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FULL ARTICLE

# Optimizing entrepreneurial development processes for smart specialization in the European Union

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## Abstract

This paper demonstrates how the Regional Entrepreneurship and Development Index (REDI) can be used to optimize local entrepreneurial discovery processes, in a manner which can support smart specialization strategies (S3). While S3 industry prioritization is based on the identification of local strengths, regional improvement can be achieved by improving the weakest features of the local entrepreneurial ecosystem. REDI based suggestions are place-based and offer rationale for tailor-made regional policy interventions. We found that without optimizing the entrepreneurial ecosystem, the industry specialization alone may not be successful because of the inability of the ecosystem to nurture high growth ventures.

**KEYWORDS**
entrepreneurship, entrepreneurship policy, European Union, regional development

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## 1 | INTRODUCTION

Over the last decade, the research and innovation strategies for smart specialization (S3 for short) agenda has emerged in the EU arena as a policy-prioritization framework which seeks to position R&D and innovation-related policies so that they are consistent with the capabilities, strengths and potential of each region.[1] Starting from 2014 European Union member states and regions had to create their own S3 plans and these were to be implementation during the 2014–2020 programming period (Capello & Kroll, 2016; McCann & Ortega-Argilés, 2014). S3 can be considered as part of the regional (place-based) growth policy framework (OECD, 2013; Pugh, 2014), an innovative policy concept (Foray & Goenaga, 2013), or as one might say "the most ambitious innovation programme" of the EU so far (Morgan, 2017, p. 569).

The theoretical principles of smart specialization strategies along with its implementation logic within EU Cohesion Policy are all based on the understanding that knowledge-driven growth is a systemic phenomenon in which there are different drivers and inhibitors at the regional level. These drivers and inhibitors include skills and abilities, market conditions, institutional and governance issues, entrepreneurial aspirations and business culture, and agglomeration factors, among many others (Foray, 2015; McCann & Ortega-Argilés, 2014, 2015). For EU Cohesion Policy policy-making purposes EU regions are expected to assess and evaluate the key features of their economies and to identify areas of growth potential which have both novelty and scale (European Commission, 2014a, 2014b). Critically, the selected policy actions should facilitate entrepreneurial search processes, but the nature and characteristics of these processes are likely to differ significantly among places. Entrepreneurial search processes in different places are likely to be characterized not only by different sets of drivers and inhibitors but by different combinations and arrangements of these different drivers and inhibitors (Gianelle, Guzzo, & Mieszkowski, 2019; Iacobucci, 2014; Kroll, 2015; Magro & Wilson, 2019).

The early-stage experience of the S3 implementation across many EU regions suggests that the benefits of S3 tend to be multi-dimensional rather than purely technological and research, also involving institutional and governance dimensions. There is now a growing body of analysis and evidence which helps to identify both the benefits and also the challenges to be faced in adopting and implementing an S3 approach to policy prioritization (Gianelle et al., 2019; Aranguren, Magro, Navarro, & Wilson, 2019; Kroll, 2017; 2019b, Varga, Sebestyén, Szabó, & Szerb, 2020). The more recently-emerging understanding is much broader and richer than earlier understandings of innovation and entrepreneurship policy, which tended to focus purely on narrow scientific R&D and firm-creation related aspects, whereas today they are more inclusive as they tend to focus on local and societal aspects, involve public and private sector actors, and engage society via participatory actions (Foray, 2019; Kroll, 2015; McCann & Ortega-Argilés, 2014, 2016a).

McCann and Ortega-Argilés (2016b) show that the approach to S3 priorities and implementation has varied across the EU regions, and it is not necessarily the economically stronger regions in which early signs of S3 responses are the most positive. Region-specific economic and governance characteristics play a key role in shaping how S3 is implemented in each region (Aranguren et al., 2019; Kroll, 2019a). Trippl, Zukauskaite, and Healy (2019) find that improvements in stakeholder engagement and modern policy-thinking are most evident in less developed and intermediate regions, whereas in some advanced regions approaches to S3 are incremental and rarely extending beyond existing practices and parties involved in innovation-related policies. Having said that, S3 policy implementations seem to be insufficient in the very lowest developed regions (Capello & Kroll, 2016; Foray, 2019; Magro & Wilson, 2019). Aranguren et al. (2019) find that the early experience of S3 tends to be dominated by government, with private sector and civil society engagements being relatively few, thereby potentially limiting the centrality of entrepreneurial discovery processes in the S3 agendas. Indeed, Gianelle et al. (2019) find evidence that in a

