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Is a balanced entrepreneurial ecosystem essential for success? A configurational analysis of European regional entrepreneurial ecosystems

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Abstract

This study challenges the assumption that well-balanced and bottleneck-free entrepreneurial ecosystems (EEs) are the sole drivers of high regional economic performance. Using a comprehensive dataset covering 125 regions across 24 European countries, we find that high regional economic performance does not universally necessitate the presence of every ecosystem component. Rather, contextual nuances across European macro-regions show that both balanced and unbalanced ecosystems can lead to significant economic success, emphasizing the importance of recognizing uniqueness. Our research contributes to the EE literature by integrating individual and institutional factors through the REDI conceptual model. The nuanced macro-regional analysis underscores the need for region-specific assessments. We conclude that policy efforts should focus on acknowledging and leveraging the uniqueness of regional ecosystems rather than striving for a one-size-fits-all approach to enhance economic performance.

Keywords Entrepreneurship · Entrepreneurial ecosystem (EE) · Fuzzy-set qualitative comparative analysis (fsQCA) · Regional economic performance · Regional entrepreneurship and development index (REDI)

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1 Introduction

Why do certain countries provide more entrepreneurial opportunities, thus leading to greater economic success compared to others? Addressing this question, the *entrepreneurial ecosystem* (EE) approach has gained significant recognition to support productive entrepreneurship and, ultimately, enhance productivity (Cao & Shi, 2021; Content et al., 2020; García-Lillo et al., 2023; Leendertse et al., 2022; Malecki, 2018). In their study, Stam and van de Ven (2021) define the EE as follows: *"The entrepreneurial ecosystem comprises a set of interdependent actors and factors that are governed in such a way that they enable productive entrepreneurship."* (p. 809). Furthermore, they present their conceptual framework model with key elements, outputs, and outcomes of the EE. They argue that entrepreneurial activity can take many forms, such as innovative start-ups, high-growth start-ups, and entrepreneurial employees, and not just high-growth start-ups or scale-ups. They draw on the seminal work of Baumol (1993), who introduced the term productive entrepreneurship which refers to *"any entrepreneurial activity that contributes directly or indirectly to net output of the economy or to the capacity to produce additional output"* (p. 30). While the intermediate output of an EE is productive entrepreneurship according to the Stam & van de Ven (2021) model, *new value creation* is the ultimate outcome of an EE.

Vedula and Kim (2019), investigating how EE quality influences new venture survival rates in the US, found that high-quality ecosystems, characterized by strong support networks, financial resources, and knowledge spillovers, significantly enhance venture survival. According to Feldman et al. (2019), the success of innovation and entrepreneurial ecosystems is influenced by five key factors: human capital (developed at local universities), knowledge creation (from research-intensive universities and new technology start-ups), access to finance (especially to risk finance), market access, and relevant infrastructure. The authors highlight the complexity and diversity of EEs, noting that they vary significantly across different contexts. This variability necessitates *tailored approaches* to ecosystem development and management. Therefore, the authors call for more interdisciplinary research and the adaptation of more nuanced research methodologies to better understand the multifaceted nature of entrepreneurial ecosystems. They also advocate for longitudinal studies to track the evolution of ecosystems over time, using both qualitative and quantitative approaches to study the interactions within ecosystems, and comparative studies to identify best practices across different regions.

There are several conceptual models for measuring the performance of EEs, which allow for a comparative assessment of nationally aggregated or regional EEs (e.g., Acs et al., 2014; Bell-Masterson & Stangler, 2015; Lai & Vonortas, 2019; Stam & van de Ven 2021; Sternberg et al., 2022; Szerb et al., 2020). However, the existing models and their measures have certain limitations, highlighting the undertheorized nature of EE research (Autio et al., 2018). First, these models, except for two, only consider institutional factors and *ignore the individual aspect* (actors' attitudes) while both aspects appear important in explaining the performance of EEs (Acs et al., 2014; Muñoz et al., 2022). The Global Entrepreneurship Index (GEI, Acs et al., 2014), and its regional version, the Regional Entrepreneurship and Development Index (REDI, Szerb et al., 2013, 2017) are the only EE measures that consider both the individual and institutional factors. Secondly, EE, as a complex adaptive system, requires a systemic approach, but all current models are built upon *oversimplified assumptions* regarding the interrelationships among the EE elements. Thirdly, the models assume *equal weights for EE components* despite their varying importance across nations and regions. Lastly, one line of EE research assumes a complementary relationship between EE elements, implying that stable and efficient EEs are those *"that are balanced—i.e., that all component values are at the same level"* (Acs et al., 2014, p. 484). The complementary approach is presented by Acs et al. (2014), as part of which they introduced the *concept of bottlenecks* to demonstrate system interactions. The authors argue that the performance of an ecosystem is hampered by missing or underperforming elements, and these bottlenecks can affect the entire ecosystem. Eliminating these bottlenecks leads to a more balanced and efficient ecosystem. Acs et al. (2018) demonstrated that the quality of the ecosystem positively correlates with economic growth, indicating that a more balanced ecosystem leads to higher economic growth. However, other studies, e.g., Spigel (2017), Kapturkiewicz (2022), acknowledge that while some EE elements are complementary, others exhibit substitutable characteristics, meaning they can replace each other under certain conditions to achieve similar outcomes. As for the interaction between the different institutions, Hall and Soskice (2001) specify that *"two institutions can be said to be complementary if the presence (or efficiency) of one increases the returns from (or efficiency of) the other"*, and "*two institutions can be said to be 'substitutable' if the absence or inefficiency of one increases the returns to using the other"* (p. 17). In relation to EEs, this was confirmed by Vedula and Kim (2019) who found that entrepreneurial experience can partially compensate for deficiencies in a lower-quality EE. Specifically, they noted that this compensation applies to venture capital access, human capital availability, and regional innovation capacity. However, entrepreneurial experience cannot effectively substitute for entrepreneurial culture, access to loans and grants, and support from formal organizations like universities, accelerators, and incubators.

The qualitative comparative analysis (QCA) methodology has gained considerable popularity in the entrepreneurship literature (Oana et al., 2021). It presents a potential solution to address the issues concerning the operationalization of the entrepreneurial ecosystem. This method, based on Boolean logic, assumes that only *combination(s)* of components can explain a phenomenon. It can help reveal the causal complexity of phenomena *without any simplifying assumption* about the relationships between elements. Our study aims to analyze the regional EE of 125 EU NUTS regions using fuzzy QCA. Our objective is to identify *which regional EEs in the European Union (EU) can achieve high economic performance, and whether a balanced EE is necessary for high regional performance*. QCA can explore *whether several combinations of EE conditions could lead to the same outcome, or whether there is only one way to economic success*. In this study, we used the pillars of REDI as the main components of regional EEs. REDI was chosen because it is the only analytical tool for measuring regional EE that considers both individual and institutional factors.

Section 2 discusses the theoretical background and shortcomings of the EE concept, Sect. 3 explains the data source and the fsQCA method, Sect. 4 describes the results of the analyses, and the last section presents the study's discussion and conclusions.

2 Entrepreneurial ecosystem challenges

The EE concept is gaining increasing popularity—as noted by several literature review papers (Cao & Shi, 2021; Cavallo et al., 2019; Malecki, 2018; Spigel & Harrison, 2018; Theodoraki et al., 2022). While EE research is still in an exploratory stage (Dejardin and Levratto, 2023), some general conclusions can be drawn. EE can be viewed a complex adaptive system that exhibits non-linearity, high heterogeneity, sensitivity to initial conditions, and temporal variability (Roundy et al., 2018). In the EE models, productive entrepreneurship is an intermediate *output* that leads to economic growth, which is the ultimate *outcome* (Stam, 2015; Szerb et al., 2019). EE is place-based, yet industry-neutral (Spigel & Harrison, 2018; Stam, 2015). At the core of EE, the entrepreneur plays a critical role in disseminating knowledge and initiating or managing a start-up or scale-up (Feld, 2012). EE recognizes the importance of interactions among stakeholders and institutional factors as key mechanisms for knowledge spillovers and resource exploitation capacity (Acs et al., 2014). The broader context serves to regulate the quality and outcomes of the entire entrepreneurial process (Autio et al., 2014; Baker & Welter, 2020). EE underscores the significance of customized, grassroots actions as an effective means of fostering local entrepreneurship rather than duplicating successful models through top-down approaches (Acs et al., 2014; Thompson et al., 2017).

Models provide useful insights on how to profile EEs but are inconsistent with the definition of EE and lack clarity in the selection criteria for components (Autio et al., 2018; O'Shea et al., 2019). On the one hand, to understand the complexities of EE, it appears crucial to integrate both individual and institutional factors into the conceptual models. However, most EE conceptual models fail to consider the individual perspective. In their research on local EEs in Chile, Muñoz et al. (2022) show that the way local actors perceive their own ecosystem has a strong impact on ecosystem performance. On the other hand, EE requires a systematic approach, but most models and methods of measuring it oversimplify the relationships among its different elements (Acs et al., 2014; Autio et al., 2018). Although EE performance is generally considered as the sum of its components, case studies show that the relationships between EE elements are more complex (Mack & Mayer, 2016; Neck et al., 2004). Traditionally, studies look at the impact of potential factors on EE in isolation from the impact of other factors, which may, however, have different effects when they operate within a system in combination with other elements. Furthermore, all factors in the models are considered equally important, although the weight of each factor may vary. It follows from the above that it is essential to develop a more comprehensive approach to measure EE that considers not just the individual and institutional factors but also the complex interactions between the different elements of the ecosystem.

Furthermore, while significant strides have been made in developing analytical frameworks for EEs, network theory has not been fully utilized in this field. Scholars have pointed out the potential of network theory in improving our understanding of causal relationships and dynamics within EEs (Alvedalen & Boschma, 2017; Cunningham et al., 2019; Stam, 2015). Spigel and Harrison (2018) suggest that a network perspective could help in revealing how resources and support flow through ecosystems, impacting entrepreneurial success. Recent studies by Purbasari et al. (2019) and Chen et al. (2020) have demonstrated the relevance of network theory in understanding actors' roles and network diversity in EEs. Prokop and Thompson (2023) have emphasized the benefits of ecosystem openness to diverse actors. Despite these insights, the application of network theory in EE research to better understand the complex interdependencies within EEs is still limited.

The Regional Entrepreneurship and Development Index (REDI), as a composite indicator, assesses EEs at the regional level, using the same conceptual model and method as the Global Entrepreneurship Index (GEI) that measures EE performance at the national level. Both indices have gained significant scientific recognition (Audretsch & Belitski, 2017; Capello & Lenzi, 2016; EC 2014; Szerb et al., 2019, 2020).

REDI captures the key features of an EE by emphasizing its regional clustering of stakeholders, incorporating regional-level measures with distinct geographic and socio-cultural boundaries. It employs a multiplicative approach for calculating various elements of EEs, known as pillar scores. This method introduces non-linearity into the analysis, indicating that interactions and relationships between different components are complex and interdependent, rather than merely additive. Essentially, REDI considers the combined effects of various factors, accounting for their interactions and mutual influences, which adds complexity to the analysis. To reflect the multi-dimensional nature of entrepreneurship, REDI combines individual entrepreneurial characteristics with contextual (institutional) factors. Additionally, the adaptability of an EE to changing conditions is a vital feature. REDI scores are calculated using a common benchmark that includes all available years, allowing for unbiased comparisons across different periods. This capability enables the examination of EEs' adaptability over time. Moreover, REDI highlights the systemic relationships between the elements of an EE. The components of an EE interact with each other, and if they are not balanced, REDI assumes that entrepreneurship will be hindered. To address this, the components must be adjusted to achieve balance. The REDI approach is based on the theory of the weakest link (TWL) and the theory of constraints (TOC) (Goldratt, 1994; Tol & Yohe, 2007), which propose that the different elements of the ecosystem are only partially substitutable for each other. By using the Penalty for Bottleneck (PFB) algorithm, REDI identifies systemic bottlenecks that constrain the system, suggesting that the performance of the ecosystem is limited by its weakest components. Therefore, EEs with bottlenecks cannot fully leverage their strengths, and for an EE to be stable and well-performing, it must be optimized and balanced (Tables 1 and 2).

