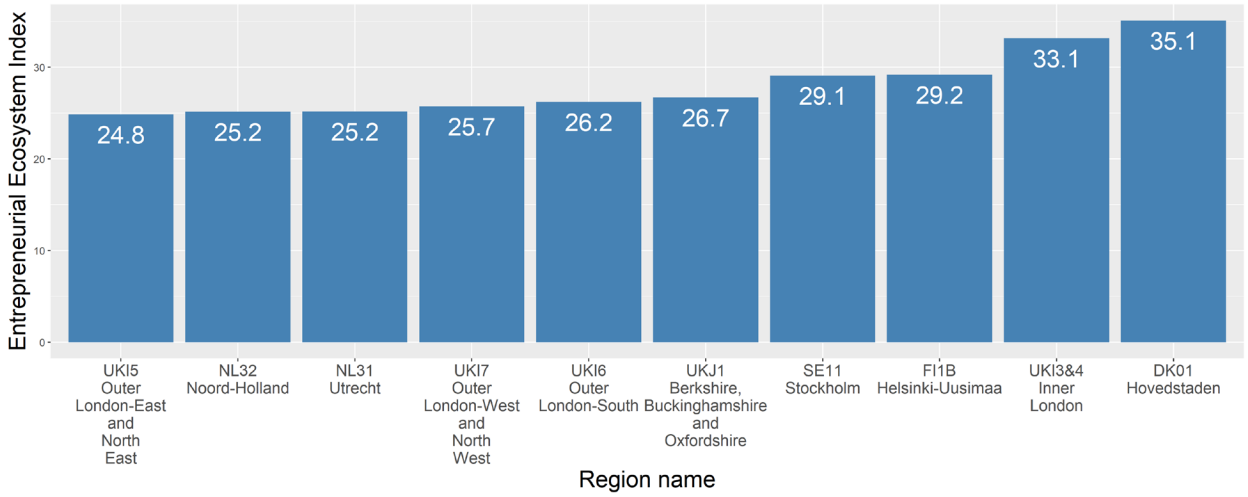



**Fig. 2**

NUTS 2 regions with the highest Entrepreneurial Ecosystem Index scores.

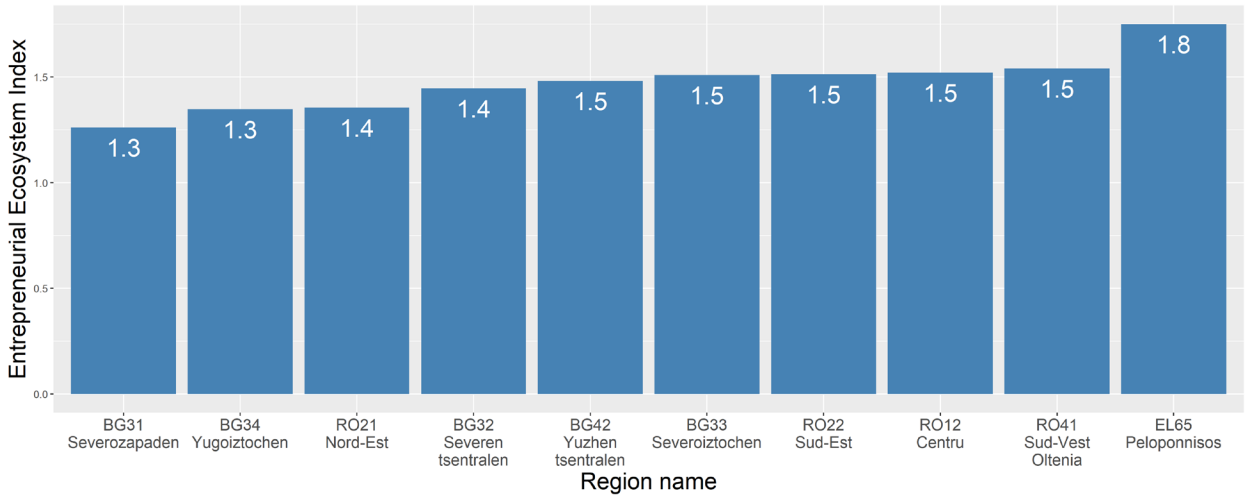



**Fig. 3**

NUTS 2 regions with the lowest Entrepreneurial Ecosystem Index scores.

The EEI simply adds the different elements and subsequently creates a ranking based on the total value of the ten elements. A different approach to classify regions is to use a cluster analysis on the ten ecosystem elements, which creates groups of regions which are closest to each other on the scores for each element. Particularly, we use k-means clustering which minimizes the total intra-cluster variation (sum of squared errors) using Euclidean distance measures for an a priori fixed number of clusters (Tan et al., 2018). K-means clustering is the most popular clustering technique and was originally proposed by MacQueen (1967). The number of clusters is a parameter that has to be set by the user. After considering the total intra-cluster variation, the average silhouette of clusters, the gap statistic, and the interpretability of the outcomes we selected the approach with three clusters. The results (Table 5) show a large first cluster which includes low-performing regions, including for example Athens, Budapest and Sicily. The second cluster forms a middle group and includes Manchester, Cologne and Luxembourg. Finally, the third cluster is the smallest group with high performing regions including Berlin, London, and Brussels. Table 5 shows a clear pattern in the average index values of the regions across the clusters. This is further confirmed through the visual representation of the clusters which shows that the cluster distribution closely aligns with the scores of the EEI (figure B1 in the appendix). Using clustering as an alternative method to classify regions we thus find highly similar results to the index.