[1]Commissioner Janez Potočnik established in 2005 a group of experts (supported from DG Research) in order to elaborate policy recommendations. The Knowledge for Growth (K4G) Expert Group operated as an independent advisory and issued policy related studies between 2006 and 2009. The Smart Specialization concept was developed by Dominique Foray, Paul A. David and Brown Hall. http://ec.europa.eu/invest-in-research/pdf/download_en/kfg_policy_brief_no9.pdf?11111

significant number of cases S3 is only being partially implemented, with aspects of the strategy development process themselves potentially undermining the S3 intervention logic.

These various findings all raise the important questions about the ability of S3 practices to foster enhanced local entrepreneurial discovery processes and the extent to which potential inhibitors or blockages to successful S3 implementation are already inherent in the early stages of the policy process itself. In order to better overcome any such inherent inhibitors so as to ensure that the fostering of entrepreneurial discovery processes is genuinely at the heart of the design of the S3 strategy, there needs to be a way of identifying up front the key inhibitors and blockages to the local entrepreneurial search processes.

The entrepreneurship ecosystem (EE) approach provides a way for understanding how we can enhance regional development (Mason & Brown, 2014; Stam, 2015) and the EE approach shares many common features with the S3 approach. The systemic view, the centrality of the entrepreneurial discovery process (EDP), the importance of bottom-up policy actions relying on local actors, and the important shaping and constraining roles played by region-specific forces, are all key features of both concepts. Similar to S3, EE also aims to foster the emergence of innovative, high growth firms, but the emphasis of EE is different in that it focuses on a wider set of individual and institutional factors, not only on the innovative features of the local system. At the same time, while S3 underlines the importance of specialization and diversity, embeddedness and cluster development, EE takes a broader view by looking at all the interrelated agents, actors, organizations, and institutions (Acs, Åstebro, Audretsch, & Robinson, 2016), including issues such as entrepreneurial attitudes, abilities and aspirations.

In terms of S3 policy, the research question we address is how can we consistently identify and measure the strengths and weaknesses of the regional EDP, building on insights from the EE literature, in a manner which lends itself to helping S3 policy prioritization processes? At the moment, what has been missing in S3 for both analytical and policy-making considerations is a consistent framework for empirically assessing the scale of the strengths and weaknesses of the various EE elements (and their interconnections) and the likely role that they play in fostering or inhibiting EDPs. Ideally, such a framework needs to be able to capture all of these different elements in a manner which allows us to understand both local specificities and broader national and regional comparisons. The ability to more accurately identify the strengths and weaknesses of the local EDP should help to ensure that *ex ante* S3 priority-setting is more firmly-grounded on objective criteria and less determined by local institutional pressures, and this in turn should also allow for more realistic *ex post* evaluation processes.

The purpose of this paper is to identify the inhibitors to local entrepreneurial discovery processes, in a manner which can support S3 policy prioritization processes. We argue that the Regional Entrepreneurship and Development Index (REDI) are ideally suited to play such a role. REDI can produce consistent quantifiable measures which capture both the strengths and weaknesses of the individual features of the EE as well as the local EE as a whole. This is important for S3 because while S3 is a combination of top-down and bottom-up processes, the vertical S3 policy prioritization based on the fostering of EDPs is needed because horizontal policies alone have not been able to help move many regions into the knowledge economy (Foray, 2015), and nor have many largely top-down largely sectoral approaches. Having a better systemic understanding of the strengths and weakness of the local EE and a clear sense of the magnitude of the individual EE elements should help S3 prioritization, because many of these features cannot be identified simply by deliberation among stakeholders, nor by looking at comparison cases, nor by considering individual datasets. As such, the largely horizontal perspective afforded by the EE-REDI framework can enhance the primarily vertical parts of S3 processes.