Many entrepreneurship policy experts argue that policies should address weak components in EEs, as these can hinder overall system performance by holding back other elements (Audretsch et al., 2007; Lundström & Stevenson, 2006; Mason & Brown, 2014). On the other hand, we cannot entirely rule out the possibility that strong components may positively influence weaker ones (Szerb et al., 2020). This idea aligns with systems theory, which suggests that the whole is greater than the sum of its parts, meaning improvements in one area can benefit others through synergy and feedback loops (Checkland, 1981). For example, educational systems help develop entrepreneurial skills and innovation (Bosio et al., 2018), while strong institutions that reduce uncertainty (e.g., low corruption, effective government) encourage risk-taking, all of which ultimately foster innovation and entrepreneurship (Klapper et al., 2006). Roundy's (2018) view of entrepreneurial ecosystems as complex adaptive systems suggests that interactions are non-linear. Minor changes in one component can lead to significant and unpredictable outcomes due to interconnectedness and feedback loops. In brief, although REDI makes complex assumptions about the relationship between EE components, it may not be enough. The interactions between EE elements may be more complex, requiring further refinement of the methodology. The concept of EE is "seductive" (Stam, 2015, p. 1764), but as we highlight above, its measurement is challenging due to the uniqueness of each ecosystem. EE, like a "kaleidoscope" (Gartner, 1985, p. 701), comprises diverse components, resulting in countless combinations of these components. To address these issues, our study aims to explore the complex relationships between EE components and, rather than making restrictive assumptions, we acknowledge the diversity of interrelatedness between EE components (Tables 3 and 4).

Traditional statistical methods may not be enough to capture the intricate relationships between EE elements (Baker & Welter, 2020; Muñoz et al., 2022, Roundy, et al., 2018). To depict the interconnectedness of EE elements more accurately, we utilized the qualitative comparative analysis (QCA) method, which complements traditional methods by dealing with uniqueness (Ragin, 2008). Based on Boolean algebra, QCA

Table 1 Entrepreneurial abilities (ABT) and aspirations (ASP) pillars of the REDI. *Source:* own edition based on Szerb et al., 2017

Subindex	Pillars	Individual/Institutional variable name and description	
Entrepreneurial abilities	Opportunity startup	*Opportunity motivation*	*Percentage of Total Early-Stage Entrepreneurial Activity (TEA) businesses initiated because of opportunity startup motive (GEM Adult Population Survey)*
		Business environment	Business environment is represented by taxation (World Bank Ease of Doing Business, country level) and by quality of government (EU QoG index (EQI), regional level)
	Technology adoption	*Technology level*	*Percentage of TEA businesses that are active in technology sectors (GEM Adult Population Survey)*
		Absorptive capacity	Absorption capacity measures the technological readiness of firms at country level (Firm-level technology Absorption, WEF Global Competitiveness Report) and the regional level of employment in knowledge-intensive and high technology firms (Eurostat)
	Human capital	*Educational level*	*Percentage of TEA business owners/managers having participated in secondary education (GEM Adult Population Survey)*
		Education & training	Education & Training variables show the involvement of the region's population in training and life-long learning (Eurostat) as well as the state of labour market regulations at country level (Labor freedom index, Heritage Foundation)
	Competition	*Competitors*	*Percentage of TEA businesses started in those markets where not many businesses offer the same product (GEM Adult Population Survey)*
		Business strategy	Business strategy measures the country's nature of competitive advantage (WEF Global Competitiveness Report), the ratio of foreign control of enterprises (Eurostat), and the regional level sophistication of the businesses (Employment and GVA in K-N sectors, Eurostat)

Table 1 (continued)

Subindex	Pillars	Individual/Institutional variable name and description	
Entrepreneurial aspiration	Product innovation	*New product*	*Percentage of TEA businesses offering products that are new to at least some of the customers (GEM Adult Population Survey)*
		Technology transfer	Technology transfer refers to the regions' potential to patent (Eurostat) and to create scientific publications (EU Regional Competitiveness Report)
	Process innovation	*New technology*	*Percentage of TEA businesses using new technology that is less than 5 years old (GEM Adult Population Survey)*
		Technology development	Technology development measures the effect of GERD (Eurostat), as well as the ratio of researchers and R&D employees in higher education sector (Eurostat)
	High growth	*Gazelle*	*Percentage of TEA businesses having high job expectation average (over 10 more jobs, and over 50% growth in jobs, in 5 years) (GEM APS)*
		Clustering	Clustering captures the effect of clustering (DG Region data), the state of cluster development (country level), and the availability of VC (country level)
	Globalization	*Export*	*Percentage of TEA businesses where at least some customers are outside the country (over 1%) (GEM Adult Population Survey)*
		Connectivity	Connectivity reflects the quality of different form of accessibility at the regional level (EU Regional Competitiveness Report, Infrastructure sub-index) and the complexity of a national economy (Hidalgo—Hausmann)
	Financing	*Informal Investment*	*Informal financing possibilities measured by the amount of Informal Investment and Business Angel (percentage of the population aged 18–64 who provided funds for new businesses in past 3 years, excluding stocks and funds) variables (GEM Adult Population Survey)*
		Financing	Depth of Capital Market is a complex variable measuring the access to different capital and debt markets at country level (The Global Venture Capital and Private Equity Country Attractiveness Index), while the institutional part of Financing pillar captures the concentration of financial services at regional level (Eurostat)

The individual variables are in italics, the institutional ones in roman

Table 2 Non-calibrated and calibrated values of the input and outcome variables. *Source*: own edition

Conditions/Statistics	Min. value		Full non- membership		Crossover point		Full membership		Max. value	
Input conditions	Uncalib	Calib	Uncalib	Calib	Uncalib	Calib	Uncalib	Calib	Uncalib	Calib
1. Opportunity startup	0.04	0.00	0.24	0.05	0.40	0.50	0.55	0.95	0.88	1.00
2. Technology Adoption	0.00	0.00	0.03	0.05	0.05	0.50	0.09	0.95	0.28	1.00
3. Human capital	0.02	0.00	0.09	0.05	0.13	0.50	0.20	0.95	0.72	1.00
4. Competition	0.04	0.00	0.11	0.05	0.16	0.50	0.24	0.95	0.33	1.00
5. Innovation	0.02	0.00	0.07	0.05	0.11	0.50	0.17	0.95	0.38	1.00
6. High growth	0.00	0.00	0.05	0.05	0.07	0.50	0.10	0.95	0.18	1.00
7. Globalization	0.07	0.00	0.23	0.05	0.34	0.50	0.42	0.95	0.60	1.00
8. Financing	0.00	0.00	0.03	0.05	0.06	0.50	0.09	0.95	0.35	1.00
Outcome variable										
High Regional Economic Performance (HREP)	10.88	0.00	54.15	0.05	59.39	0.50	64.63	0.95	98.49	1.00

Table 3 Necessary analysis of high regional performance (HREP). *Source*: own edition

Outcome variable	**HREP**							
Macro region	**EU 125**		**NWE**		**ME**		**CEE**	
Conditions (calibrated)	*Consistency*	*Coverage*	*Consistency*	*Coverage*	*Consistency*	*Coverage*	*Consistency*	*Coverage*
Opportunity startup	0.861	**0.643**	0.753	**0.549**	0.795	**0.598**	0.690	**0.504**
Technology adoption	0.795	**0.619**	0.761	**0.548**	0.721	0.476	0.781	**0.530**
Human capital	0.735	**0.592**	0.725	**0.541**	0.760	**0.565**	0.674	0.493
Competition	0.833	**0.637**	0.752	**0.500**	0.791	**0.555**	0.474	0.327
Innovation	0.874	**0.679**	0.726	**0.521**	0.908	**0.689**	0.862	**0.573**
High growth	0.583	0.441	0.548	0.384	0.693	**0.521**	0.648	0.430
Globalization	0.604	0.463	0.466	0.333	0.744	**0.546**	0.817	**0.582**
Financing	0.667	0.544	0.559	0.398	0.810	**0.582**	0.654	0.461

NWE: northwestern Europe macro-region, ME: mediterranean Europe macro-region, CEE: central Eastern European macro-region. Color codes in consistency columns: black = "always" necessary, dark grey = "almost always" necessary, light grey = "usually" necessary. Color codes in coverage columns: number in bold = coverage is higher than 0.5, empirically relevant condition.

Table 4 Sufficiency analysis of high regional performance (HREP). *Source*: own edition

Outcome variable	**HREP**								
Macro regions	**EU 125**			**NWE**		**ME**		**CEE**	
Conditions	C1	C2	C3	C4	C5	C6	C7	C8	C9
fs/Opportunity Startup	•	•	⨂	•	•	●	●	●	●
fs/Technology adoption	•		⨂	●	●	•		•	•
fs/Human capital	●	●	●	•	•	●	●	•	•
fs/Competition	●	●	●	•	•	●	●	●	●
fs/Innovation	•	•	•	●	●	●	●	•	•
fs/High growth		•	⨂	⨂	⨂		•	⊗	•
fs/Globalization		•	•	•	⊗	●	●	●	●
fs/Financing	●	●	●	⊗	•	●	●	⊗	•
Raw coverage	0.41	0.28	0.07	0.11	0.12	0.31	0.41	0.15	0.14
Unique coverage	0.16	0.01	0.02	0.06	0.07	0.05	0.15	0.13	0.11
Consistency	0.86	0.85	0.81	0.81	0.81	0.91	0.93	0.85	0.94
Overall solution coverage	**0.46**			**0.18**		**0.46**		**0.27**	
Overall solution consistency	**0.87**			**0.86**		**0.94**		**0.90**	

assumes causal complexity, meaning that it does not analyze the effect of each condition in isolation, but instead looks at how they interact to co-produce an outcome (Rihoux & Ragin, 2009). In the field of entrepreneurship, there is an increasing interest in QCA to understand the complexity of entrepreneurial endeavors. Specifically, QCA is used to identify the specific combinations of various factors, such as entrepreneurial attitudes, intentions, individual characteristics, and barriers, that are necessary and sufficient to achieve high business dynamism, innovation, firm performance, and so on (Alves et al., 2019; Beynon et al., 2020; Douglas et al., 2020; Ferreira & Dionísio, 2019; Muñoz et al., 2022; Velilla et al., 2018). However, EE studies that utilize QCA typically focus on either individual or contextual factors rather than examining both together. Additionally, these studies primarily focus on the direct output of EEs (i.e., productive entrepreneurship) rather than their outcomes. According to Audretsch (2021), it might be misleading to associate high-quality EEs only with highly innovative, fast-growing ventures. As EEs are context-sensitive, their outputs consequently vary depending