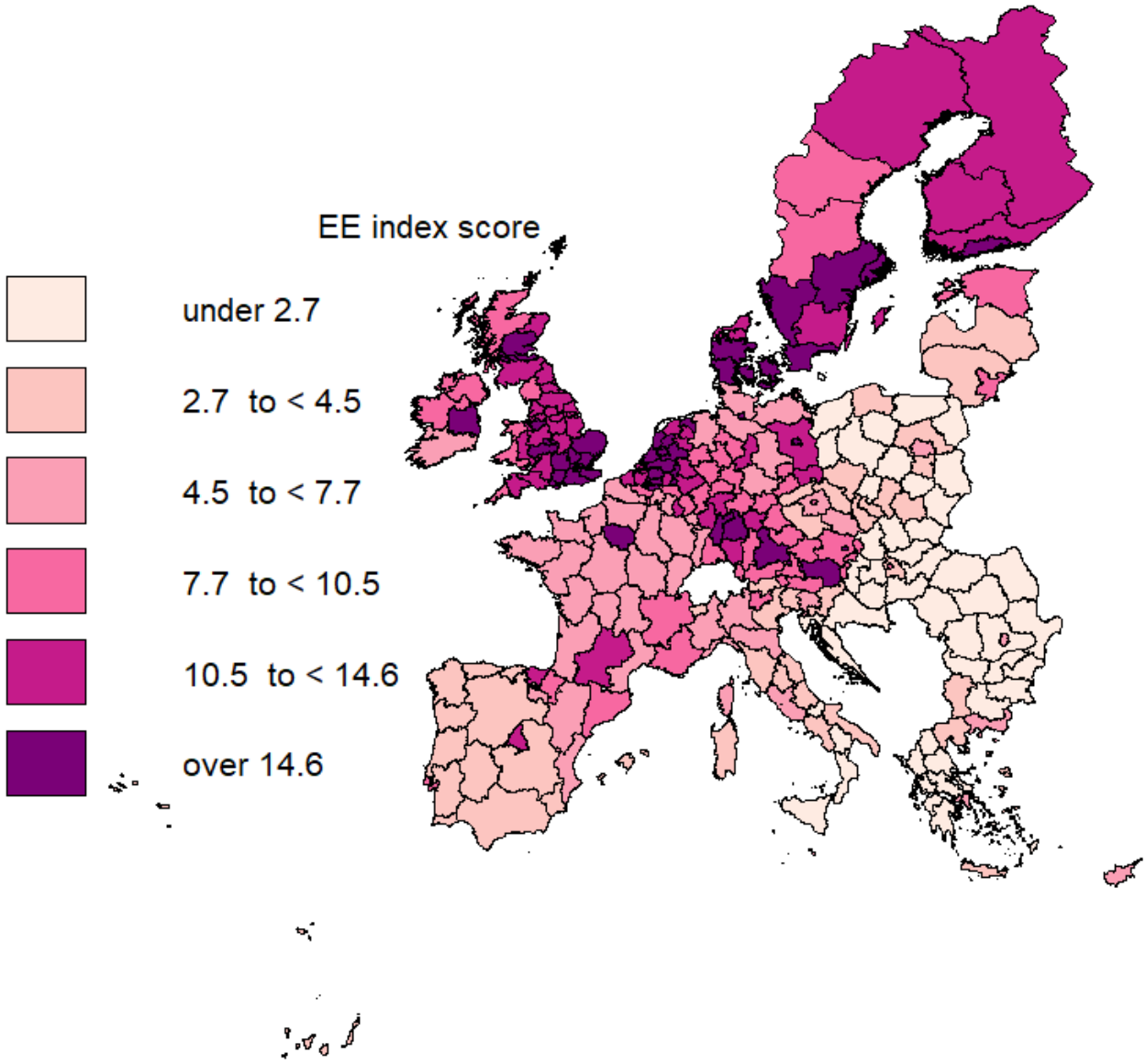



**Fig 4.**

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

**Table 5**.

Summary statistics of index and output by cluster

| | Cluster 1 (N=148) | Cluster 2 (N=95) | Cluster 3 (N=29) | Overall (N=272) |
|---|---|---|---|---|
| **Number of Crunchbase enterprises** | | | | |
| Mean (SD) | 0.575 (0.767) | 0.777 (0.554) | 2.51 (1.64) | 0.852 (1.02) |
| Median [Min, Max] | 0.337 [0.0143, 5.00] | 0.685 [0.178, 4.47] | 2.18 [0.288, 5.00] | 0.466 [0.0143, 5.00] |
| **EE index additive** | | | | |
| Mean (SD) | 4.34 (2.25) | 12.0 (2.62) | 22.3 (5.13) | 8.93 (6.46) |
| Median [Min, Max] | 3.58 [1.26, 11.4] | 11.8 [7.58, 19.1] | 21.4 [14.4, 35.1] | 7.66 [1.26, 35.1] |
| **EE index log** | | | | |
| Mean (SD) | -11.3 (4.75) | -1.39 (2.34) | 5.32 (2.52) | -6.06 (7.16) |
| Median [Min, Max] | -11.5 [-22.0, -1.56] | -1.52 [-6.34, 3.51] | 5.09 [0.970, 10.6] | -5.29 [-22.0, 10.6] |
| **Unicorn output** | | | | |
| Mean (SD) | 0.0203 (0.183) | 0.0316 (0.176) | 1.48 (2.91) | 0.180 (1.05) |
| Median [Min, Max] | 0 [0, 2.00] | 0 [0, 1.00] | 0 [0, 15.0] | 0 [0, 15.0] |

*4.4. Entrepreneurial Ecosystem Index and entrepreneurial output*

After discussing the creation and reliability of the EEI we now use regression analysis to study if regions with better ecosystems indeed have higher entrepreneurial outputs. Table 5 showed that the regions in the third cluster with a high EEI score have significantly higher outputs than the middle and laggard clusters. This provides an indication that the relation between the index and entrepreneurial output is not linear. This indication is confirmed through a scatterplot (Fig. 7).

An increase in performance on the index thus goes together with a disproportionately large increase in the number of start-ups. To capture this nonlinearity in the relation between the quality of an entrepreneurial ecosystem and its entrepreneurial outputs, we performed a regression with quadratic effects, for the results see table B2 in the appendix. The quadratic effects are significant ($p<0.001$) and show that the relation between the index and the entrepreneurial output is indeed nonlinear. However, the convex relation between the index and output means that adding quadratic effects forces a quadratic curve on the observations that looks like a U-shape. This is an unintended side effect of using quadratic effects in a linear regression.[10]

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

Therefore, to better capture the nonlinear relationship between the index and output we instead perform a piecewise linear regression. This allows breakpoints in the regression line that is fitted to the data. The results are presented in Figure 7 and Table 7. The breakpoint that optimizes model fit for the additive index is located at an index score of 19.[11] At this point the slope quite sharply increases from 0.08 to 0.39. For both the first and the second line we find a positive and significant relation between the index and entrepreneurial output ($p<0.01$). The large increase in the slope of the regression line further shows that at the high end of the index there is a small group of regions with very high performance regarding entrepreneurial output. This corresponds with our findings in the cluster analysis presented above.[12] The results of the regression analyses with the unicorn output as dependent variable can be found in Table B3 in the appendix[13] and are consistent with the findings reported in Table 7.

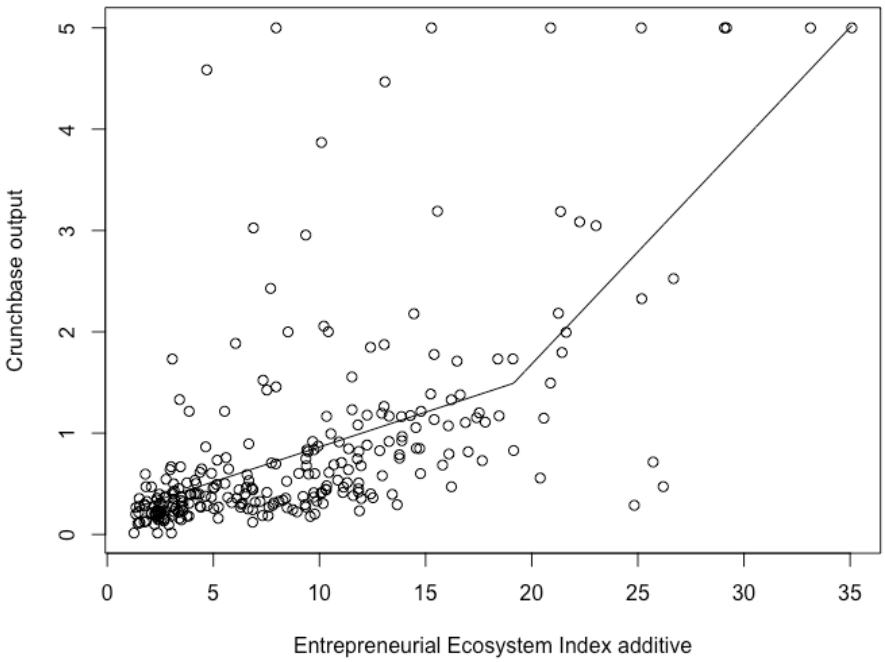



**Fig. 7** Scatter plot with line showing the fitted values of the piecewise linear regression

[11] We get a very similar result when we allow for a structural break in the line. The main method shown assumes a continuous relation and uses the R package *'segmented'* (Muggeo, 2008).

[12] As an additional robustness test, we also performed the regression analyses using the principal components (see appendix C). The results of these regressions showed nearly identical results, serving as evidence for the robustness of our results.

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

**Table 7.**
Piecewise linear regression

| | Crunchbase output | |
|---|---|---|
| | (1) | (2) |
| EE index additive | 0.081*** | |
| | (0.014) | |
| Difference slope EE index additive | 0.315** | |
| | (0.146) | |
| EE index logarithmic | | 0.047*** |
| | | (0.009) |
| Difference slope EE index logarithmic | | 0.475*** |
| | | (0.088) |
| Constant | 0.103 | 1.034*** |
| | (0.120) | (0.129) |
| Observations | 272 | 272 |
| $R^2$ | 0.422 | 0.431 |
| Adjusted $R^2$ | 0.415 | 0.425 |
| F Statistic | 65.213***(df=3;268) | 67.697***(df=3;268) |

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

The scatter plot (Fig. 7) shows that even with the piecewise linear regression there are several regions that do not seem to fit the plotted line. Particularly, we see some regions with very high entrepreneurial output and low index values. The regions in the upper left corner of the plot are for example Malta and Luxembourg which are known for very favourable tax regulations, which in previous studies have been shown to increase the amount of high growth entrepreneurship (Guzman and Stern, 2015). On the other hand, regions with high index values but relatively low entrepreneurial output are for example several outer London regions.[14] These are all regions with good conditions for entrepreneurship but located very close to even more 'vibrant' entrepreneurial areas which attract a disproportionate share of innovative new firms (e.g. Inner London).

Since we compare regions in different countries, it is important to check whether the index does not just capture between country differences but also has explanatory power within countries. We

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

therefore run a multilevel analysis with country-specific intercepts and our EEI. The results of the multilevel analysis are presented in Table 8. The index variables still show a significant and positive relation with the entrepreneurial output ($p<0.001$). Adding country specific intercepts improves the model as evidenced by an increased $R^2$ as well as the likelihood ratio tests. The random effects in the bottom of the table show the regional variation ($\sigma^2$) and the variation between countries ($\tau_{00}$). The strong coefficient and significance of our index when we compare regions within countries shows the robustness of the index. In addition, the high regional variation supports our choice to focus on the regional level when studying entrepreneurial ecosystems.

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

**Table 8.**

Multilevel analysis

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

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

*4.6 Comparison with existing indices*

In the previous sections we showed that the EEI proved to be a good predictor of productive entrepreneurship. However, the question remains whether the EEI also outperforms existing rankings on similar topics. Therefore, we compare the EEI with two existing indices, first the RCI

which measures the competitiveness of a region and second the RIS which measures the innovative ability in the region. Furthermore, we also include the GRP per capita as an alternative measure. The results (Table 9) show that, as expected, there are strong correlations between our index and the RCI (0.92), the RIS (0.90) and GDP (0.77). However, our index clearly has a higher correlation with both entrepreneurial output measures than any of the alternatives. This shows that there is clearly added value in developing theory-based metrics to measure the quality of regional entrepreneurial ecosystems and that our measure captures dimensions of the ecosystem which go beyond the level of economic development of a region.