The rest of the paper is structured as follows. The next section provides the conceptual backgrounds about the intersection of S3 and EE concepts. Section 3 explains the structure and the calculation methodology of the REDI. Section 4 discusses on how the REDI could contribute to S3 policy implementation by providing a solution to four S3 policy caveats as (i) measuring the necessary basic conditions for smart specialization in a mix of 125 NUTS 1 and NUTS2 European Union regions; (ii) identifying the institutional and individual weaknesses at local levels; (iii) providing a comprehensive view about the harmonization of the components of EE; and (iv) presenting some simulations on how additional policy efforts could be optimized to alleviate bottlenecks of the regional ecosystem.

Finally, the paper concludes with some policy suggestions and discussions about limitations and future research domains. We found that industry prioritization is necessary but not sufficient condition to sustain high growth firms.

## 2 | ENTREPRENEURIAL ECOSYSTEM BASED POLICIES AND SMART SPECIALIZATION STRATEGIES

In this section, we provide a conceptual background to the EDP, which is the central concept of our research. EDP is mostly a spontaneous, practice-oriented procedure including opportunity recognition and exploitation, trials and errors and learning-by-doing techniques. However, it is also something that can be partially shaped and reshaped affected by the contextual and institutional factors influencing the individuals. These institutional factors interact with the participating agents and can affect their incentives, their trust relations and their interactions with other agents (Rodríguez-Pose, 2017).

### 2.1 | Smart specialization strategies and the entrepreneurial discovery process

Having its roots in the regional innovation system, smart specialization builds on the coupling of different theoretical findings (Foray, David, & Hall, 2011; Hassink & Gong, 2019). With the common goal of creating a theoretical framework for explaining (regional) economic growth potential, S3 has been built with contributions from different research fields inter alia regional science, economic geography, innovation theory, and entrepreneurship (McCann & Ortega-Argilés, 2013, 2015; OECD, 2013). On the policy side, S3 "came as a reaction to the failures of old-style dirigismes and from the frustration with hands-off government policies" (Kyriakou, 2017, p. 5). The strength of S3 is that it works as a practical melting-pot of theories complemented with the conclusions drawn from the experiences of earlier policy concepts and implementation strategies of the EU and the OECD (del Hermosa, Elorduy, & Eguía, 2015; OECD, 2013).

In the past few years, S3 has gained widespread acceptance in academic and policy arenas the European Union and beyond (Kyriakou, 2017). Politically, it has become a fully-institutionalized strategy framework which serves as an *ex ante* conditionality in the current Structural Funds programming period (European Commission, 2014c). S3[2] is first and foremost a policy prioritization framework aimed at finding ways to enhance the scale and effectiveness of entrepreneurial processes trying to develop regions' indigenous potential. S3 aims to promote innovation and entrepreneurship via enhanced technological diversification, embeddedness and connectivity (Foray, 2014; McCann & Ortega-Argilés, 2015, 2016a) and this is to be achieved by better policy prioritization and experimentation. The idea behind S3 is that policy resources must be prioritized on those activities, technologies or sectors where a region has the most realistic chances to develop wide-ranging and large-scale impacts and which also develop and build on many different local and interregional linkages and connections (Foray et al., 2012). A common feature in this policy context must be that the entrepreneurial actions contain a sufficient degree of experimentalism and self-discovery (Hausmann & Rodrik, 2003) as this is essential in all forms of innovation and entrepreneurship.

S3 is now seen as a new policy framework that has transformed policy thinking from either largely top-down vertical sectoral approaches or primarily horizontal innovation policy programmes (focused on improving human capital, accelerating transfer of technologies, creating incubators, cluster-policy implementation) to a holistic, inclusive, place-based bottom-up and smart policy mix approach which combines both vertical and horizontal perspectives (Kyriakou, 2017; Nauwelaers, Forte, & Midtkandal, 2014). Identifying smarter goals for a given region is only a beginning, because S3 is not intended to be a one-off process, necessary simply to respond to *ex ante* conditionalities, but

[2]S3 Platform has a repository of RIS3 from member states and regions, http://s3platform.jrc.ec.europa.eu/home

rather an ongoing process of governance and policy-making upgrading (Balland, Boschma, Crespo, & Rigby, 2019; McCann & Ortega-Argilés, 2016b; Thissen, Van Oort, Diodato, & Ruijs, 2013).