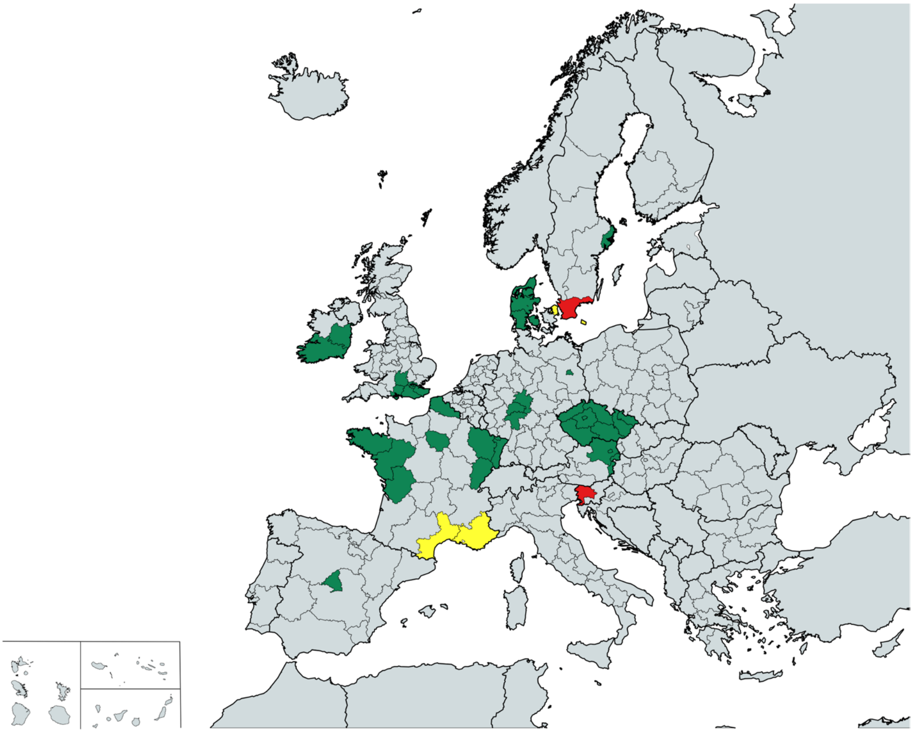

Fig. 1 Balanced and unbalanced EE regions in the EU. Color codes: green – regions with balanced EE, red—regions with unbalanced EE, yellow—balanced/unbalanced where it depends on the level of investigation (EU 125 or macro-region). *Source*: own edition

on the context. A better approach is to explore the outcomes of EEs rather than their outputs, as economic performance can be interpreted for all regions.

Consequently, in this study, we aim to determine whether a high regional economic performance can be achieved solely through a balanced ecosystem or whether other unbalanced but well-performing EE configurations exist. A balanced ecosystem is one where all EE components are important for achieving high regional performance to a certain extent. On the other hand, an unbalanced ecosystem is one where some components are dominant, while others are less significant or completely absent. On this basis, we formulate the following alternative hypotheses:

H1: Regions in the EU can achieve high economic performance only with balanced EE.

H2: Different ecosystem configurations lead to high economic performance in various geographical sub-regions of Europe.

3 Data & method

3.1 Sample

REDI has been calculated twice (Szerb et al., 2013, 2017). It consists of 14 pillars that are documented as being the key components of EEs. These pillars are a combination of individual and institutional variables. The individual variables are based on pooled data (2012–2014) of the GEM adult population survey (APS). It was possible to create a regional representation of the GEM dataset for 125 European NUTS1 and NUTS2 regions across 24 European Union countries.[1] Appendix 1 (Table 5) contains a list of the NUTS regions involved in the analysis.

By using QCA, we also investigate which ecosystem configurations lead to high regional economic performance for the three European macro-regions. Therefore, we used the varieties of capitalism (VoC) framework to classify the regions into three macro-regions. This approach takes into consideration the existence of various forms of capitalism in different countries. These forms are usually shaped by a complex interplay of socio-institutional heritage, historical context, cultural orientation, policy choices, and global influences. The VoC framework provides a fresh perspective on the similarities and differences between the institutional structures of developed economies. Consequently, like the analysis of Dilli et al. (2018), we use the institutional classifications from the VoC literature to categorize different market economies of Europe. We identified Northwestern European (I) market economies, which include Coordinated and Liberal market economies, covering NUTS regions in Austria, Belgium, Germany, Denmark, Finland, Sweden, the Netherlands, Ireland, and the United Kingdom. The Mediterranean European (ME) market economies consist of regions in Greece, Spain, France, Italy, and Portugal, while the Central Eastern European (CEE) market economies include regions in Croatia, Czechia, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, and Slovakia.

3.2 Variables

3.2.1 Input variables

We used the REDI 2017 report's pillar-level data as causal conditions. All 14 pillars of REDI are set up by combining institutional and individual indicators. All individual indicators of the REDI to describe the perceptions of ecosystem actors on EE are derived from GEM database (see Szerb et al., 2017, Table 2, page 15). The GEM survey measures self-reported attitudes of towards entrepreneurship culture among both the general population and different categories of entrepreneurs (nascent, start-ups, scale-ups, etc.), including risk-taking, perceptions of entrepreneurship as a good career choice, recognition of opportunities, abilities and skills needed, willingness to innovation and grow etc. The 14 pillars of the REDI conceptual framework are grouped into three sub-indices: the *entrepreneurial attitude* (ATT) captures the attitudes of a region's population as they relate to entrepreneurship, while the *entrepreneurial abilities* (ABT) and *entrepreneurial aspiration* sub-indices (ASP) measure the abilities and aspirations of nascent and new business entrepreneurs. First, the three sub-indices are based on different populations. ATT evaluates the attitudes towards entrepreneurship of the entire population of a given region (between 18 and 64 aged population). While ABT and ASP sub-indexes focus on the abilities, skills, and growth aspirations of nascent and new entrepreneurs in the region. In sum, the GEM indicators used for the three sub-indices present different aspects of the entrepreneurial culture, however, the pillar related to ABT and ASP focuses exclusively on entrepreneurial perceptions. For this study, we chose 9 of the 14 pillars, belonging to the ABT and ASP sub-indexes, based on conceptual and methodological considerations

[1] For more details about the individual data sets, see Szerb, et al., 2017, p. 16–17.

(Table 1). First, changing a society's attitudes towards entrepreneurship takes a long time, making it challenging to influence through policy efforts (Fritsch & Wyrwich, 2019). However, the abilities and aspirations of entrepreneurs can be controlled more effectively in the short- to medium-term. Second, in the case of QCA method, when selecting cases, a key consideration is maximum homogeneity (Rihoux & Ragin, 2009). It is important that the cases to be examined have common background characteristics, i.e., they should be similar in some respect for the comparison to be meaningful. In the case of joint analysis of different groups (one set of indicators for the total population, another set exclusively for entrepreneurs), this methodological requirement would have been violated. Third, including too many causal conditions in a QCA analysis can be problematic due to limited diversity.[2] Since there is no strict rule for the number of conditions, we followed the common practice suggested by Rihoux and Ragin (2009). By merging the Product innovation and Process innovation pillars into one (Product & Process innovation), we obtained eight REDI pillars for analysis, resulting in a decrease of the 256 logical combinations to 125 cases (0.488).

3.2.2 Output variable

While the intermediate output of an EE is productive entrepreneurship according to the Stam & van de Ven (2021) model, new value creation is the ultimate outcome of an EE. Traditional indicators like gross value added (GVA) are used to measure new value creation and economic growth at the country level, providing a comprehensive view of economic value. As the outcome variable for our QCA analysis, we measured regional economic performance using the average GVA per employee for 2014–2016. We focused on EE outcomes rather than EE outputs for the QCA analysis for the following reasons. As Baumol (1993) highlighted productive entrepreneurship encompasses various activities. Also Audretsch (2021), highlighting the context-dependency of EE outputs, argues that the recent view of productive entrepreneurship held by scholars and academics is highly skewed and exclusive. Since EEs are unique, hence, their *outputs are unique* as well, they can be productive, sometimes unproductive, or even destructive (Baumol, 1990). Innovative (also known as quality, radical, or Schumpeterian) entrepreneurship, based on high-tech, venture capital-funded firms, should be considered *a special output of a specific EE*. While innovative entrepreneurship, like that seen in Silicon Valley, contributes to higher local/regional economic performance compared to quantity entrepreneurship (Szerb et al., 2019), it cannot address nationwide wealth and income disparities. Exclusively emphasizing this form of entrepreneurship may lead to policies favoring a select group, neglecting the majority (which is more prevalent in reality) including self-employed individuals and family businesses. Evaluating entrepreneurial performance solely through a "Silicon-valley" lens overlooks broader linkages, positive externalities, and long-term perspectives. To emphasize in entrepreneurship policy its exclusive support for all regions, simply because this form of productive entrepreneurship can generate the greatest regional results, is as misleading as the one-sided emphasis on quantity entrepreneurship. Successful entrepreneurship is not confined to high-tech ventures; context-sensitive interpretation is crucial. For instance, the German Mittelstand, composed of family businesses, exemplifies successful entrepreneurship without exclusively generating high-growth, high-tech ventures (Pahnke & Welter, 2019). Consequently, lacking a single comprehensive regional indicator for productive entrepreneurship, focusing on

[2] In this situation, the observed data are less rich than the logical (but not observed in the sample) combinations, risking that the analysis leads to an individual explanation for each case. If an analysis involves k conditions, the number of possible combinations will be 2^k (Ragin, 2008).

just one type would be misleading. Therefore, we chose to explore regional entrepreneurial ecosystem configurations that result in high EE outcomes, specifically high regional GVA.

3.3 Method: fuzzy QCA

Qualitative comparative analysis (QCA) is a research method that analyzes complex social phenomena by systematically comparing cases to identify patterns. The method assumes that combinations of causal conditions, called *configurations*, collectively contribute to causing a particular outcome (*multiple conjunctural causation*). QCA examines the causes that lead to an outcome (causes-of-effect), rather than measuring the isolated effects of individual causes in a result (effect-of-causes). It emphasizes *equifinality*, where different configurations can lead to the same outcome. It bridges the gap between qualitative (in-case) and quantitative (cross-case) analysis; consequently, it is more context-sensitive, which helps better understand complexity (Ragin, 2008; Rihoux & Ragin, 2009).

QCA treats the investigated phenomena as sets, using Boolean logic to analyze different set relations. It identifies which combinations of conditions are necessary or sufficient for reaching a certain outcome. A condition is a *necessary* when the outcome (Y) occurs only if the condition (X) is present ($X \leftarrow Y$). A necessary condition means that the configuration must contain a given condition, but this is not sufficient alone to provide the outcome. A *sufficient* condition means when the condition (X) is met, the outcome (Y) also occurs ($X \rightarrow Y$). A sufficient condition implies the outcome but does not preclude the possibility that the outcome may also stem from other conditions (Oana et al., 2021).

In this paper, fuzzy QCA is used to identify necessary and sufficient configurations of EE's elements (pillars of REDI) that are associated with high levels of regional economic outcome measured by regional real GVA per worker.