**Table 9.**

Correlation table indices and outcomes

| | EE index add | EE index log | RCI 2019 | RIS 2019 | GRP per capita | Crunchbase output |
|---|---|---|---|---|---|---|
| EE index log | 0.985**** | | | | | |
| RCI 2019 | 0.920**** | 0.941**** | | | | |
| RIS 2019 | 0.900**** | 0.902**** | 0.885**** | | | |
| GRP per capita | 0.773**** | 0.782**** | 0.820**** | 0.724**** | | |
| Crunchbase output | 0.696**** | 0.695**** | 0.573**** | 0.588**** | 0.585**** | |
| Unicorn output | 0.351**** | 0.362**** | 0.300**** | 0.286**** | 0.281**** | 0.400**** |

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

## 5. Discussion and conclusions

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

We answered three main research questions. First, how can we compose a harmonized data set to measure the quality of key elements of entrepreneurial economies? We built on prior entrepreneurial ecosystem research and composed a harmonized data set that measures each element of entrepreneurial ecosystems in the context of 273 regions in 28 European countries. To do so we sourced a wide variety of data from existing datasets and online databases. However, not

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

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

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

There are several additional opportunities for improving these metrics that deserve substantial attention in follow-up research. First, the internal validity of the index should be tested more carefully, in particular with other (more direct) tests of causality, with longer time lags between changes in the quality of entrepreneurial ecosystems and the resulting entrepreneurial outputs, and with some quasi-natural experiments in which a set of similar regions is confronted with substantially different changes in one or a few elements. In sum, we need to move from a comparative static analysis to a dynamic analysis, and for this we need longitudinal datasets. This

would make it possible to better trace processes within entrepreneurial ecosystems (Spigel and Harrison, 2018) and allow us to measure the distinct properties of complex systems that arise from interdependencies, such as nonlinearity, emergence, tipping-points, spontaneous order, adaptation, and feedback loops. Second, even though Europe provides a wide variety of regions to develop and test our entrepreneurial ecosystem metrics, these metrics need to be developed and tested in other contexts as well, in large sets of regions in the US, Asia, Africa, and Latin America. Finally, statistical regions are not always overlapping with either the relevant jurisdictions or the spatial reach of the causal mechanisms involved (for example as related to culture and the provision of finance). Developing tailor made spatial units and taking into account the nestedness of elements (cities, in regions, in countries) and neighbourhood effects is also a challenge for future research. With the help of spatial econometrics spill-over effects between regions could be analysed. Our empirical research implicitly assumed an equal weight of all regional units. Future research can improve upon this by taking into account the differential (population, economic) size of regions, which might lead to more adequate regression analyses.

## 6. Policy implications

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

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

It is thus important to combine these metrics with qualitative insights about particular entrepreneurial ecosystems.

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

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

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

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**Appendix A**

**Description of data**

**Table A1.**

Description of indicator data sources

| Element | Indicators | Measurement and description | Source | Geographical level | Year |
|---|---|---|---|---|---|
| Formal institutions | Quality of Governance indicators for Corruption, Impartiality, and Quality and accountability | Average of z-score for the three indicators (Corruption, Impartiality, and Quality and accountability) based on survey answers | Quality of Government Index | NUTS 2<br>NUTS 1 for BE, DE, EL, SE, and UK<br>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 | Global Entrepreneurship Monitor | Country | 2014 |

| | | | | | |
|---|---|---|---|---|---|
| | | can potentially increase personal wealth and income. Rating: 1=highly insufficient, 5=highly sufficient | | | |
| Entrepreneurship culture | Innovative and creative | Percentage of respondents that agree to: it is important to think of new ideas and be creative | European Social Survey | NUTS 2<br>NUTS 1 for DE, UK<br>Missing for FRM0, ITF2, LU00, MT00, PT20, PT30 | 2008 - 2016 |
| Entrepreneurship culture | Trust | Survey question on scale 0-1: Most people can be trusted | European Social Survey | NUTS 2<br>NUTS 1 for DE, UK<br>Missing for FRM0, ITF2, LU00, MT00, PT20, PT30 | 2008 - 2016 |
| Entrepreneurship culture robustness | Birth of new firms | Number of new firms per capita | Eurostat, OECD and national statistics offices | NUTS 2<br>NUTS 1 for DE and UK<br>Country for EL | 2010-2016 |
| Networks | Innovative SMEs collaborating with others | Percentage of innovative SMEs in SME business population collaborating with others | RIS & EIS (for countries which are a NUTS 2 region) (also available in RCI) | NUTS 2<br>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 neighbourhood 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 neighbourhood 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 | 2013 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | NUTS 1 for BE, DE, and UK | |
| Talent | Lifelong learning | Percentage of population aged 25-64 participating in education and training | Eurostat | NUTS 2<br>NUTS 1 for BE, DE, and UK | 2013 |
| Talent | Business and entrepreneurship education | The extent to which training in creating or managing SMEs is incorporated within the education and training system The extent to which training in creating or managing SMEs is incorporated within the education and training system. Rating: 1=highly insufficient, 5=highly sufficient | Global Entrepreneurship Monitor | Country | 2014 |
| Talent | E-skills | Percentage of individuals in active population with high levels of e-skills | Eurostat | Country | 2014 |
| New knowledge | R&D expenditure | Intramural R&D expenditure as percentage of Gross Regional Product | Eurostat | NUTS 2 | 2015 |
| Demand | Disposable income per capita | Net adjusted disposable household income in PPCS per capita (index EU average=100) | Eurostat | NUTS 2 | 2014 |
| Demand | Potential market size in GRP | Index GRP PPS (EU population-weighted average=100) | Eurostat | NUTS 2 | 2016 |
| Demand | Potential market size in population | Index population (EU average=100) | Eurostat | NUTS 2 | 2018 |

| | | | | | |
|---|---|---|---|---|---|
| Intermediate services | Incubators | Percentage of incubators in total business population | Own data | NUTS 2 | 2019 |
| Intermediate services | Knowledge intensive services | Percentage employment in knowledge-intensive market services | Eurostat | NUTS 2 | 2018 |
| Productive entrepreneurship | Innovative new firms | Number of new firms registered in Crunchbase in the last five years per capita | Crunchbase | NUTS 2 | 2019 |
| Productive entrepreneurship | High-value new firms (unicorns) | Absolute number of entrepreneurial firms valued above $1 billion founded in the last ten years | CB Insights & Dealroom | NUTS 2 | 2019 |