With regards to entrepreneurship, S3 distances itself from traditional innovation policy and industry policy frameworks (OECD, 2013) by emphasizing the role of EDP (Foray, David, & Hall, 2009). The argument here is that local agents are best positioned to search for the *ex ante* knowledge and identify the unique local characteristics, assets and competitive advantages of their region, and then discover the priorities regarding their innovation resources and capacities that can lead new market opportunities (European Commission, 2012; McCann & Ortega-Argilés, 2015). Finally, this bottom-up process should result in a "collective strategy" with the broad engagement of the key actors using "an inclusive governance structure, a capacity-building toolbox, and an evaluation system" (Sotarauta, 2018, p. 4).

The smart specialization literature considers EDP as one of the central elements of S3 (Foray, 2019; Martínez-López & Palazuelos-Martínez, 2019) and probably the most ambitious element when it comes to its practical implementation S3 (del Hermosa et al., 2015; Krammer, 2017; Ranga, 2013; Sotarauta, 2018). The EDP "that it is the heart of the S3 approach is by construction an inclusive, continuous, embedded and bottom-up process" (Kyriakou, 2017, p. 5). In order to maintain the originality of place-based approaches, the European Commission does not want to narrow the scope of the bottom-up EDPs by providing precise policy recommendations which would limit many opportunities and therefore shies away from methodological normativity. This intention is quite explicitly expressed in the recently published handbook on "Implementing Smart Specialization Strategies" (European Commission,Gianelle, Kyriakou, and Cohen 2016; Navarro et al., 2014). However, one thing is increasingly certain, that an evidence-based analytical framework is highly recommended to get a clearer picture of the institutional constellation in which local agents interact (Kotnik & Petrin, 2017; McCann & Ortega-Argilés, 2014, 2016b; Rodríguez-Pose, 2017).

The success of any place-based policies, such as S3, is influenced by the institutional context at the regional level (Coffano & Foray, 2014). Less developed regions often have problems with their institutional capabilities and therefore EDPs are "hard to trigger and, even more so, to keep alive between administratively rigid governments and week business sectors that lack both trust and experience in mutual collaborations" (Kroll, 2019b, p. 36). According to Benner (2019, p. 1791), the EDP has two institution-related functions: it helps to discover specific regional institutional patterns, and offer policies "either consistent with existing institutions or aiming at institutional change." Therefore, the effective regional policy requires understanding regionally specific obstacles, mainly as institutional settings (Kroll, 2019b) "instead of copying 'best practices', translating policies to a region's institutional context can be useful" (Benner, 2018, p. 14).

## 2.2 | Entrepreneurial ecosystem and the entrepreneurial discovery process

Entrepreneurship research has changed considerably over the last two decades. While early entrepreneurship scholars focused on the entrepreneur itself and/or on the creation of the new venture, recent researchers consider the entrepreneur not in isolation but within a context of the environment (Welter, 2011, 2019). When someone compares the present definitions of entrepreneurship to older ones, one can recognize the movement from the individually focused one-dimensional view to the environmental/contextual multidimensional approaches up to the most recent EE concepts (Acs, Autio, & Szerb, 2014; Autio, Nambisan, Thomas, & Wright, 2018).

The EE approach makes a clear distinction between entrepreneurial outputs or activities and its antecedent, interconnected "systemic" factors. Moreover, EE scholars also differentiate potentially high impact, high growth entrepreneurial outputs from low impact entrepreneurial activities (Stam, 2015). At the same time, the nature of the connection between EE and the whole entrepreneurship process has only been emerging most recently (Audretsch & Belitski, 2017).

The notion of EDP is developed from a Kirznerian perspective (Foray, 2017; Kirzner, 1979; Roman & Nyberg, 2017) and also reflects the view of Hausmann and Rodrik (2003) regarding the phenomenon of self-

discovery (Foray & Goenaga, 2013). The concept is based on the observation that "the knowledge about what to do is not obvious. It is knowledge 'of time and place'; this is local knowledge which is dispersed, decentralized and divided. It is hidden and needs to be discovered" (Foray, 2016, p. 1433). EDP is, by nature, spontaneous, and the discovery of a new idea leading to high impact potential venture startup is a result of trial and error experimentation (Acs et al., 2014; Fiet & Patel, 2008). For opportunity discovery, we need valuable opportunities and enterprising individuals (Shane & Venkataraman, 2000). While some entrepreneurship scholars highlight the individual aspects of opportunity recognition such as traits, personal networks or prior experiences (Ardichvili, Cardozo, & Ray, 2003), others emphasize the role of the environment (Welter, 2011). Fundamentally, EE provides the locally embedded contextual, "systemic factors that interact and influence the identification and commercialization of entrepreneurial opportunities" (Audretsch & Belitski, 2017, p. 2). Successful EE supports potential entrepreneurs to be able to discover and exploit valuable business opportunities by offering growing markets, favorable culture, formal and informal infrastructure, and finance (Spigel & Harrison, 2017). While systems can be examined at a national level, ecosystems are local and regional constructs. Hence, the focus of regional entrepreneurship policy, namely the improvement of the EE, provides a fertile field for the EDP and the potential emergence of high impact startups, and ultimately regional growth.