3.4 Calibration

QCA treats the condition and outcome variables as a set. Consequently, following model specification, the subsequent step is calibration, where cases are converted into set membership scores to indicate how well they fit into a specific set. A fuzzy QCA is applied to allow for differences in the degree of membership instead of using a dichotomy of 0 and 1 membership. Calibration involves transforming the scores of casual conditions and outcome variables to fuzzy membership scores between 0 and 1, based on the thresholds of the three qualitative anchors: full membership (1.0), full non-membership (0.0), and the crossover point (0.5). The crossover point refers to a point of maximum ambiguity that a case is more in or out of a set (Rihoux & Ragin, 2009). Once the thresholds are decided, calibration is easy to perform with the fsQCA software.[3] In this case, for each NUTs region, one must assess whether it is a member of each of the causal conditions and the outcome, as well as to what degree.

For the calibration of the outcome variable, we created a fuzzy set measure of above-average regional performance, which we refer to as *high regional economic performance* (HREP). For full membership, we set the threshold at the 75th percentile, and for full non-membership, we set it at the 50th percentile of GVA per employment. The crossover point is determined by the average of these two thresholds. As highlighted above, we used eight REDI pillars for the analysis as casual conditions. The calibrated input variables are also

[3] http://www.socsci.uci.edu/~cragin/fsQCA/software.shtml

related to different thresholds of the three qualitative anchors. In this case, we use the 25th, 50th, and 75th percentile values for full non-membership, crossover point, and full membership, respectively. Due to the breakpoint values, we measured the membership in the set of European NUTs regions with "high regional performance", coding membership as fully out of the set if a region showed input values of the 25th percentile or below and fully in the set if a region showed input values of the 75th percentile or higher. The crossover point was at the 50th percentile. Table 2 contains both the non-calibrated and calibrated data. Appendix 2 (Tables 6 and 7) contains calibrated input and output variables.

4 Results

4.1 Necessary analysis

A causal condition is necessary if it is a superset of the outcome set. The QCA software calculates the *consistency for necessity* ($Cons_{nec}$) measure (Eq. 1), which is a numerical expression that measures how much proportion of the outcome set (Y) that is included in the condition set (X). The measure indicates how much a set relation deviates from a perfect superset relationship, expressed as a number from 0 to 1. A consistency score for necessity above 0.9 is "always necessary," above 0.8 is "almost always" necessary, while a score between 0.65 and 0.8 is "usually" necessary (Ide & Mello, 2022; Ragin, 2008).

$$Cons_{nec} = \frac{S\min(Xi, Yi)}{SYi} \tag{1}$$

$$Cov_{nec} = \frac{S\min(Xi, Yi)}{SXi} \tag{2}$$

X_i = causal condition of the ith region, Y_i = outcome variable the ith region.

Once we have identified the necessary conditions, we determine their empirical significance (trivialness). To do this, we calculate the *coverage for the necessity* (Cov_{nec}) measure, which also ranges from 0 to 1 (Eq. 2). Coverage can be interpreted as the proportion of causal condition (X) covered by its intersection with the outcome variable (Y). According to the literature, a coverage over 0.5 suggests empirical relevance for an outcome (Oana et al., 2021). Table 3 presents the results of the necessary analysis.

Table 3 shows EE components that are "always" (black), "almost always" (dark grey), and "usually" (light grey) necessary to achieve a high HREP. Looking at the 125 EU regions together, we find that Innovation, Opportunity startup, and Competition are "almost always" necessary for HREP. Technology adoption, Human capital, and Financing components are only "usually" necessary. However, no component is proven to be "always" necessary to achieve this above-average regional economic performance.

When analyzing the ecosystem components of each macro-region, it becomes evident that the Innovation component is essential for all of them, but to varying degrees. In the NWE macro-region, all entrepreneurial ability (ABT) pillars and Innovation are "usually" necessary. Overall, the necessary factors for the 125 EU regions are similar to those of the NWE macro-region. This is not surprising given that most regions in the NWE macro-region have above-average regional economic performance in the EU. In the ME, all factors are essential to varying degrees, but Innovation is "always" necessary, and Financing is "almost always" necessary. In the CEE region, Opportunity startup, Technology adoption, Human capital, and Financing are "usually" necessary, while Innovation and Globalization pillars are "almost always" necessary. The importance of Globalization (internationalization, global connectivity–accessibility) suggests that the presence of FDI is decisive in the performance of the CEE's regions.

When comparing the macro-regions, Innovation seems to be necessary in case of all macro-regions, but its degree varies. This is why the Innovation pillar appears "almost always" at the EU level. Furthermore, the coverage values suggest that even "almost always" necessary conditions are empirically relevant for this high outcome.

4.2 Sufficiency analysis

A causal condition is sufficient if it is a subset of the outcome set. The QCA software generates a truth table to identify sufficient conditions. The table lists all possible combinations of conditions and outcome variables. It also shows the distribution of regions across the causal combinations. For our eight conditions, there are 256 (2 to the power of 8) possible configurations.[4] The 125 NUTS regions are distributed with some degree of membership in all eight combinations in this 8-dimensional vector space. The truth table is presented in Appendix 3 (Table 8); it lists those regions with greater than 0.5 membership in the first column. Out of the 256 possible combinations, there are 41 good cases (regions with greater than 0.5 membership) and 215 counterfactual cases that are logically excluded for simplification purposes.

To proceed, we must set a frequency cutoff. For 125 cases, we have set it to one region. This means that a configuration with one or more regions is valid and selected, while others are removed. As a part of the sufficiency analysis, the consistency and coverage of sufficiency measures are calculated. In the truth table, the combinations are ranked according to their consistency scores, which evaluate the strength of causal relationships. The *consistency for sufficiency* ($\mathrm{Cons}_{\mathrm{suf}}$) refers to the proportion of the cases where both X and Y happen (the intersection between X and Y), out of all cases where X happen (Eq. 3). This percentage indicates how frequently the specific combination of conditions aligns with the outcome. It can range between 0 and 1, where a high consistency score indicates that the specific combination of conditions consistently leads to the outcome. The *coverage for sufficiency* ($\mathrm{Cov}_{\mathrm{suf}}$) also ranges from 0 to 1, indicating how much of the outcome is accounted for by the specific configuration (Eq. 4). Higher coverage values suggest that the configuration is more empirically relevant for explaining the outcome, as it covers a larger portion of cases where the outcome occurs (Oana et al., 2021).

$$Cons_{suf} = \frac{S\min(Xi, Yi)}{SXi} \tag{3}$$

$$Cov_{suf} = \frac{S\min(Xi, Yi)}{SYi} \tag{4}$$

X_i = causal condition of the ith region, Y_i = outcome variable the ith region.

When analyzing truth tables, the next step is to choose a consistency cutoff. Rihoux and Ragin (2009) suggest selecting a threshold as close to 1 as possible and avoiding using a threshold below 0.75. A consistency cutoff of 0.8 is commonly used (Schneider &

[4] However, the fact that a configuration may logically exist does not imply that they can be observed in reality. The problem of limited diversity is that it may not be possible to observe all the theoretically possible configurations in reality, even with a large sample size (Fiss, 2011).

Wagemann, 2012). This means that the presence of the outcome in each configuration is checked for each region. If the presence of the outcome is consistent across at least 80% of the regions, then that configuration is treated as a sufficient condition for the outcome.

The logical minimization process results in one or more solutions that meet the outcomes. The QCA software creates three different solutions based on logical remainders. We present the intermediate solution as it is the most interpretable. Woodside (2013) suggests an informative solution has an overall consistency score exceeds 0.74 and overall coverage is between 0.25 and 0.65.

The format for visualization used in sufficiency analysis results includes black circles (●) for present conditions and a circle with a cross (⊗) for absent ones. Large circles indicate core conditions and small circles indicate peripheral ones. A condition is considered a core condition if it is also part of the parsimonious solutions, while a peripheral condition is only included in the intermediate solutions. Blank spaces represent a "do not care" solution, in which the causal condition can be either present or absent sufficiently to lead to a particular outcome (Fiss, 2011).

Table 4 contains all sufficient configurations that have a higher consistency score than 0.74 and that are also empirically relevant (coverage score is higher than 0.25), except in the case of NWE macro-region (0.18). We observe that Innovation, Human capital, and Competition are all essential causal conditions in creating sufficient configurations for the EU 125 regions or any of its macro-regions. Looking at each sufficient configuration separately, the following conclusions can be drawn.

Looking at 125 regions covering the EU, the sufficiency analysis yields three sufficient configurations (C1, C2, and C3). For configurations C1 and C2, high regional performance is achieved through a *balanced* EE in the regions observed. The EE conditions are either present or their presence/absence is irrelevant ("don't care") for the outcome. Overall, there is minimal difference between the two configurations. Several regions in Denmark (DK01, DK04, DK05), the Netherlands (NL3, NL4), the UK (UKJ, UKI), Germany (DE3, DE6, DE7), France (FR1, FR5), Ireland (IE02), Austria (AT1), and Sweden (SE11) achieve high regional performance due to these two balanced configurations. To differentiate between the two: C1 has a surplus of entrepreneurial abilities (ATT), while C2 has a surplus of entrepreneurial aspirations (ASP). However, for the C3 configuration, the High growth, Opportunity startup, and Technology adoption variables are missing. This configuration is described by the French (FR8) region alone. The configuration demonstrates that high regional performance is feasible for regions that are deficient in certain factors, i.e. high performance does not require "all-round" ecosystems.

If we look at groups of regions that are homogeneous in some respects, we see that the configurations defined by the sufficiency analysis differ significantly. For the NWE macro-region, we obtain two sufficiency configurations (C4 and C5). In the case of NWE, High Growth is absent in both configurations, while Financing is missing in C5 and Globalization in C4. Of the NWE macro-regions, only one Swedish (SE22) and one Danish (DK01) region were able to achieve high regional performance with these configurations. This is a very interesting result in the light of the fact that when comparing Europe with the US—especially with the Silicon Valley ecosystem—it is usually pointed out that Europe is not able to achieve high economic performance because it lacks fast-growing startups (gazelles, unicorns), venture capitalists, or multinational corporations. However, these two European regional EEs suggest that this claim is generally not valid, as the weak High growth, Globalization, and Financing component are compensated for by other components, thereby still achieving above average economic performance.

In contrast, in the case of ME, we see two configurations with high regional performance that are perfectly balanced (C5 and C6): most of the factors are present in the configurations or belong to the “do not care” category, i.e., their presence or absence do not affect the outcome. These configurations cover French (FR1, FR3, FR4, FR5, FR8) and Spanish (ES30) regions.

For the CEE macro-region, we also obtain two sufficient configurations (C7 and C8). The C8 configuration is fully balanced (i.e., all EE variables are either present or “do not care”), such as the Czechia (CZ01), while the Slovak region (SI02) is a good example of an unbalanced high-performing configuration, where High growth and Financing did not contribute to high regional performance.

Based on the results of QCA analysis, we reject hypothesis H1. Balanced EE is not the only way to achieve high regional economic performance. Unbalanced EE can deliver equally high performance by compensating for shortcomings in some EE elements with other factors. Additionally, hypothesis H2 is accepted, as other factors are necessary for each macro-region. Figure 1 illustrates that regions with a balanced (red) and unbalanced (blue) entrepreneurial ecosystem resulted in a high regional economic performance. The map shows that capital regions in Europe’s leading economies typically have a balanced ecosystem (SE11—Stockholm, DK01—Copenhagen, DE30—Berlin, NL3—Amsterdam, UKI—London, IE02—Dublin, AT1—Vienna, FR1—Paris, ES30—Madrid).