## Appendix B

## Methods

## Table B1.

Correlation table

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

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

**Figure B1.**
Pairwise scatter plot of output and index with clusters of regions

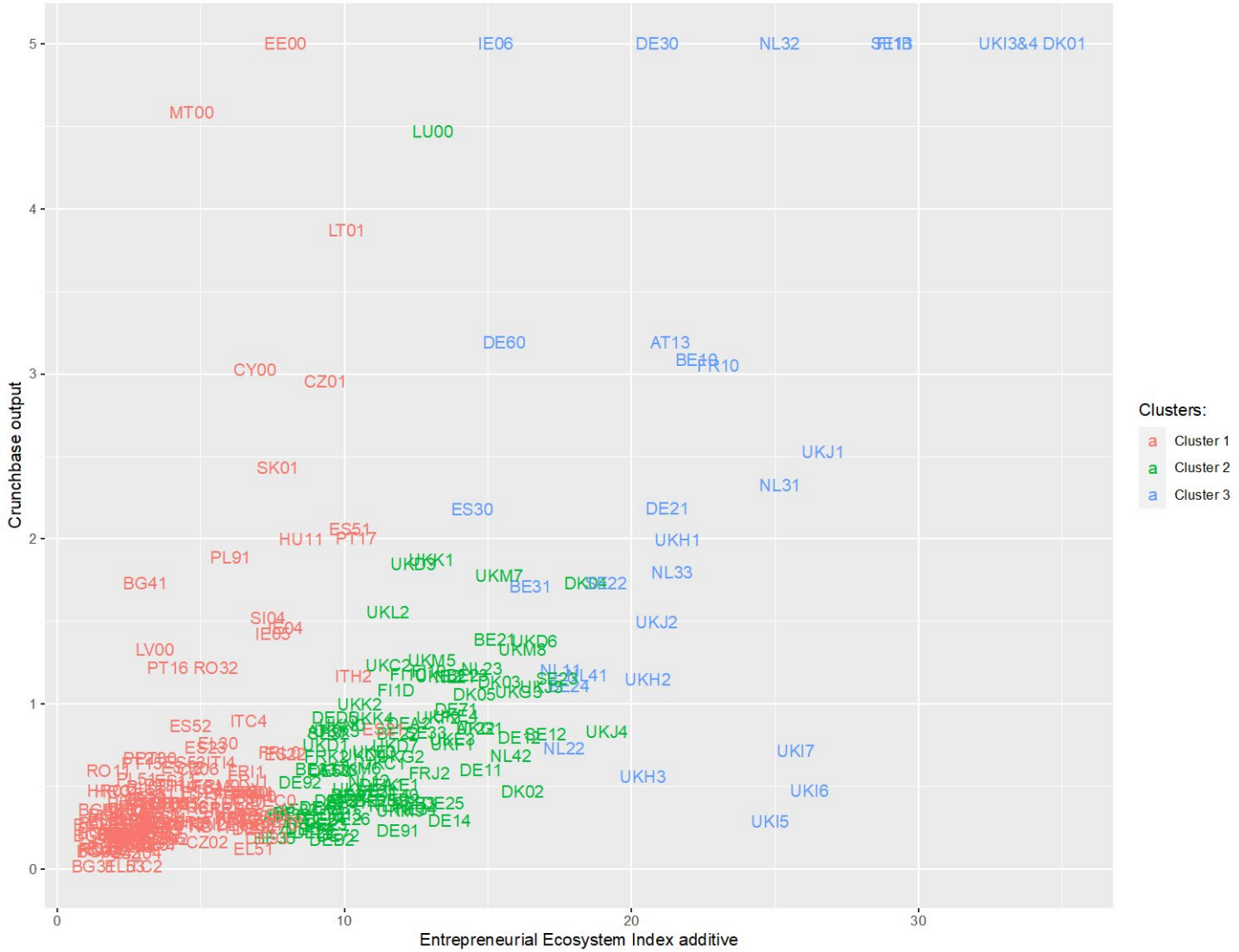

**Table B2.**

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

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

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

**Table B3.**

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

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

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

## Appendix C

## Index robustness

As a first robustness test we do not execute any of the modifications outlined in section 3.16. This robustness test actually results in a higher R2 of 0.62 (Table C1). However, the results are now strongly influenced by the extreme values measured in several regions that we discussed in the methodology section. Therefore, we performed a second robustness test which follows the approach outlined in the method section but instead removes those regions with a value more than four standard deviations from the mean. This concerned Inner London (as a result of a high number of incubators, leadership, and Crunchbase start-ups per population), Braunschweig (as a result of the high R&D intensity) in Germany, and Hovedstaden (as a result of leadership) in Denmark (Table C2). Since we prefer not to discard observations of which the data is reliably measured, we also performed the regression with all observations after transforming the data. We transformed the data using the Tukey transformation (Tukey, 1957) for all the variables with a huge range of variation (standard deviations above 4), instead of only the output variable as we did in the main analysis (Table C3). The result of this transformation is a distribution of data which is close to a normal distribution, thus reducing the standard deviations from the variables with extreme values. Fourth, we used a categorical approach to create each of the index elements and the output by using quantiles to give each element a score from 1-10. The index then has a minimum value of 10 and maximum value of 100 (Table C4). Furthermore, we find that many of the top performing regions are regions in which a capital city is located (see Fig. 3). To test whether the explanatory power of our index holds after controlling for the influence of capital cities on the output variable we run the regressions with a capital city indicator added, which is a dummy variable indicating whether a region contains a capital city (no = 0, yes = 1). The results are displayed in Table C5 and indeed show that capital regions perform significantly better than non-capital regions ($p<0.001$). Nevertheless, the effect of the EEI remains significant ($p<0.001$) and only shows a small decrease in coefficients.

Sixth, we also performed a regression using the principal components discussed in section 4.1. This method does not build on the assumption that all ecosystem elements have equal weights and for PC1 we find highly similar outcomes as for our index (Table C6). Finally, we perform a regression in which we control for the GRP per capita, which is one of the existing measured we compared our index with in section 4.6. The results show that the regression with the index significantly outperforms the regression with only the GRP (Table C7). It is important to note that the GRP of a region is already included in our

measure for demand. Nevertheless, we found it important to test the robustness of our index when including this crucial control variable. In sum, the findings of all seven robustness tests are consistent with those presented in the main analysis, indicating the robustness of our chosen approach of calculating our index.