## 2.3 | Smart specialization and regional entrepreneurship policy

While both S3 and EE based regional entrepreneurship policy aims to improve EDP, there are slightly different emphases from the policy perspective. For example, from the perspective of participating actors/agents, S3 is more *exploratory* than REP by identifying entrepreneurial agents—firms (suppliers, manufacturers, service providers), innovators, higher education institutions, research institutions—policy-makers, leaders and all stakeholders who take part directly or indirectly in the EDP (Coffano & Foray, 2014; McCann & Ortega-Argilés, 2016a; Rodríguez-Pose,- 2017). Meanwhile, the REP focuses on those formal and informal, direct and indirect, institutional factors—such as markets, infrastructure, culture, talents, finance, networks, supporting institutions and services—that could lead to the emergence of high growth ventures (Spigel & Harrison, 2017; Stam, 2015). In this sense REP is more *regulatory* than S3.

While both S3 and EE based REP highlight the entrepreneur as the key figure in EDP, S3 is more focused on the *agency* while the EE emphasis is on the *institutional* aspects. As we demonstrate in the next section, REDI combines both the individual and the institutional sides of EE, therefore balancing both the agency and the institutional characteristics of a regional EE. Whereas S3 highlights the *bottom-up* nature of voluntary participation, EE based REP puts more emphasis on the institutional development, therefore it is more a *top-down* policy approach. However, *harmonization* is also a key in policy implementation talking about either stakeholders (S3 approach) or institutional components (EE) (Acs et al., 2014; Santini, Marinelli, Boden, Cavicchi, & Haegeman, 2016). Another common feature of EE based REP and S3 is that both underline the reliance on local strengths and space-based, tailor-made policy initiation (Autio & Levie, 2017; Mason & Brown, 2014; Spigel, 2017).

Summing up, S3 and ecosystem based REP view the EDP process and the emergency of high growth, innovative ventures partially differently, although these two approaches share many commonalities and are largely complements rather than substitutes, therefore opening up the possibility of informing each other in the S3 policy prioritization process.

Figure 1 provides a wider picture about the interconnections of different innovation and entrepreneurship related components.

EDP can be viewed at the intersection of the RIS and the EE. From the S3 perspective, it is the interaction of the industry specialization/diversification and the improvement of the EDP that leads to the emergence of new industries and new, potentially high growth firms. The initial experience of S3 experimentation was to focus on the