5 Discussion, conclusions, limitations

The economic performance of a region and the extent to which entrepreneurship thrives therein are largely determined by the entrepreneurial ecosystem (EE) of the region. Previous EE conceptual models, including the REDI method, assumed that all components are equally important and weak components (bottlenecks) hinder the efficiency of EE; consequently, only regions with balanced and bottlenecks-free EE can succeed. However, this assumption is based on a simplistic understanding of the relationship between different EE factors. To analyze EE through the lens of complexity theory and recognize it as a complex system, we should accept that interactions among its elements can be diverse. For example, a good-performing component may pull up other factors, or some only have an indirect effect if other factors are present. To understand the intricate interplay among the components of EE, our study employed fuzzy QCA. It is a novel method in EE research that acknowledges that complex phenomena arise from the interaction of multiple causal factors and cannot be fully explained by measuring the isolated effects of each cause.

Based on the QCA *necessary analysis*, we find that achieving high regional economic performance does not “always” (even “almost always”) require every component of an EE. In EU regions, a supportive ecosystem that fosters *competition, innovation, and opportunity-driven entrepreneurship* is crucial for high economic outcome. However, for macro-regions, the necessary EE components that contribute to high performance can vary. For instance, besides the presence of innovative attitudes, the ME region “always” required high-level financing opportunities, while the CEE region “almost always” depended on globalization. In the NWE regions, a diverse range of entrepreneurial skills, innovative attitudes, and supportive institutions all played an almost equally important role in achieving high economic performance. While in their case no single factor was “always” necessary, most elements were only “usually” vital.

By analyzing the various configurations of EE factors that contribute to regional economic performance, *sufficiency analysis* provides us with valuable insights. Whether we examine the EU 125 regions or the three macro-regions, we observe that *balanced and* *unbalanced ecosystems can both lead to high regional economic performance*. Although all the factors in the conceptual model are present in regions with balanced EE, their importance varies across regions (core, periphery, or "do not care"). The findings of the sufficiency analysis of the three macro-regions show that the configurations obtained for the EU are a combination of macro-regional configurations. Therefore, combining data at the EU level obscures significant differences. It is important to emphasize that, in QCA, the absence of a component should not be interpreted as an indication that this factor is not an EE element at all. Instead, when assessing the relative importance and contribution of each factor, the absence indicates that the importance of a given element is insignificant *when considered with the others* at a given level of the outcome.

Our findings have relevant implications for scholars and policymakers. Wurth et al. (2022) highlighted the importance of examining EEs through a complex systems perspective, which recognizes the interdependencies and feedback mechanisms among various EE elements and emphasize the need for a comprehensive understanding of how these interactions produce high-performance outcomes. Furthermore, Wurth et al. (2023) emphasize that the measurement of ecosystem outcomes should be tailored to the specific configuration and context of each ecosystem. Building on these insights, our study contributes to addressing the undertheorized nature of EEs by employing fuzzy-set qualitative comparative analysis (fs/QCA) to explore the causal mechanisms within EEs. Using the QCA method to investigate EEs, some studies find that having multiple, but typically unbalanced, configurations of EE lead to a high level of productive entrepreneurship (EE output) (Alves et al., 2021; Ferreira & Dionísio, 2019; Zhao et al., 2023). Schrijvers et al. (2023) showed that EU regions with balanced configurations are more likely to have high entrepreneurial output; although their results confirm that unbalanced configurations are still possible. Our findings support both approaches, demonstrating that balanced and unbalanced ecosystems can both lead to high performance, but the configurations of necessary elements differ based on regional contexts. For instance, high-level financing opportunities are crucial in the ME region, whereas the CEE region often depends on globalization.

The study reveals that there can be various entrepreneurial ecosystems that can exist and still result in high regional economic performance. This challenges the notion that all elements of an entrepreneurial ecosystem must be at a high level to achieve such performance. Our study recognizes the complexity of entrepreneurial ecosystems (EEs), echoing the insights of Theodoraki and Messeghem (2017), who advocate for the perception of EEs as comprising multiple sub-ecosystems. The concept of sub-ecosystems emphasizes that within a larger EE, there can be specialized niches or clusters, each with distinct characteristics and requirements. For instance, a sub-ecosystem focused on digital entrepreneurship might prioritize different elements of the EE. The study of Torres and Godinho (2022) also challenges the traditional EE models, which assume that all components are equally important and that weak components hinder overall performance. Using both necessary condition analysis (NCA) and fuzzy QCA, they highlight that while all Digital Entrepreneurial Ecosystem (DEE) elements are necessary for digitally enabled unicorns, but their level of necessity varies, indicating that not all elements need to be at their highest levels simultaneously to achieve high performance.

Our findings imply that policymakers should adopt a flexible approach to development and recognize that both balanced and unbalanced entrepreneurial ecosystems can lead to high regional economic performance. While our study highlights the possibility of high regional economic performance, even in the absence of certain elements of an entrepreneurial ecosystem, it emphasizes that highly performing ecosystems generally exhibit robust development across all elements. Uniqueness can make up for shortcomings, but only if they are recognized. To enhance regional economic performance, our research emphasizes that policymakers should design and implement tailored policies that align with the specific needs of each region. Policymakers should also avoid relying solely on aggregated EU-level data since our research indicates significant differences in configurations at macro-regional levels. Recognizing the diversity among macro-regions is crucial for crafting effective policies that consider the specific needs and nuances of each region.

This study also has certain limitations. First, the geographical scope is limited to 125 European regions. Secondly, the utilization of the fsQCA method within this study is restricted to only analyzing eight pillars. Consequently, there may be instances of unobserved heterogeneity that could hold significant influence due to variables that were not taken into consideration. Moreover, calibration is a critical step in QCA, which involves deciding whether to include cases in the set for each variable. To ensure accuracy, we conducted two additional QCA analyses using different thresholds for the outcome variable: 1) a strict version for "outstanding", and 2) a less strict version for "high" regional economic outcome. The results of these robustness checks are presented in *Online resource 1*. We discover that, on the one hand, achieving outstandingly high performance is much more challenging, with most EE components always necessary. However, on the other hand, results for less demanding thresholds are almost identical to those presented in Sect. 4. This suggests that the set of necessary factors and sufficient configurations that determine high (above-average) regional performance, as characterized by these thresholds, is quite robust.

Table 5 List of the 125 EU NUTS1, NUTS2 regions

NUTS code	Name of the NUTS region	NUTS code	Name of the NUTS region
EL1	Voreia Ellada	UKK	South West (UK)
EL2	Kentriki Ellada	UKL	Wales
EL3	Attiki	UKM	Scotland
EL4	Nisia Aigaiou, Kriti	UKN	Northern Ireland (UK)
NL1	Noord-Nederland	DK01	Hovedstaden
NL2	Oost-Nederland	DK02	Sjælland
NL3	West-Nederland	DK03	Syddanmark
NL4	Zuid-Nederland	DK04	Midtjylland
BE1	Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest	DK05	Nordjylland
BE2	Vlaams Gewest	SE11	Stockholm
BE3	Région wallonne	SE12	Östra Mellansverige
FR1	Île de France	SE21	Småland med öarna
FR2	Bassin Parisien	SE22	Sydsverige
FR3	Nord—Pas-de-Calais	SE23	Västsverige
FR4	Est (FR)	SE31	Norra Mellansverige
FR5	Ouest (FR)	SE32	Mellersta Norrland
FR6	Sud-Ouest (FR)	SE33	Övre Norrland
FR7	Centre-Est (FR)	PL1	Region Centralny
FR8	Méditerranée	PL2	Region Poludniowy
ES11	Galicia	PL3	Region Wschodni
ES12	Principado de Asturias	PL4	Region Pólnocno-Zachodni
ES13	Cantabria	PL5	Region Poludniowo-Zachodni
ES21	País Vasco	PL6	Region Pólnocny
ES22	Comunidad Foral de Navarra	DE1	Baden-Württemberg
ES23	La Rioja	DE2	Bayern
ES24	Aragón	DE3	Berlin
ES30	Comunidad de Madrid	DE4	Brandenburg
ES41	Castilla y León	DE5	Bremen
ES42	Castilla-la Mancha	DE6	Hamburg
ES43	Extremadura	DE7	Hessen
ES51	Cataluña	DE8	Mecklenburg-Vorpommern
ES52	Comunidad Valenciana	DE9	Niedersachsen
ES53	Illes Balears	DEA	Nordrhein-Westfalen
ES61	Andalucía	DEB	Rheinland-Pfalz
ES62	Región de Murcia	DEC	Saarland
ES70	Canarias (ES)	DED	Sachsen
HU10	Közép-Magyarország	DEE	Sachsen-Anhalt
HU21	Közép-Dunántúl	DEF	Schleswig–Holstein
HU22	Nyugat-Dunántúl	DEG	Thüringen
HU23	Dél-Dunántúl	PT11	Norte
HU31	Észak-Magyarország	PT15	Algarve
HU32	Észak-Alföld	PT16	Centro (PT)
HU33	Dél-Alföld	PT17	Lisboa

Table 5 (continued)

NUTS code	Name of the NUTS region	NUTS code	Name of the NUTS region
ITC	Nord-Ovest	PT18	Alentejo
ITF	Sud	IE01	Border, Midland and Western
ITG	Isole	IE02	Southern and Eastern
ITH	Nord-Est	FI19	Länsi-Suomi
ITI	Centro (IT)	FI1B	Helsinki-Uusimaa
RO1	Macroregiunea unu	FI1C	Etelä-Suomi
RO2	Macroregiunea doi	FI1D	Pohjois- ja Itä-Suomi
RO3	Macroregiunea trei	LT	Lithuania
RO4	Macroregiunea patru	LV	Latvia
AT1	Ostösterreich	EE	Estonia
AT2	Südösterreich	HR03	Jadranska Hrvatska (Adriatic Croatia)
AT3	Westösterreich	HR04	Kontinentalna Hrvatska (Continental Croatia)
UKC	North East (UK)	SI01	Vzhodna Slovenija
UKD	North West (UK)	SI02	Zahodna Slovenija
UKE	Yorkshire and The Humber	CZ0	Czech Republic
UKF	East Midlands (UK)	SK01	Bratislavský kraj
UKG	West Midlands (UK)	SK02	Západné Slovensko
UKH	East of England	SK03	Stredné Slovensko
UKI	London	SK04	Východné Slovensko
UKJ	South East (UK)		

Appendix 1

See Table 5.