**Table C1.**

Regression with no transformation of extreme values

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

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

**Table C2.**

Regression excluding observations with extreme values

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

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

**Table C3.**

Regression including Tukey transformation to variables with extreme values

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

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

**Table C4.**

Regression with categorical calculation of the index

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

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

**Table C5.**

Regression with dummies for capital cities

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

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

**Table C6.**

Regression with principal components

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

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

**Table C7.**

Regression with GRP as a control variable

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

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

## Appendix D

## Data appendix

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

| NUTS2 code | Crunchbase output | Formal institutions | Culture | Networks | Physical infrastructure | Finance | Leadership | Talent | Knowledge | Demand | Intermediate | EE index additive | EE index log |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DE23** | 0.27 | 1.77 | 1.21 | 0.23 | 0.82 | 2.47 | 0.26 | 0.58 | 0.64 | 1.18 | 0.19 | 9.35 | -3.84 |
| **DE24** | 0.30 | 1.77 | 1.21 | 0.31 | 0.64 | 2.47 | 0.26 | 0.58 | 0.60 | 1.34 | 0.14 | 9.33 | -4.03 |
| **DE25** | 0.40 | 1.77 | 1.21 | 0.31 | 1.37 | 2.47 | 0.37 | 0.58 | 3.29 | 1.74 | 0.32 | 13.43 | -0.12 |
| **DE26** | 0.31 | 1.77 | 1.21 | 0.38 | 0.92 | 2.47 | 0.27 | 0.58 | 0.70 | 1.64 | 0.23 | 10.17 | -2.56 |
| **DE27** | 0.45 | 1.77 | 1.21 | 0.48 | 1.13 | 2.47 | 0.21 | 0.58 | 0.43 | 1.81 | 0.20 | 10.30 | -2.92 |
| **DE50** | 0.60 | 1.55 | 1.31 | 0.41 | 0.93 | 0.75 | 0.80 | 0.56 | 1.30 | 1.42 | 0.46 | 9.49 | -1.52 |
| **DE60** | 3.19 | 1.68 | 0.92 | 0.29 | 2.18 | 2.94 | 0.53 | 0.74 | 0.79 | 2.70 | 2.79 | 15.56 | 1.92 |
| **DE71** | 0.97 | 1.53 | 1.40 | 0.35 | 2.73 | 1.28 | 0.31 | 0.61 | 1.82 | 2.72 | 1.14 | 13.89 | 1.04 |
| **DE72** | 0.20 | 1.53 | 1.40 | 0.40 | 1.31 | 1.28 | 0.23 | 0.61 | 1.06 | 1.74 | 0.22 | 9.78 | -2.50 |
| **DE73** | 0.29 | 1.53 | 1.40 | 0.25 | 0.69 | 1.28 | 0.20 | 0.61 | 0.43 | 1.21 | 0.21 | 7.80 | -5.07 |
| **DE80** | 0.27 | 1.61 | 0.87 | 0.37 | 0.49 | 0.93 | 0.26 | 0.48 | 0.57 | 0.52 | 0.18 | 6.28 | -6.43 |
| **DE91** | 0.23 | 1.68 | 1.03 | 0.29 | 0.71 | 0.73 | 0.41 | 0.46 | 5.00 | 1.32 | 0.25 | 11.88 | -2.51 |
| **DE92** | 0.53 | 1.68 | 1.03 | 0.52 | 1.03 | 0.73 | 0.26 | 0.46 | 0.93 | 1.57 | 0.24 | 8.45 | -3.55 |
| **DE93** | 0.19 | 1.68 | 1.03 | 0.37 | 0.82 | 0.73 | 0.20 | 0.46 | 0.24 | 1.54 | 0.24 | 7.31 | -5.77 |
| **DE94** | 0.24 | 1.68 | 1.03 | 0.34 | 0.72 | 0.73 | 0.21 | 0.46 | 0.24 | 1.25 | 0.20 | 6.85 | -6.34 |
| **DEA1** | 0.51 | 1.30 | 1.03 | 0.29 | 2.39 | 1.27 | 0.23 | 0.48 | 0.51 | 3.37 | 0.44 | 11.30 | -2.32 |
| **DEA2** | 0.88 | 1.30 | 1.03 | 0.50 | 2.19 | 1.27 | 0.56 | 0.48 | 1.34 | 2.92 | 0.67 | 12.24 | 0.25 |
| **DEA3** | 0.38 | 1.30 | 1.03 | 0.56 | 1.53 | 1.27 | 0.23 | 0.48 | 0.28 | 2.34 | 0.21 | 9.23 | -3.80 |
| **DEA4** | 0.34 | 1.30 | 1.03 | 0.39 | 0.94 | 1.27 | 0.22 | 0.48 | 0.56 | 1.89 | 0.20 | 8.28 | -4.25 |
| **DEA5** | 0.41 | 1.30 | 1.03 | 0.54 | 1.80 | 1.27 | 0.24 | 0.48 | 0.46 | 2.39 | 0.23 | 9.73 | -3.04 |
| **DEB1** | 0.37 | 1.58 | 1.28 | 0.34 | 1.56 | 1.77 | 0.19 | 0.52 | 0.19 | 2.11 | 0.21 | 9.74 | -4.18 |
| **DEB2** | 0.18 | 1.58 | 1.28 | 0.53 | 0.59 | 1.77 | 0.21 | 0.52 | 1.50 | 1.42 | 0.18 | 9.57 | -3.08 |
| **DEB3** | 0.40 | 1.58 | 1.28 | 0.36 | 1.90 | 1.77 | 0.33 | 0.52 | 2.15 | 2.27 | 0.27 | 12.42 | -0.61 |
| **DEC0** | 0.42 | 1.50 | 0.88 | 0.56 | 0.86 | 0.98 | 0.26 | 0.41 | 0.42 | 1.45 | 0.20 | 7.52 | -4.83 |
| **DED2** | 0.42 | 1.34 | 1.32 | 0.63 | 0.61 | 1.57 | 0.49 | 0.60 | 3.94 | 0.99 | 0.34 | 11.84 | -0.87 |
| **DED4** | 0.24 | 1.34 | 1.32 | 1.34 | 0.57 | 1.57 | 0.21 | 0.60 | 0.52 | 1.11 | 0.16 | 8.74 | -3.73 |
| **DED5** | 0.92 | 1.34 | 1.32 | 0.93 | 1.18 | 1.57 | 0.37 | 0.60 | 0.66 | 1.10 | 0.60 | 9.68 | -1.22 |
| **DEE0** | 0.40 | 1.19 | 0.62 | 0.66 | 0.93 | 0.99 | 0.22 | 0.48 | 0.36 | 0.87 | 0.17 | 6.49 | -5.96 |
| **DEF0** | 0.27 | 1.56 | 0.90 | 0.44 | 0.96 | 0.90 | 0.26 | 0.47 | 0.39 | 1.41 | 0.33 | 7.62 | -4.43 |
| **DEG0** | 0.33 | 1.44 | 0.89 | 0.44 | 0.58 | 1.26 | 0.28 | 0.56 | 0.64 | 0.93 | 0.18 | 7.20 | -4.96 |
| **DK01** | 5.00 | 2.98 | 5.00 | 0.63 | 4.68 | 2.11 | 5.00 | 5.00 | 5.00 | 0.90 | 3.78 | 35.08 | 10.58 |
| **DK02** | 0.47 | 2.81 | 3.48 | 0.60 | 1.18 | 1.88 | 0.28 | 4.76 | 0.29 | 0.58 | 0.36 | 16.22 | 0.03 |
| **DK03** | 1.13 | 3.01 | 3.90 | 0.74 | 0.56 | 0.44 | 0.40 | 5.00 | 0.60 | 0.42 | 0.35 | 15.40 | -1.01 |
| **DK04** | 1.73 | 3.50 | 3.89 | 0.58 | 0.58 | 0.99 | 1.90 | 5.00 | 1.10 | 0.42 | 0.45 | 18.40 | 2.19 |
| **DK05** | 1.06 | 2.99 | 3.75 | 0.50 | 0.55 | 0.91 | 0.73 | 4.05 | 0.40 | 0.29 | 0.37 | 14.54 | -1.03 |
| **EE00** | 5.00 | 0.93 | 0.69 | 0.66 | 0.41 | 1.01 | 1.34 | 1.65 | 0.40 | 0.10 | 0.76 | 7.96 | -4.39 |
| **EL30** | 0.76 | 0.13 | 0.34 | 0.94 | 0.65 | 0.10 | 0.34 | 0.37 | 0.29 | 0.93 | 1.51 | 5.60 | -8.87 |
| **EL41** | 0.31 | 0.11 | 0.48 | 0.64 | 0.19 | 0.05 | 1.56 | 0.23 | 0.20 | 0.03 | 0.35 | 3.85 | -15.07 |
| **EL42** | 0.34 | 0.11 | 0.79 | 0.33 | 0.17 | 0.05 | 0.19 | 0.17 | 0.12 | 0.09 | 0.32 | 2.35 | -17.30 |
| **EL43** | 0.23 | 0.11 | 0.47 | 1.59 | 0.13 | 0.07 | 0.28 | 0.20 | 0.42 | 0.11 | 0.20 | 3.58 | -14.80 |
| **EL51** | 0.12 | 0.10 | 0.51 | 0.56 | 0.12 | 0.06 | 4.70 | 0.20 | 0.19 | 0.12 | 0.29 | 6.85 | -13.58 |
| **EL52** | 0.32 | 0.10 | 0.27 | 0.63 | 0.18 | 0.12 | 1.20 | 0.25 | 0.22 | 0.27 | 0.31 | 3.57 | -13.03 |
| **EL53** | 0.01 | 0.10 | 0.13 | 1.14 | 0.11 | 0.05 | 0.19 | 0.22 | 0.15 | 0.15 | 0.12 | 2.37 | -18.41 |
| **EL54** | 0.28 | 0.10 | 0.13 | 0.26 | 0.10 | 0.06 | 0.26 | 0.22 | 0.31 | 0.11 | 0.23 | 1.78 | -18.53 |
| **EL61** | 0.22 | 0.13 | 0.45 | 0.58 | 0.11 | 0.06 | 0.23 | 0.24 | 0.19 | 0.17 | 0.23 | 2.39 | -16.18 |
| **EL62** | 0.30 | 0.13 | 0.14 | 0.43 | 0.17 | 0.05 | 0.20 | 0.17 | 0.16 | 0.09 | 0.21 | 1.75 | -18.76 |