Table 6 Original values

Regional code	Opportunity startup	Technology adoption	Human capital	Competition	Innovation	High growth	Globalization	Financing	GVA per workers
AT1	0.52	0.11	0.17	0.31	0.19	0.05	0.49	0.07	67.66
AT2	0.5	0.09	0.12	0.25	0.19	0.05	0.41	0.02	58.6
AT3	0.54	0.06	0.12	0.26	0.18	0.03	0.45	0.07	65.54
BE1	0.38	0.05	0.34	0.29	0.35	0.14	0.45	0.05	93.45
BE2	0.36	0.08	0.23	0.14	0.18	0.05	0.55	0.1	77.61
BE3	0.35	0.05	0.2	0.2	0.17	0.07	0.55	0.11	67.46
CZ	0.26	0.06	0.11	0.13	0.12	0.1	0.55	0.06	28.05
DE1	0.54	0.13	0.13	0.2	0.28	0.11	0.58	0.14	64.17
DE2	0.53	0.1	0.1	0.21	0.27	0.13	0.51	0.11	64.63
DE3	0.44	0.19	0.18	0.24	0.18	0.11	0.49	0.08	57.42
DE4	0.31	0	0.13	0.28	0.08	0.06	0.49	0.14	50.72
DE5	0.5	0.09	0.11	0.18	0.32	0.16	0.25	0.1	63.38
DE6	0.54	0.13	0.15	0.26	0.2	0.16	0.57	0.15	77.41
DE7	0.47	0.11	0.15	0.23	0.15	0.09	0.49	0.22	67.33
DE8	0.41	0.05	0.13	0.26	0.07	0.04	0.38	0.01	46.28
DE9	0.53	0.02	0.1	0.21	0.13	0.09	0.41	0.13	56.98
DEA	0.46	0.07	0.12	0.23	0.15	0.11	0.48	0.12	60.83
DEB	0.53	0.12	0.09	0.16	0.07	0.12	0.5	0.07	57.78
DEC	0.55	0.12	0.11	0.13	0.14	0.13	0.6	0.19	56.28
DED	0.41	0.11	0.13	0.25	0.1	0.09	0.37	0.15	46.82
DEE	0.49	0.05	0.11	0.23	0.07	0.03	0.39	0.13	48.81
DEF	0.51	0.09	0.11	0.27	0.09	0.06	0.4	0.18	55.08
DEG	0.42	0.07	0.05	0.14	0.09	0.09	0.45	0.04	46.13
DK01	0.86	0.24	0.72	0.33	0.38	0.07	0.33	0.28	88.5

Table 6 (continued)

Regional code	Opportunity startup	Technology adoption	Human capital	Competition	Innovation	High growth	Globalization	Financing	GVA per workers
DK02	0.83	0.1	0.48	0.29	0.09	0.06	0.12	0.06	70.28
DK03	0.86	0.07	0.42	0.29	0.18	0.07	0.21	0.15	76.97
DK04	0.81	0.11	0.53	0.27	0.26	0.09	0.13	0.35	72.62
DK05	0.88	0.16	0.39	0.2	0.13	0.05	0.18	0.23	71.5
EE	0.39	0.06	0.16	0.15	0.11	0.1	0.24	0.02	27.48
EL1	0.18	0.02	0.1	0.07	0.1	0.02	0.19	0.04	33.58
EL2	0.15	0.01	0.08	0.07	0.08	0.01	0.21	0.03	32.92
EL3	0.17	0.06	0.15	0.13	0.12	0.03	0.29	0.03	51.01
EL4	0.21	0.01	0.09	0.06	0.12	0	0.22	0.05	34.28
ES11	0.24	0.04	0.1	0.08	0.07	0.03	0.11	0.06	47.92
ES12	0.38	0.06	0.12	0.1	0.08	0.01	0.07	0.03	49.79
ES13	0.37	0.04	0.1	0.11	0.08	0.03	0.12	0.08	50.61
ES21	0.39	0.11	0.19	0.11	0.13	0.03	0.12	0.07	59.07
ES22	0.38	0.05	0.16	0.09	0.18	0.02	0.12	0.05	56.91
ES23	0.37	0.02	0.09	0.06	0.06	0.02	0.13	0.03	54.15
ES24	0.33	0.05	0.12	0.1	0.08	0.02	0.11	0.05	53.5
ES30	0.4	0.17	0.25	0.14	0.16	0.07	0.23	0.1	57.81
ES41	0.38	0.04	0.13	0.1	0.06	0.03	0.18	0.08	50.64
ES42	0.24	0.03	0.07	0.08	0.03	0.02	0.11	0.04	49.53
ES43	0.35	0.02	0.08	0.08	0.05	0.02	0.08	0.03	45.31
ES51	0.31	0.07	0.13	0.13	0.14	0.04	0.19	0.06	55.11
ES52	0.29	0.05	0.13	0.12	0.08	0.03	0.16	0.04	50.09
ES53	0.35	0.04	0.07	0.12	0.05	0.02	0.2	0.08	50.95
ES61	0.3	0.03	0.1	0.11	0.07	0.05	0.16	0.04	47.39
ES62	0.32	0.03	0.09	0.08	0.06	0.03	0.11	0.06	44.65

Table 6 (continued)

Regional code	Opportunity startup	Technology adoption	Human capital	Competition	Innovation	High growth	Globalization	Financing	GVA per workers
ES70	0.28	0.03	0.08	0.11	0.04	0.02	0.14	0.03	49.19
FI19	0.63	0.05	0.13	0.16	0.16	0.06	0.21	0.03	64.78
FI1B	0.74	0.22	0.26	0.2	0.37	0.13	0.35	0.04	78.79
FI1C	0.65	0.09	0.08	0.17	0.19	0.06	0.3	0.02	65.79
FI1D	0.63	0.04	0.08	0.13	0.18	0.08	0.11	0.02	63.31
FR1	0.45	0.12	0.25	0.27	0.29	0.18	0.56	0.15	93
FR2	0.45	0.03	0.11	0.19	0.1	0.07	0.29	0.09	62.2
FR3	0.42	0.02	0.15	0.22	0.13	0.07	0.47	0.07	62.01
FR4	0.41	0.03	0.12	0.16	0.16	0.09	0.46	0.08	62.63
FR5	0.43	0.01	0.16	0.23	0.14	0.08	0.35	0.07	60.66
FR6	0.4	0.03	0.15	0.15	0.13	0.07	0.07	0.1	62.02
FR7	0.47	0.08	0.26	0.24	0.3	0.12	0.47	0.05	65.89
FR8	0.37	0.04	0.17	0.25	0.16	0.02	0.38	0.09	64.12
HR03	0.11	0.02	0.05	0.14	0.07	0.07	0.28	0.06	24.14
HR04	0.14	0.03	0.05	0.18	0.08	0.09	0.31	0.06	23.58
HU10	0.19	0.08	0.18	0.15	0.1	0.09	0.43	0.03	24.17
HU21	0.23	0.04	0.07	0.11	0.02	0.05	0.33	0.01	20.03
HU22	0.27	0.03	0.08	0.12	0.02	0.05	0.49	0.01	21.14
HU23	0.18	0.03	0.07	0.15	0.04	0.09	0.25	0	18.34
HU31	0.21	0.04	0.08	0.09	0.02	0.09	0.3	0.01	18.08
HU32	0.16	0.02	0.07	0.09	0.04	0.07	0.26	0.01	18.28
HU33	0.2	0.03	0.06	0.1	0.04	0.04	0.32	0.01	18.07
IE01	0.56	0.07	0.3	0.22	0.1	0.1	0.35	0.05	61.46
IE02	0.54	0.11	0.35	0.29	0.17	0.12	0.36	0.12	96.34
ITC	0.22	0.09	0.04	0.09	0.19	0.02	0.3	0.07	65.55

Table 6 (continued)

Regional code	Opportunity startup	Technology adoption	Human capital	Competition	Innovation	High growth	Globalization	Financing	GVA per workers
ITF	0.07	0.03	0.02	0.11	0.09	0.03	0.23	0.04	49.09
ITG	0.08	0.01	0.03	0.14	0.08	0.02	0.3	0.1	50.43
ITH	0.35	0.04	0.02	0.11	0.17	0.06	0.32	0.01	61.92
ITI	0.18	0.06	0.05	0.13	0.2	0.02	0.31	0.05	60.21
LT	0.26	0.03	0.23	0.11	0.07	0.12	0.28	0.04	24.43
LV	0.25	0.03	0.14	0.18	0.04	0.15	0.32	0.05	22.94
NL1	0.7	0.06	0.13	0.22	0.12	0.05	0.34	0.11	70.13
NL2	0.68	0.05	0.15	0.23	0.14	0.03	0.39	0.08	56.95
NL3	0.67	0.11	0.22	0.26	0.19	0.08	0.38	0.09	71.83
NL4	0.68	0.06	0.19	0.24	0.25	0.05	0.42	0.11	63.3
PL1	0.17	0.05	0.17	0.08	0.09	0.11	0.47	0.08	26.69
PL2	0.2	0.03	0.13	0.06	0.07	0.09	0.44	0.08	22.51
PL3	0.18	0.01	0.09	0.04	0.05	0.09	0.31	0.03	15.92
PL4	0.2	0.02	0.09	0.04	0.05	0.08	0.35	0.09	23.92
PL5	0.21	0.03	0.1	0.05	0.07	0.08	0.41	0.03	26.68
PL6	0.2	0.01	0.1	0.05	0.05	0.08	0.34	0.03	21
PT11	0.3	0.02	0.05	0.11	0.11	0.05	0.38	0.02	28.12
PT15	0.43	0.03	0.05	0.13	0.05	0.06	0.35	0.03	34.44
PT16	0.33	0.02	0.06	0.1	0.1	0.07	0.34	0.03	28.49
PT17	0.32	0.08	0.1	0.16	0.16	0.07	0.37	0.09	42.21
PT18	0.49	0.01	0.05	0.13	0.07	0.08	0.37	0.03	34.19
RO1	0.11	0.02	0.06	0.09	0.03	0.16	0.27	0.04	13.72
RO2	0.04	0	0.05	0.09	0.02	0.14	0.24	0.06	10.88
RO3	0.04	0.04	0.11	0.09	0.07	0.17	0.38	0.06	20.4
RO4	0.07	0.01	0.06	0.07	0.03	0.14	0.25	0.02	12.73

Table 6 (continued)

Regional code	Opportunity startup	Technology adoption	Human capital	Competition	Innovation	High growth	Globalization	Financing	GVA per workers
SE11	0.69	0.28	0.31	0.32	0.37	0.12	0.45	0.07	98.49
SE12	0.72	0.11	0.22	0.3	0.26	0.08	0.39	0.06	76.73
SE21	0.67	0.05	0.1	0.19	0.08	0.05	0.2	0.02	69.46
SE22	0.63	0.16	0.25	0.3	0.31	0.07	0.48	0.05	73.86
SE23	0.72	0.12	0.21	0.3	0.24	0.08	0.34	0.02	77.77
SE31	0.6	0.09	0.16	0.2	0.1	0.02	0.28	0.01	73.81
SE32	0.78	0.1	0.14	0.26	0.06	0	0.21	0.03	75.24
SE33	0.59	0.09	0.2	0.31	0.27	0.09	0.19	0.02	78.42
SI01	0.37	0.05	0.12	0.22	0.08	0.08	0.42	0.04	31.35
SI02	0.29	0.12	0.15	0.24	0.22	0.07	0.43	0.03	36.52
SK01	0.2	0.17	0.18	0.08	0.26	0.11	0.6	0.13	44.05
SK02	0.23	0.03	0.06	0.05	0.04	0.1	0.49	0.06	29.24
SK03	0.19	0.03	0.05	0.06	0.05	0.11	0.37	0.06	25.88
SK04	0.15	0.02	0.04	0.07	0.07	0.11	0.34	0.04	26.32
UKC	0.59	0.04	0.29	0.22	0.11	0.05	0.34	0	53.74
UKD	0.57	0.05	0.25	0.16	0.1	0.08	0.22	0.03	56.52
UKE	0.62	0.04	0.31	0.23	0.1	0.1	0.31	0.01	52.52
UKF	0.5	0.05	0.25	0.23	0.16	0.05	0.35	0.03	53.84
UKG	0.59	0.04	0.25	0.23	0.09	0.08	0.35	0.02	54.21
UKH	0.6	0.1	0.3	0.27	0.21	0.11	0.37	0.01	59.32
UKI	0.62	0.11	0.42	0.3	0.14	0.15	0.49	0.08	87.95
UKJ	0.6	0.11	0.35	0.26	0.17	0.1	0.36	0.11	66.86
UKK	0.56	0.1	0.26	0.25	0.11	0.09	0.37	0.07	55.26
UKL	0.46	0.03	0.24	0.21	0.08	0.05	0.3	0.06	50.86
UKM	0.53	0.05	0.34	0.25	0.14	0.09	0.32	0.06	60.65