| NUTS2 code | Crunchbase output | Formal institutions | Culture | Networks | Physical infrastructure | Finance | Leadership | Talent | Knowledge | Demand | Intermediate | EE index additive | EE index log |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EL63** | 0.19 | 0.13 | 0.28 | 0.58 | 0.10 | 0.05 | 0.32 | 0.21 | 0.34 | 0.14 | 0.13 | 2.27 | -16.96 |
| **EL64** | 0.21 | 0.13 | 0.26 | 0.41 | 0.12 | 0.07 | 0.19 | 0.17 | 0.17 | 0.31 | 0.25 | 2.09 | -16.77 |
| **EL65** | 0.12 | 0.13 | 0.21 | 0.32 | 0.15 | 0.06 | 0.18 | 0.18 | 0.15 | 0.17 | 0.21 | 1.75 | -18.16 |
| **ES11** | 0.53 | 0.33 | 0.29 | 0.40 | 0.35 | 0.77 | 0.29 | 0.68 | 0.23 | 0.35 | 0.43 | 4.13 | -9.54 |
| **ES12** | 0.61 | 0.46 | 0.16 | 0.36 | 0.41 | 0.71 | 0.55 | 0.77 | 0.20 | 0.35 | 0.38 | 4.37 | -9.29 |
| **ES13** | 0.28 | 0.52 | 0.80 | 0.24 | 0.44 | 0.41 | 0.35 | 0.76 | 0.22 | 0.38 | 0.26 | 4.38 | -9.17 |
| **ES21** | 0.85 | 0.58 | 0.44 | 0.70 | 0.58 | 1.03 | 4.63 | 1.19 | 0.59 | 1.06 | 0.57 | 11.37 | -1.56 |
| **ES22** | 0.70 | 0.54 | 0.45 | 0.35 | 0.42 | 1.67 | 1.90 | 0.99 | 0.45 | 0.64 | 0.53 | 7.94 | -4.06 |
| **ES23** | 0.73 | 0.47 | 0.86 | 0.29 | 0.32 | 0.44 | 1.25 | 0.80 | 0.23 | 0.37 | 0.15 | 5.18 | -8.45 |
| **ES24** | 0.46 | 0.44 | 0.26 | 0.25 | 1.08 | 0.49 | 0.95 | 0.77 | 0.23 | 0.28 | 0.29 | 5.04 | -8.47 |
| **ES30** | 2.18 | 0.37 | 0.92 | 0.26 | 3.21 | 1.90 | 2.11 | 1.19 | 0.49 | 2.05 | 1.97 | 14.45 | 0.97 |
| **ES41** | 0.40 | 0.35 | 0.45 | 0.24 | 0.44 | 0.92 | 0.32 | 0.74 | 0.25 | 0.28 | 0.22 | 4.21 | -9.77 |
| **ES42** | 0.18 | 0.35 | 0.41 | 0.25 | 0.75 | 0.67 | 0.20 | 0.57 | 0.17 | 0.31 | 0.18 | 3.85 | -10.90 |
| **ES43** | 0.26 | 0.42 | 0.32 | 0.24 | 0.27 | 0.70 | 0.25 | 0.53 | 0.19 | 0.13 | 0.16 | 3.20 | -12.65 |
| **ES51** | 2.06 | 0.34 | 0.64 | 0.26 | 1.30 | 2.01 | 2.46 | 0.71 | 0.41 | 0.87 | 1.20 | 10.21 | -2.22 |
| **ES52** | 0.86 | 0.33 | 0.38 | 0.24 | 0.60 | 0.69 | 0.48 | 0.70 | 0.26 | 0.53 | 0.43 | 4.64 | -8.30 |
| **ES53** | 0.65 | 0.31 | 0.37 | 0.13 | 0.62 | 1.43 | 0.23 | 0.52 | 0.14 | 0.32 | 0.38 | 4.45 | -10.53 |
| **ES61** | 0.45 | 0.28 | 0.39 | 0.23 | 0.38 | 0.44 | 0.30 | 0.54 | 0.26 | 0.31 | 0.25 | 3.38 | -11.21 |
| **ES62** | 0.40 | 0.39 | 0.28 | 0.21 | 0.56 | 0.63 | 0.35 | 0.56 | 0.22 | 0.40 | 0.31 | 3.91 | -10.04 |
| **ES70** | 0.41 | 0.29 | 0.33 | 0.17 | 0.49 | 0.37 | 0.25 | 0.54 | 0.16 | 0.21 | 0.26 | 3.07 | -12.55 |
| **FI19** | 1.20 | 1.88 | 2.86 | 0.95 | 0.41 | 1.27 | 0.52 | 3.13 | 1.42 | 0.17 | 0.33 | 12.94 | -1.09 |
| **FI1B** | 5.00 | 2.05 | 3.05 | 0.89 | 1.55 | 3.13 | 5.00 | 5.00 | 2.76 | 0.75 | 5.00 | 29.18 | 8.85 |
| **FI1C** | 1.18 | 1.95 | 2.28 | 1.23 | 0.64 | 1.23 | 0.37 | 2.98 | 0.64 | 0.27 | 0.65 | 12.24 | -0.62 |
| **FI1D** | 1.08 | 1.99 | 2.41 | 0.78 | 0.30 | 1.33 | 0.59 | 2.92 | 1.04 | 0.05 | 0.40 | 11.81 | -2.87 |
| **FI20** | 0.72 | 3.16 | 2.43 | NA | NA | NA | 0.18 | 3.06 | 0.13 | 0.07 | 4.83 | NA | NA |
| **FR10** | 3.05 | 0.64 | 0.68 | 0.77 | 5.00 | 2.96 | 2.64 | 1.95 | 1.48 | 3.58 | 3.32 | 23.03 | 6.12 |
| **FRB0** | 0.36 | 0.61 | 0.87 | 0.47 | 0.71 | 0.72 | 0.21 | 1.13 | 0.46 | 0.74 | 0.18 | 6.10 | -6.30 |
| **FRC1** | 0.37 | 0.57 | 0.66 | 0.47 | 0.41 | 0.54 | 0.21 | 1.10 | 0.25 | 0.49 | 0.20 | 4.90 | -8.40 |
| **FRC2** | 0.31 | 0.54 | 1.03 | 0.47 | 0.26 | 0.55 | 0.22 | 1.19 | 1.25 | 0.63 | 0.22 | 6.38 | -6.32 |
| **FRD1** | 0.26 | 0.61 | 0.84 | 0.47 | 0.33 | 0.62 | 0.22 | 0.87 | 0.33 | 0.52 | 0.22 | 5.01 | -7.99 |
| **FRD2** | 0.30 | 0.63 | 0.68 | 0.47 | 0.85 | 0.73 | 0.19 | 1.09 | 0.38 | 1.01 | 0.29 | 6.31 | -5.87 |
| **FRE1** | 0.46 | 0.58 | 0.75 | 0.54 | 0.98 | 1.00 | 0.21 | 1.22 | 0.23 | 1.02 | 0.25 | 6.79 | -5.64 |
| **FRE2** | 0.25 | 0.61 | 0.58 | 0.54 | 1.24 | 0.67 | 0.21 | 0.77 | 0.37 | 1.25 | 0.39 | 6.63 | -5.36 |
| **FRF1** | 0.45 | 0.60 | 0.48 | 0.48 | 0.72 | 1.03 | 0.33 | 1.32 | 0.49 | 1.20 | 0.20 | 6.84 | -5.28 |
| **FRF2** | 0.32 | 0.59 | 1.19 | 0.48 | 0.97 | 0.75 | 0.19 | 0.84 | 0.20 | 0.47 | 0.19 | 5.87 | -7.28 |
| **FRF3** | 0.37 | 0.56 | 0.85 | 0.48 | 0.47 | 0.83 | 0.18 | 1.08 | 0.32 | 0.76 | 0.16 | 5.68 | -7.32 |
| **FRG0** | 0.46 | 0.72 | 0.89 | 0.64 | 0.50 | 0.85 | 0.22 | 1.44 | 0.31 | 0.68 | 0.32 | 6.56 | -5.62 |
| **FRH0** | 0.44 | 0.74 | 0.57 | 0.64 | 0.36 | 1.19 | 0.25 | 1.65 | 0.64 | 0.57 | 0.25 | 6.86 | -5.42 |
| **FRI1** | 0.59 | 0.71 | 0.80 | 0.68 | 0.52 | 0.93 | 0.26 | 1.42 | 0.44 | 0.53 | 0.29 | 6.59 | -5.35 |
| **FRI2** | 0.27 | 0.68 | 0.73 | 0.68 | 0.17 | 0.54 | 0.22 | 1.39 | 0.25 | 0.37 | 0.19 | 5.24 | -8.66 |
| **FRI3** | 0.28 | 0.58 | 0.48 | 0.68 | 0.35 | 0.44 | 0.19 | 1.03 | 0.24 | 0.51 | 0.21 | 4.71 | -8.83 |
| **FRJ1** | 0.53 | 0.53 | 0.76 | 0.57 | 0.53 | 1.08 | 0.22 | 1.26 | 0.92 | 0.51 | 0.30 | 6.67 | -5.30 |
| **FRJ2** | 0.58 | 0.62 | 0.63 | 0.57 | 0.46 | 1.55 | 0.35 | 2.45 | 5.00 | 0.51 | 0.82 | 12.96 | -1.26 |
| **FRK1** | 0.44 | 0.62 | 0.87 | 0.77 | 0.34 | 0.91 | 0.21 | 1.06 | 0.80 | 0.49 | 0.13 | 6.21 | -6.51 |
| **FRK2** | 0.68 | 0.67 | 0.81 | 0.77 | 0.60 | 1.57 | 0.31 | 2.09 | 1.31 | 0.95 | 0.32 | 9.39 | -2.31 |
| **FRL0** | 0.71 | 0.55 | 0.83 | 0.45 | 0.75 | 1.24 | 0.25 | 1.40 | 1.01 | 0.75 | 0.51 | 7.74 | -3.68 |

| NUTS2 code | Crunchbase output | Formal institutions | Culture | Networks | Physical infrastructure | Finance | Leadership | Talent | Knowledge | Demand | Intermediate | EE index additive | EE index log |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FRM0** | 0.50 | 0.51 | 1.00 | 0.45 | 0.24 | 1.56 | 0.18 | 0.80 | 0.13 | 0.14 | 0.53 | 5.55 | -9.00 |
| **HR03** | 0.47 | 0.16 | 0.07 | 0.22 | 0.22 | 0.12 | 0.21 | 0.15 | 0.14 | 0.12 | 0.42 | 1.82 | -18.09 |
| **HR04** | 0.47 | 0.16 | 0.10 | 0.29 | 0.22 | 0.15 | 0.22 | 0.14 | 0.27 | 0.24 | 0.28 | 2.08 | -16.23 |
| **HU11** | 2.00 | 0.14 | 0.24 | 0.32 | 0.69 | 0.82 | 0.69 | 0.46 | 0.57 | 0.73 | 3.86 | 8.52 | -5.78 |
| **HU12** | 0.27 | 0.14 | 0.24 | 0.32 | 0.69 | 0.82 | 0.20 | 0.46 | 0.57 | 0.73 | 0.25 | 4.41 | -9.78 |
| **HU21** | 0.36 | 0.18 | 0.16 | 0.22 | 0.34 | 0.50 | 0.22 | 0.24 | 0.24 | 0.46 | 0.14 | 2.71 | -13.92 |
| **HU22** | 0.25 | 0.18 | 0.18 | 0.26 | 0.31 | 0.48 | 0.21 | 0.25 | 0.17 | 0.38 | 0.13 | 2.55 | -14.41 |
| **HU23** | 0.24 | 0.18 | 0.35 | 0.21 | 0.15 | 0.52 | 0.18 | 0.25 | 0.15 | 0.22 | 0.13 | 2.34 | -15.45 |
| **HU31** | 0.21 | 0.17 | 0.15 | 0.25 | 0.16 | 0.44 | 0.20 | 0.24 | 0.16 | 0.33 | 0.14 | 2.24 | -15.65 |
| **HU32** | 0.36 | 0.16 | 0.16 | 0.18 | 0.14 | 0.60 | 0.20 | 0.26 | 0.28 | 0.26 | 0.12 | 2.35 | -15.61 |
| **HU33** | 0.30 | 0.21 | 0.14 | 0.25 | 0.17 | 0.50 | 0.22 | 0.25 | 0.46 | 0.25 | 0.14 | 2.57 | -14.49 |
| **IE04** | 1.46 | 1.67 | 1.06 | 0.63 | 0.18 | 1.27 | 1.43 | 0.62 | 0.57 | 0.20 | 0.32 | 7.96 | -4.76 |
| **IE05** | 1.43 | 1.60 | 1.08 | 0.69 | 0.29 | 0.70 | 0.97 | 0.89 | 0.28 | 0.37 | 0.65 | 7.52 | -4.26 |
| **IE06** | 5.00 | 1.60 | 0.79 | 0.68 | 0.88 | 1.95 | 3.97 | 0.89 | 0.30 | 0.66 | 3.58 | 15.28 | 1.28 |
| **ITC1** | 0.49 | 0.17 | 0.34 | 0.39 | 0.80 | 0.37 | 0.38 | 0.18 | 0.74 | 1.25 | 0.54 | 5.15 | -8.38 |
| **ITC2** | 0.01 | 0.23 | 0.37 | 0.20 | 0.24 | 0.28 | 0.25 | 0.18 | 0.19 | 0.77 | 0.32 | 3.02 | -12.96 |
| **ITC3** | 0.38 | 0.17 | 0.17 | 0.22 | 0.66 | 0.34 | 0.83 | 0.21 | 0.38 | 0.86 | 0.77 | 4.62 | -9.65 |
| **ITC4** | 0.89 | 0.25 | 0.40 | 0.27 | 0.76 | 0.78 | 0.48 | 0.20 | 0.32 | 2.07 | 1.14 | 6.67 | -6.74 |
| **ITF1** | 0.29 | 0.12 | 0.27 | 0.28 | 0.27 | 0.46 | 0.22 | 0.19 | 0.24 | 0.58 | 0.47 | 3.10 | -12.71 |
| **ITF2** | 0.24 | 0.17 | 0.14 | 0.27 | 0.13 | 0.28 | 0.21 | 0.18 | 0.19 | 0.50 | 0.32 | 2.39 | -15.17 |
| **ITF3** | 0.22 | 0.12 | 0.41 | 0.17 | 0.38 | 0.41 | 0.23 | 0.16 | 0.32 | 0.68 | 0.49 | 3.37 | -12.19 |
| **ITF4** | 0.22 | 0.14 | 0.57 | 0.29 | 0.30 | 0.43 | 0.21 | 0.16 | 0.25 | 0.42 | 0.36 | 3.14 | -12.45 |
| **ITF5** | 0.38 | 0.14 | 0.70 | 0.16 | 0.18 | 0.30 | 0.21 | 0.17 | 0.18 | 0.34 | 0.36 | 2.73 | -14.26 |
| **ITF6** | 0.20 | 0.10 | 0.60 | 0.26 | 0.21 | 0.30 | 0.21 | 0.17 | 0.19 | 0.27 | 0.32 | 2.64 | -14.32 |
| **ITG1** | 0.15 | 0.14 | 0.20 | 0.22 | 0.27 | 0.29 | 0.19 | 0.15 | 0.25 | 0.38 | 0.34 | 2.42 | -14.65 |
| **ITG2** | 0.43 | 0.17 | 0.19 | 0.60 | 0.30 | 0.71 | 0.21 | 0.18 | 0.21 | 0.23 | 0.35 | 3.15 | -12.83 |
| **ITH1** | 0.33 | 0.27 | 0.67 | 0.28 | 0.17 | 0.28 | 0.44 | 0.22 | 0.20 | 0.77 | 0.19 | 3.49 | -11.88 |
| **ITH2** | 1.17 | 0.27 | 1.91 | 0.45 | 0.21 | 0.28 | 5.00 | 0.24 | 0.53 | 1.02 | 0.42 | 10.33 | -5.59 |
| **ITH3** | 0.40 | 0.26 | 0.49 | 0.24 | 0.51 | 0.34 | 0.37 | 0.18 | 0.28 | 1.25 | 0.42 | 4.34 | -9.86 |
| **ITH4** | 0.50 | 0.25 | 0.44 | 0.30 | 0.37 | 0.61 | 0.41 | 0.22 | 0.42 | 0.82 | 0.32 | 4.19 | -9.45 |
| **ITH5** | 0.46 | 0.26 | 0.43 | 0.22 | 0.53 | 0.45 | 0.58 | 0.21 | 0.53 | 1.41 | 0.37 | 4.99 | -8.53 |
| **ITI1** | 0.40 | 0.21 | 0.40 | 0.26 | 0.39 | 0.53 | 0.43 | 0.20 | 0.34 | 0.87 | 0.47 | 4.11 | -9.82 |
| **ITI2** | 0.35 | 0.15 | 0.25 | 0.27 | 0.25 | 0.37 | 0.33 | 0.23 | 0.25 | 0.68 | 0.39 | 3.17 | -12.31 |
| **ITI3** | 0.28 | 0.16 | 0.40 | 0.28 | 0.41 | 0.51 | 0.25 | 0.21 | 0.22 | 0.68 | 0.35 | 3.47 | -11.49 |
| **ITI4** | 0.65 | 0.15 | 0.50 | 0.42 | 0.89 | 0.40 | 0.85 | 0.24 | 0.44 | 1.16 | 0.66 | 5.72 | -7.17 |
| **LT01** | 3.87 | 0.55 | 0.28 | 1.71 | 0.28 | 0.10 | 0.54 | 1.09 | 0.26 | 0.28 | 4.99 | 10.09 | -6.41 |
| **LT02** | 0.39 | 0.55 | 0.28 | 0.87 | 0.19 | 0.10 | 0.22 | 1.09 | 0.26 | 0.19 | 0.18 | 3.95 | -12.02 |
| **LU00** | 4.47 | 0.54 | 1.26 | 0.50 | 0.70 | 2.26 | 1.16 | 2.69 | 0.33 | 1.91 | 1.73 | 13.08 | 0.60 |
| **LV00** | 1.33 | 0.61 | 0.52 | 0.15 | 0.23 | 0.10 | 0.27 | 0.83 | 0.18 | 0.11 | 0.41 | 3.41 | -13.16 |
| **MT00** | 4.59 | 0.19 | 0.04 | 0.20 | 0.42 | 0.39 | 0.58 | 0.19 | 0.21 | 0.25 | 2.23 | 4.69 | -12.60 |
| **NL23** | 1.22 | 1.18 | 3.90 | 0.99 | 2.81 | 1.07 | 0.23 | 1.22 | 0.48 | 1.81 | 1.09 | 14.79 | 1.30 |
| **NL32** | 5.00 | 1.05 | 5.00 | 0.99 | 2.81 | 3.02 | 3.08 | 1.92 | 0.48 | 1.81 | 5.00 | 25.16 | 7.03 |
| **NL11** | 1.20 | 1.19 | 4.68 | 1.41 | 0.87 | 1.39 | 4.47 | 1.38 | 0.69 | 0.73 | 0.73 | 17.53 | 3.06 |
| **NL12** | 0.54 | 1.19 | 3.92 | 0.89 | 1.13 | 0.99 | 0.23 | 1.01 | 0.22 | 0.73 | 0.56 | 10.86 | -2.34 |
| **NL13** | 0.38 | 1.19 | 3.67 | 1.45 | 0.79 | 1.43 | 0.20 | 1.06 | 0.21 | 0.89 | 0.69 | 11.59 | -1.63 |
| **NL21** | 1.16 | 1.18 | 4.29 | 1.03 | 1.57 | 1.66 | 0.65 | 1.24 | 0.56 | 1.16 | 0.51 | 13.86 | 1.30 |