Table 6 (continued)

Regional code	Opportunity startup	Technology adoption	Human capital	Competition	Innovation	High growth	Globalization	Financing	GVA per workers
UKN	0.62	0.05	0.19	0.22	0.11	0.09	0.28	0.05	53.94
full member	0.55	0.09	0.2	0.24	0.17	0.1	0.42	0.09	64.63
crossover	0.4	0.05	0.13	0.16	0.11	0.07	0.34	0.06	54.15
full non-member	0.24	0.03	0.09	0.11	0.07	0.05	0.23	0.03	34.19
min	0.04	0	0.02	0.04	0.02	0	0.07	0	10.88
max	0.88	0.28	0.72	0.33	0.38	0.18	0.6	0.35	98.49

Table 7 Calibrated fuzzy-set values

Regional code	fs/ Opportunity startup	fs/ Technology adoption	fs/ Human capital	fs/ Competition	fs/ Innovation	fs/ High growth	fs/ Globalization	fs/ Financing	VHREP_very strict (version 1)	VHREP_less strict (version 2)	**HREP**
AT1	0.92	0.99	0.85	1.00	0.98	0.05	1.00	0.73	0.15	0.97	0.99
AT2	0.88	0.95	0.32	0.97	0.98	0.05	0.93	0.02	0.00	0.29	0.39
AT3	0.94	0.68	0.32	0.98	0.97	0.00	0.98	0.73	0.07	0.91	0.97
BE1	0.41	0.50	1.00	0.99	1.00	1.00	0.98	0.27	1.00	1.00	1.00
BE2	0.32	0.90	0.99	0.23	0.97	0.05	1.00	0.98	0.93	1.00	1.00
BE3	0.28	0.50	0.95	0.82	0.95	0.50	1.00	0.99	0.14	0.96	0.99
CZ	0.07	0.68	0.18	0.14	0.62	0.95	1.00	0.50	0.00	0.00	0.00
DE1	0.94	1.00	0.50	0.82	1.00	0.98	1.00	1.00	0.04	0.84	0.94
DE2	0.93	0.98	0.10	0.87	1.00	1.00	1.00	0.99	0.05	0.87	0.95
DE3	0.69	1.00	0.89	0.95	0.97	0.98	1.00	0.88	0.00	0.19	0.24
DE4	0.16	0.00	0.50	0.99	0.10	0.18	1.00	1.00	0.00	0.01	0.01
DE5	0.88	0.95	0.18	0.68	1.00	1.00	0.08	0.98	0.03	0.79	0.91
DE6	0.94	1.00	0.70	0.98	0.99	1.00	1.00	1.00	0.92	1.00	1.00
DE7	0.80	0.99	0.70	0.93	0.88	0.88	1.00	1.00	0.14	0.96	0.99
DE8	0.55	0.50	0.50	0.98	0.05	0.01	0.82	0.01	0.00	0.00	0.00
DE9	0.93	0.01	0.10	0.87	0.73	0.88	0.93	1.00	0.00	0.16	0.20
DEA	0.77	0.82	0.32	0.93	0.88	0.98	0.99	1.00	0.01	0.53	0.70
DEB	0.93	0.99	0.05	0.50	0.05	0.99	1.00	0.73	0.00	0.21	0.28
DEC	0.95	0.99	0.18	0.14	0.82	1.00	1.00	1.00	0.00	0.12	0.14
DED	0.55	0.99	0.50	0.97	0.32	0.88	0.75	1.00	0.00	0.00	0.00
DEE	0.86	0.50	0.18	0.93	0.05	0.00	0.87	1.00	0.00	0.00	0.00
DEF	0.90	0.95	0.18	0.98	0.18	0.18	0.90	1.00	0.00	0.07	0.08
DEG	0.60	0.82	0.00	0.23	0.18	0.88	0.98	0.12	0.00	0.00	0.00
DK01	1.00	1.00	1.00	1.00	1.00	0.50	0.43	1.00	1.00	1.00	1.00

Table 7 (continued)

Regional code	fs/ Opportunity startup	fs/ Technology adoption	fs/ Human capital	fs/ Competition	fs/ Innovation	fs/ High growth	fs/ Globalization	fs/ Financing	VHREP_very strict (version 1)	VHREP_less strict (version 2)	**HREP**
DK02	1.00	0.98	1.00	0.99	0.18	0.18	0.00	0.50	0.36	0.99	1.00
DK03	1.00	0.82	1.00	0.99	0.97	0.50	0.03	1.00	0.91	1.00	1.00
DK04	1.00	0.99	1.00	0.98	1.00	0.88	0.00	1.00	0.60	1.00	1.00
DK05	1.00	1.00	1.00	0.82	0.73	0.05	0.01	1.00	0.48	0.99	1.00
EE	0.45	0.68	0.78	0.35	0.50	0.95	0.06	0.02	0.00	0.00	0.00
EL1	0.02	0.01	0.10	0.00	0.32	0.00	0.02	0.12	0.00	0.00	0.00
EL2	0.01	0.00	0.02	0.00	0.10	0.00	0.03	0.05	0.00	0.00	0.00
EL3	0.01	0.68	0.70	0.14	0.62	0.00	0.20	0.05	0.00	0.01	0.01
EL4	0.03	0.00	0.05	0.00	0.62	0.00	0.04	0.27	0.00	0.00	0.00
ES11	0.05	0.18	0.10	0.01	0.05	0.00	0.00	0.50	0.00	0.00	0.00
ES12	0.41	0.68	0.32	0.03	0.10	0.00	0.00	0.05	0.00	0.01	0.00
ES13	0.36	0.18	0.10	0.05	0.10	0.00	0.00	0.88	0.00	0.01	0.01
ES21	0.45	0.99	0.93	0.05	0.73	0.00	0.00	0.73	0.00	0.33	0.45
ES22	0.41	0.50	0.78	0.01	0.97	0.00	0.00	0.27	0.00	0.15	0.19
ES23	0.36	0.01	0.05	0.00	0.02	0.00	0.00	0.05	0.00	0.05	0.05
ES24	0.21	0.50	0.32	0.03	0.10	0.00	0.00	0.27	0.00	0.04	0.03
ES30	0.50	1.00	0.99	0.23	0.92	0.50	0.05	0.98	0.00	0.22	0.29
ES41	0.41	0.18	0.50	0.03	0.02	0.00	0.01	0.88	0.00	0.01	0.01
ES42	0.05	0.05	0.01	0.01	0.00	0.00	0.00	0.12	0.00	0.01	0.00
ES43	0.28	0.01	0.02	0.01	0.01	0.00	0.00	0.05	0.00	0.00	0.00
ES51	0.16	0.82	0.50	0.14	0.82	0.01	0.02	0.50	0.00	0.07	0.08
ES52	0.11	0.50	0.50	0.08	0.10	0.00	0.01	0.12	0.00	0.01	0.00
ES53	0.28	0.18	0.01	0.08	0.01	0.00	0.02	0.88	0.00	0.01	0.01
ES61	0.13	0.05	0.10	0.05	0.05	0.05	0.01	0.12	0.00	0.00	0.00

Table 7 (continued)

Regional code	fs/ Opportunity startup	fs/ Technology adoption	fs/ Human capital	fs/ Competition	fs/ Innovation	fs/ High growth	fs/ Globalization	fs/ Financing	VHREP_very strict (version 1)	VHREP_less strict (version 2)	**HREP**
ES62	0.18	0.05	0.05	0.01	0.02	0.00	0.00	0.50	0.00	0.00	0.00
ES70	0.10	0.05	0.02	0.05	0.01	0.00	0.00	0.05	0.00	0.00	0.00
FI19	0.99	0.50	0.50	0.50	0.92	0.18	0.03	0.05	0.05	0.88	0.96
FI1B	1.00	1.00	1.00	0.82	1.00	1.00	0.59	0.12	0.95	1.00	1.00
FI1C	0.99	0.95	0.02	0.59	0.98	0.18	0.25	0.02	0.08	0.92	0.98
FI1D	0.99	0.18	0.02	0.14	0.97	0.73	0.00	0.02	0.03	0.78	0.90
FR1	0.73	0.99	0.99	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00
FR2	0.73	0.05	0.18	0.75	0.32	0.50	0.20	0.95	0.02	0.68	0.83
FR3	0.60	0.01	0.70	0.90	0.73	0.50	0.99	0.73	0.02	0.66	0.82
FR4	0.55	0.05	0.32	0.50	0.92	0.88	0.99	0.88	0.02	0.73	0.86
FR5	0.65	0.00	0.78	0.93	0.82	0.73	0.59	0.73	0.01	0.51	0.67
FR6	0.50	0.05	0.70	0.35	0.73	0.50	0.00	0.98	0.02	0.67	0.82
FR7	0.80	0.90	1.00	0.95	1.00	0.99	0.99	0.27	0.08	0.92	0.98
FR8	0.36	0.18	0.85	0.97	0.92	0.00	0.82	0.95	0.04	0.84	0.94
HR03	0.00	0.01	0.00	0.23	0.05	0.50	0.16	0.50	0.00	0.00	0.00
HR04	0.01	0.05	0.00	0.68	0.10	0.88	0.31	0.50	0.00	0.00	0.00
HU10	0.02	0.90	0.89	0.35	0.32	0.88	0.97	0.05	0.00	0.00	0.00
HU21	0.04	0.18	0.01	0.05	0.00	0.05	0.43	0.01	0.00	0.00	0.00
HU22	0.08	0.05	0.02	0.08	0.00	0.05	1.00	0.01	0.00	0.00	0.00
HU23	0.02	0.05	0.01	0.35	0.01	0.88	0.08	0.00	0.00	0.00	0.00
HU31	0.03	0.18	0.02	0.01	0.00	0.88	0.25	0.01	0.00	0.00	0.00
HU32	0.01	0.01	0.01	0.01	0.01	0.50	0.10	0.01	0.00	0.00	0.00
HU33	0.02	0.05	0.01	0.03	0.01	0.01	0.37	0.01	0.00	0.00	0.00
IE01	0.96	0.82	1.00	0.90	0.32	0.95	0.59	0.27	0.01	0.60	0.77

Table 7 (continued)