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

| NUTS2 code | Crunchbase output | Formal institutions | Culture | Networks | Physical infrastructure | Finance | Leadership | Talent | Knowledge | Demand | Intermediate | EE index additive | EE index log |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SI03** | 0.37 | 0.31 | 0.31 | 0.52 | 0.29 | 0.32 | 0.26 | 0.35 | 0.45 | 0.47 | 0.18 | 3.47 | -11.00 |
| **SI04** | 1.52 | 0.31 | 0.37 | 0.71 | 0.47 | 0.51 | 2.09 | 0.53 | 1.17 | 0.51 | 0.67 | 7.34 | -4.75 |
| **SK01** | 2.43 | 0.24 | 0.67 | 0.51 | 0.72 | 1.06 | 0.62 | 0.77 | 0.55 | 1.25 | 1.32 | 7.70 | -3.62 |
| **SK02** | 0.15 | 0.23 | 0.25 | 0.23 | 0.19 | 0.40 | 0.20 | 0.29 | 0.23 | 0.52 | 0.16 | 2.69 | -13.73 |
| **SK03** | 0.16 | 0.28 | 0.33 | 0.35 | 0.11 | 0.32 | 0.19 | 0.31 | 0.29 | 0.39 | 0.14 | 2.71 | -13.75 |
| **SK04** | 0.23 | 0.28 | 0.26 | 0.33 | 0.12 | 0.36 | 0.19 | 0.31 | 0.20 | 0.30 | 0.14 | 2.51 | -14.41 |
| **UKH2** | 1.15 | 2.26 | 1.23 | 2.27 | 5.00 | 2.03 | 0.27 | 1.65 | 0.34 | 4.76 | 0.76 | 20.57 | 3.55 |
| **UKH3** | 0.56 | 2.26 | 1.23 | 2.27 | 5.00 | 2.03 | 0.23 | 1.65 | 0.34 | 4.76 | 0.63 | 20.40 | 3.21 |
| **UKI3&4** | 5.00 | 2.18 | 1.74 | 2.27 | 5.00 | 3.66 | 5.00 | 3.18 | 0.34 | 4.76 | 5.00 | 33.13 | 9.92 |
| **UKI5** | 0.29 | 2.18 | 1.74 | 2.27 | 5.00 | 3.66 | 0.21 | 3.18 | 0.34 | 4.76 | 1.49 | 24.83 | 5.55 |
| **UKI6** | 0.47 | 2.18 | 1.74 | 2.27 | 5.00 | 3.66 | 0.20 | 3.18 | 0.34 | 4.76 | 2.86 | 26.20 | 6.15 |
| **UKI7** | 0.72 | 2.18 | 1.74 | 2.27 | 5.00 | 3.66 | 0.24 | 3.18 | 0.34 | 4.76 | 2.35 | 25.72 | 6.11 |
| **UKC1** | 0.64 | 2.33 | 1.07 | 3.56 | 0.57 | 0.87 | 0.38 | 1.21 | 0.25 | 0.83 | 0.30 | 11.36 | -2.09 |
| **UKC2** | 1.23 | 2.33 | 1.07 | 3.56 | 0.64 | 0.87 | 0.50 | 1.21 | 0.32 | 0.62 | 0.43 | 11.54 | -1.39 |
| **UKD1** | 0.75 | 1.91 | 1.13 | 1.90 | 0.38 | 0.93 | 0.18 | 1.53 | 0.31 | 0.59 | 0.49 | 9.36 | -3.31 |
| **UKD3** | 1.85 | 1.91 | 1.13 | 1.90 | 1.42 | 0.93 | 0.46 | 1.53 | 0.24 | 1.91 | 0.97 | 12.40 | 0.54 |
| **UKD4** | 0.69 | 1.91 | 1.13 | 1.90 | 1.01 | 0.93 | 0.29 | 1.53 | 0.23 | 1.50 | 0.25 | 10.68 | -1.89 |
| **UKD6** | 1.38 | 1.91 | 1.13 | 1.90 | 1.35 | 0.93 | 0.24 | 1.53 | 4.19 | 2.29 | 1.15 | 16.63 | 3.06 |
| **UKD7** | 0.75 | 1.91 | 1.13 | 1.90 | 1.59 | 0.93 | 0.39 | 1.53 | 0.43 | 1.64 | 0.33 | 11.79 | -0.16 |
| **UKE1** | 0.51 | 2.09 | 0.71 | 4.75 | 0.62 | 0.76 | 0.22 | 1.40 | 0.21 | 0.87 | 0.22 | 11.85 | -3.21 |
| **UKE2** | 1.17 | 2.09 | 0.71 | 4.75 | 0.70 | 0.76 | 0.66 | 1.40 | 0.45 | 1.30 | 0.46 | 13.28 | -0.08 |
| **UKE3** | 0.79 | 2.09 | 0.71 | 4.75 | 1.16 | 0.76 | 0.69 | 1.40 | 0.32 | 1.59 | 0.29 | 13.77 | -0.11 |
| **UKE4** | 0.93 | 2.09 | 0.71 | 4.75 | 1.22 | 0.76 | 0.55 | 1.40 | 0.26 | 1.67 | 0.47 | 13.88 | 0.03 |
| **UKF1** | 0.75 | 2.06 | 1.01 | 3.81 | 0.97 | 0.66 | 0.48 | 1.47 | 1.25 | 1.67 | 0.37 | 13.77 | 1.04 |
| **UKF2** | 0.92 | 2.06 | 1.01 | 3.81 | 1.47 | 0.66 | 0.29 | 1.47 | 0.30 | 1.66 | 0.55 | 13.28 | -0.13 |
| **UKF3** | 0.71 | 2.06 | 1.01 | 3.81 | 0.39 | 0.66 | 0.26 | 1.47 | 0.14 | 0.97 | 0.26 | 11.04 | -3.58 |
| **UKG1** | 0.85 | 2.33 | 0.93 | 2.94 | 1.47 | 1.09 | 0.24 | 1.29 | 2.04 | 1.73 | 0.69 | 14.72 | 2.00 |
| **UKG2** | 0.68 | 2.33 | 0.93 | 2.94 | 1.17 | 1.09 | 0.21 | 1.29 | 0.18 | 1.54 | 0.29 | 11.96 | -1.72 |
| **UKG3** | 1.07 | 2.33 | 0.93 | 2.94 | 2.37 | 1.09 | 2.20 | 1.29 | 0.57 | 1.54 | 0.82 | 16.07 | 3.51 |
| **UKH1** | 1.99 | 2.26 | 1.23 | 1.97 | 0.69 | 2.03 | 5.00 | 1.65 | 5.00 | 1.08 | 0.70 | 21.62 | 5.49 |
| **UKJ1** | 2.53 | 2.21 | 1.25 | 3.66 | 3.55 | 1.37 | 4.80 | 2.24 | 2.81 | 3.14 | 1.64 | 26.68 | 8.95 |
| **UKJ2** | 1.49 | 2.21 | 1.25 | 3.66 | 4.66 | 1.37 | 0.37 | 2.24 | 0.43 | 3.51 | 1.18 | 20.88 | 4.55 |
| **UKJ3** | 1.10 | 2.21 | 1.25 | 3.66 | 2.33 | 1.37 | 0.41 | 2.24 | 0.73 | 1.95 | 0.71 | 16.87 | 3.42 |
| **UKJ4** | 0.83 | 2.21 | 1.25 | 3.66 | 4.96 | 1.37 | 0.26 | 2.24 | 0.32 | 2.34 | 0.53 | 19.15 | 2.77 |
| **UKK1** | 1.87 | 2.32 | 0.90 | 1.45 | 1.18 | 1.30 | 1.00 | 1.96 | 0.69 | 1.53 | 0.73 | 13.05 | 1.94 |
| **UKK2** | 0.99 | 2.32 | 0.90 | 1.45 | 0.56 | 1.30 | 0.27 | 1.96 | 0.22 | 1.10 | 0.46 | 10.54 | -2.03 |
| **UKK3** | 0.84 | 2.32 | 0.90 | 1.45 | 0.54 | 1.30 | 0.18 | 1.96 | 0.15 | 0.37 | 0.58 | 9.74 | -3.75 |
| **UKK4** | 0.91 | 2.32 | 0.90 | 1.45 | 0.58 | 1.30 | 1.11 | 1.96 | 0.28 | 0.63 | 0.40 | 10.92 | -1.04 |
| **UKL1** | 0.48 | 2.23 | 1.20 | 2.50 | 0.55 | 0.95 | 0.26 | 1.65 | 0.21 | 0.51 | 0.27 | 10.34 | -3.11 |
| **UKL2** | 1.55 | 2.23 | 1.20 | 2.50 | 0.77 | 0.95 | 0.48 | 1.65 | 0.30 | 0.87 | 0.57 | 11.53 | -0.54 |
| **UKM5** | 1.26 | 2.15 | 1.17 | 3.29 | 0.47 | 0.79 | 0.39 | 2.11 | 0.37 | 0.49 | 1.83 | 13.04 | -0.20 |
| **UKM6** | 0.61 | 2.15 | 1.17 | 3.29 | 0.26 | 0.79 | 0.25 | 2.11 | 0.16 | 0.14 | 0.13 | 10.45 | -5.94 |
| **UKM7** | 1.78 | 2.15 | 1.17 | 3.29 | 1.13 | 0.79 | 2.68 | 2.11 | 0.71 | 0.78 | 0.60 | 15.40 | 2.63 |
| **UKM8** | 1.33 | 2.15 | 1.17 | 3.29 | 3.84 | 0.79 | 0.96 | 2.11 | 0.28 | 1.02 | 0.61 | 16.21 | 2.18 |
| **UKM9** | 0.36 | 2.15 | 1.17 | 3.29 | 1.16 | 0.79 | 0.19 | 2.11 | 0.32 | 0.60 | 0.20 | 11.97 | -2.17 |
| **UKN0** | 0.87 | 1.72 | 0.96 | 2.93 | 0.68 | 0.74 | 0.32 | 1.21 | 0.45 | 0.47 | 0.45 | 9.94 | -2.40 |