Regional code	fs/ Opportunity startup	fs/ Technology adoption	fs/ Human capital	fs/ Competition	fs/ Innovation	fs/ High growth	fs/ Globalization	fs/ Financing	VHREP_very strict (version 1)	VHREP_less strict (version 2)	**HREP**
IE02	0.94	0.99	1.00	0.99	0.95	0.99	0.68	1.00	1.00	1.00	1.00
ITC	0.03	0.95	0.00	0.01	0.98	0.00	0.25	0.73	0.07	0.91	0.97
ITF	0.00	0.05	0.00	0.05	0.18	0.00	0.05	0.12	0.00	0.00	0.00
ITG	0.00	0.00	0.00	0.23	0.10	0.00	0.25	0.98	0.00	0.01	0.01
ITH	0.28	0.18	0.00	0.05	0.95	0.18	0.37	0.01	0.02	0.65	0.81
ITI	0.02	0.68	0.00	0.14	0.99	0.00	0.31	0.27	0.01	0.46	0.62
LT	0.07	0.05	0.99	0.05	0.05	0.99	0.16	0.12	0.00	0.00	0.00
LV	0.06	0.05	0.61	0.68	0.01	1.00	0.37	0.27	0.00	0.00	0.00
NL1	1.00	0.68	0.50	0.90	0.62	0.05	0.50	0.99	0.34	0.99	1.00
NL2	1.00	0.50	0.70	0.93	0.82	0.00	0.87	0.88	0.00	0.16	0.20
NL3	1.00	0.99	0.98	0.98	0.98	0.73	0.82	0.95	0.52	0.99	1.00
NL4	1.00	0.68	0.93	0.95	1.00	0.05	0.95	0.99	0.03	0.78	0.90
PL1	0.01	0.50	0.85	0.01	0.18	0.98	0.99	0.88	0.00	0.00	0.00
PL2	0.02	0.05	0.50	0.00	0.05	0.88	0.98	0.88	0.00	0.00	0.00
PL3	0.02	0.00	0.05	0.00	0.01	0.88	0.31	0.05	0.00	0.00	0.00
PL4	0.02	0.01	0.05	0.00	0.01	0.73	0.59	0.95	0.00	0.00	0.00
PL5	0.03	0.05	0.10	0.00	0.05	0.73	0.93	0.05	0.00	0.00	0.00
PL6	0.02	0.00	0.10	0.00	0.01	0.73	0.50	0.05	0.00	0.00	0.00
PT11	0.13	0.01	0.00	0.05	0.50	0.05	0.82	0.02	0.00	0.00	0.00
PT15	0.65	0.05	0.00	0.14	0.01	0.18	0.59	0.05	0.00	0.00	0.00
PT16	0.21	0.01	0.01	0.03	0.32	0.50	0.50	0.05	0.00	0.00	0.00
PT17	0.18	0.90	0.10	0.50	0.92	0.50	0.75	0.95	0.00	0.00	0.00
PT18	0.86	0.00	0.00	0.14	0.05	0.73	0.75	0.05	0.00	0.00	0.00
RO1	0.00	0.01	0.01	0.01	0.00	1.00	0.13	0.12	0.00	0.00	0.00
RO2	0.00	0.00	0.00	0.01	0.00	1.00	0.06	0.50	0.00	0.00	0.00

Table 7 (continued)

Regional code	fs/ Opportunity startup	fs/ Technology adoption	fs/ Human capital	fs/ Competition	fs/ Innovation	fs/ High growth	fs/ Globalization	fs/ Financing	VHREP_very strict (version 1)	VHREP_less strict (version 2)	**HREP**
RO3	0.00	0.18	0.18	0.01	0.05	1.00	0.82	0.50	0.00	0.00	0.00
RO4	0.00	0.00	0.01	0.00	0.00	1.00	0.08	0.02	0.00	0.00	0.00
SE11	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.73	1.00	1.00	1.00
SE12	1.00	0.99	0.98	0.99	1.00	0.73	0.87	0.50	0.90	1.00	1.00
SE21	1.00	0.50	0.10	0.75	0.10	0.05	0.02	0.02	0.28	0.98	1.00
SE22	0.99	1.00	0.99	0.99	1.00	0.50	0.99	0.27	0.72	1.00	1.00
SE23	1.00	0.99	0.97	0.99	1.00	0.73	0.50	0.02	0.93	1.00	1.00
SE31	0.98	0.95	0.78	0.82	0.32	0.00	0.16	0.01	0.71	1.00	1.00
SE32	1.00	0.98	0.61	0.98	0.02	0.00	0.03	0.05	0.82	1.00	1.00
SE33	0.98	0.95	0.95	1.00	1.00	0.88	0.02	0.02	0.95	1.00	1.00
SI01	0.36	0.50	0.32	0.90	0.10	0.73	0.95	0.12	0.00	0.00	0.00
SI02	0.11	0.99	0.70	0.95	1.00	0.50	0.97	0.05	0.00	0.00	0.00
SK01	0.02	1.00	0.89	0.01	1.00	0.98	1.00	1.00	0.00	0.00	0.00
SK02	0.04	0.05	0.01	0.00	0.01	0.95	1.00	0.50	0.00	0.00	0.00
SK03	0.02	0.05	0.00	0.00	0.01	0.98	0.75	0.50	0.00	0.00	0.00
SK04	0.01	0.01	0.00	0.00	0.05	0.98	0.50	0.12	0.00	0.00	0.00
UKC	0.98	0.18	1.00	0.90	0.50	0.05	0.50	0.00	0.00	0.04	0.04
UKD	0.97	0.50	0.99	0.50	0.32	0.73	0.04	0.05	0.00	0.13	0.16
UKE	0.99	0.18	1.00	0.93	0.32	0.95	0.31	0.01	0.00	0.02	0.02
UKF	0.88	0.50	0.99	0.93	0.92	0.05	0.59	0.05	0.00	0.04	0.04
UKG	0.98	0.18	0.99	0.93	0.18	0.73	0.59	0.02	0.00	0.05	0.05
UKH	0.98	0.98	1.00	0.98	0.99	0.98	0.75	0.01	0.01	0.36	0.49
UKI	0.99	0.99	1.00	0.99	0.82	1.00	1.00	0.88	1.00	1.00	1.00
UKJ	0.98	0.99	1.00	0.98	0.95	0.95	0.68	0.99	0.11	0.95	0.99

Table 7 (continued)

Regional code	fs/ Opportunity startup	fs/ Technology adoption	fs/ Human capital	fs/ Competition	fs/ Innovation	fs/ High growth	fs/ Globalization	fs/ Financing	VHREP_very strict (version 1)	VHREP_less strict (version 2)	**HREP**
UKK	0.96	0.98	1.00	0.97	0.50	0.88	0.75	0.73	0.00	0.08	0.09
UKL	0.77	0.05	0.99	0.87	0.10	0.05	0.25	0.50	0.00	0.01	0.01
UKM	0.93	0.50	1.00	0.97	0.82	0.88	0.37	0.50	0.01	0.51	0.67
UKN	0.99	0.50	0.93	0.90	0.50	0.88	0.16	0.27	0.00	0.04	0.04

Appendix 2

See Tables 6 and 7.

Table 8 Truth table

Best Instances	fs/Opportunity startup	fs/Technology adoption	fs/Human capital	fs/Competition	fs/Innovation	fs/High growth	fs/Globalization	fs/ Financing	Number of cases > 0.5 membership	Consistency as a subset of HREP
Berlin (DE3), Hamburg (DE6), Hessen (DE7), Île de France (FR1), Southern and Eastern Ireland (IE02), West-Nederland (NL3), Stockholm (SE11), London (UKI), Soth East, UK (UKJ)	1	1	1	1	1	1	1	1	9	**0.85**
Ouest, FR (FR5)	1	0	1	1	1	1	1	1	1	**0.84**
Nordjyland (DK05)	1	1	1	1	1	0	0	1	1	**0.83**
Ostösterreich (AT1), Zuid-Nederland (NL4)	1	1	1	1	1	0	1	1	2	**0.83**
Midtjylland (DK04)	1	1	1	1	1	1	0	1	1	**0.83**
Méditerranée, FR (FR8)	0	0	1	1	1	0	1	1	1	**0.80**
Helsinki-Uusimaa (FI1B), Centre-Est, FR (FR7), South West, UK (UKH)	1	1	1	1	1	1	1	0	3	**0.80**
Etelä-Suomi (FI1C)	1	1	0	1	1	0	0	0	1	0.78
Bayern (DE2), Nordrhein-Westfalen (DEA)	1	1	0	1	1	1	1	1	2	0.77
Westösterreich (AT3)	1	1	0	1	1	0	1	1	1	0.71
Övre Norrland (SE33)	1	1	1	1	1	1	0	0	1	0.70

Table 8 (continued)

Best Instances	fs/Opportunity startup	fs/Technology adoption	fs/Human capital	fs/Competition	fs/Innovation	fs/High growth	fs/Globalization	fs/ Financing	Number of cases > 0.5 membership	Consistency as a subset of HREP
Norra Mellansverige (SE31), Mellersta Norrland (SE32)	1	1	1	1	0	0	0	0	2	0.70
Vlaams Gewest (BE2)	0	1	1	0	1	0	1	1	1	0.68
Südösterreich (AT2)	1	1	0	1	1	0	1	0	1	0.67
Bremen (DE5)	1	1	0	1	1	1	0	1	1	0.63
Niedersachsen (DE9)	1	0	0	1	1	1	1	1	1	0.63
Pohjois- ja Ita-Suomi (FI1D)	1	0	0	0	1	1	0	0	1	0.62
Border Midland and Western, IE (IE01)	1	1	1	1	0	1	1	0	1	0.54
Nord-Ovest, IT (ITC)	0	1	0	0	1	0	0	1	1	0.51
Centro, IT (ITI)	0	1	0	0	1	0	0	0	1	0.49
Pais Vasco (ES21)	0	1	1	0	1	0	0	1	1	0.47
Saarland (DEC)	1	1	0	0	1	1	1	1	1	0.47
West Midlands, UK (UKG)	1	0	1	1	0	1	1	0	1	0.44
Schleswig–Holstein (DEF)	1	1	0	1	0	0	1	1	1	0.42
Bratislavsky kraj (SK01)	0	1	1	0	1	1	1	1	1	0.41
Nisia Aigaiou. Kriti (EL4), Nord-Est, IT (ITH)	0	0	0	0	1	0	0	0	2	0.34
Thüringen (DEG)	1	1	0	0	0	1	1	0	1	0.33
Attiki (EL3)	0	1	1	0	1	0	0	0	1	0.33
Yorkshire and The Humber (UKE)	1	0	1	1	0	1	0	0	1	0.33
Latvia (LV)	0	0	1	1	0	1	0	0	1	0.32
Algarve (PT15)	1	0	0	0	0	0	1	0	1	0.28
Közép-Magyarország (HU10)	0	1	1	0	0	1	1	0	1	0.24

Table 8 (continued)

Best Instances	fs/Opportunity startup	fs/Technology adoption	fs/Human capital	fs/Competition	fs/Innovation	fs/High growth	fs/Globalization	fs/ Financing	Number of cases > 0.5 membership	Consistency as a subset of HREP
Alentejo (PT18)	1	0	0	0	0	1	1	0	1	0.21
Lithuania (LT)	0	0	1	0	0	1	0	0	1	0.17
Cantabria (ES13), Illes Balears (ES53), Isole (ITG)	0	0	0	0	0	0	0	1	3	0.15
Principado de Asturias (ES12)	0	1	0	0	0	0	0	0	1	0.14
Region Pólnocno-Zachodni (PL4)	0	0	0	0	0	1	1	1	1	0.14
Nyugat-Dunántúl (HU22)	0	0	0	0	0	0	1	0	1	0.10
Region Poludniowo- Zachodni (PL5)	0	0	0	0	0	1	1	0	1	0.06
Voreia Ellada (EL1), Kentriki Ellada (EL2), La Rioja (ES23), Castilla-la Mancha (ES42), Extremadura (ES43), Andalucia (ES61), Canarias, ES (ES70), Közép-Dunántúl (HU21), Dél-Alföld (HU33), Sud, IT (ITF)	0	0	0	0	0	0	0	0	10	0.04
Dél-Dunántúl (HU23), Észak-Magyarország (HU31), Region Wschodni (PL3), Macroregiunea unu (RO1), Macroregiunea patru (RO4)	0	0	0	0	0	1	0	0	5	0.03

Appendix 3

See Table 8.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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