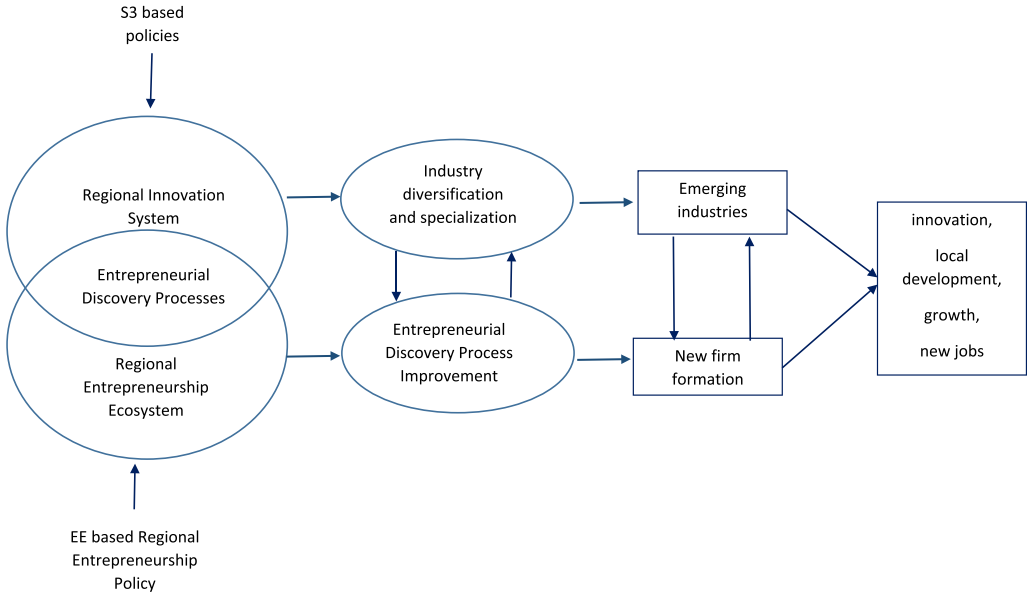



**FIGURE 1** The conceptual model of smart specialization strategy based policies and regional entrepreneurship policy influences

industry specialization (Capello & Kroll, 2016) and neglected the EDP and the new firm formation aspects. Probably this is one of the main reasons while the expected outcomes of S3 policy in innovation, development, growth and job creation failed from the initial expectations.

This view was reinforced by two conceptual frameworks that emerged in the 1990s to explain the evolution of the information technological revolution: the first was national systems of innovation; the second was Porter's diamond that defined a system of regional clusters that propelled a country to prominence. Clusters and systems of innovation had two assumptions in common. First, *they both argued that institutional embeddedness was important and second, they both relied on existing firms to implement and deploy the new technologies!* Both of these approaches had a large theoretical literature, empirical research and policy recommendations. Because they both left out of their analysis the role of new firms that was Boyan Jovanovic's great insight—that new firms were needed to implement new technologies—they were limited in their usefulness for implementing the new information technologies (Greenwood & Jovanovic, 1999). Why new firms were left out of these approaches is an interesting subject . The systems of innovation approach was in part a Swedish discovery and helps explain both the Scandinavian disdain for startups and the European Union's unwillingness to view innovation and entrepreneurship in the same unified approach (Sandström, Wennberg, & Karlson, 2019).

## 3 | REGIONAL ENTREPRENEURSHIP AND DEVELOPMENT INDEX (REDI): STRUCTURE, METHODOLOGY, AND THE DATASET

We now ask the question of how do we measure EE in order to understand the EDP working as a bottom-up process that is viewed as the weakness of both the S3 and EE concepts? We suggest in this paper that the REDI policy tool, by gauging the EE, can help us to reveal the effectiveness of the entrepreneurial discovery process that leads to the emergence of new industries and high growth firms. It provides measurable and verifiable data at the regional level for helping with the optimization of effective S3 policy strategies.

According to Acs et al. (2014, p. 119) entrepreneurship can be seen as "a dynamic, institutionally embedded interaction between entrepreneurial attitudes, ability, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures." Originally the Global Entrepreneurship Index (GEI) was created on the national level (Acs et al., 2014; Ács, Szerb, Ortega-Argilés, Aidis, & Coduras, 2015). While the entrepreneurship literature has acknowledged the importance of national differences in entrepreneurship, regional differences have also been confirmed to be equally or even more essential underlying the importance of the regional context in the individual entrepreneurial decision-making (Bosma, 2009; Mason & Brown, 2014; Stam, 2015).

## 3.1 | The REDI structure and calculation

REDI has been formed to measure the level of the entrepreneurship ecosystem in a regional context. This index uses measures of individual-level entrepreneurial attitudes, abilities, and aspirations as weights to adjust the magnitude of institutional and contextual factors in regulating the quality of the entrepreneurial dynamics. Moreover, the index helps to provide guidance on resource allocation decisions in the economy towards high-productivity uses (Acs et al., 2014). In the REDI theoretical concept, entrepreneurs are seen as operating a trial-and-error resource allocation dynamic by mobilizing resources to pursue perceived opportunities (Qian, Acs, & Stough, 2013). This feature is also along the lines of the smart specialization's entrepreneurial discovery (Foray et al., 2012). However, contextual conditions moderate the potential impact of such individual-based resource allocations—for example, the availability of high-quality human capital would regulate the growth potential of a new venture. Scarcity in high-quality human capital would constrain the ability of new ventures to meet their recruitment needs to support rapid growth. In the REDI, therefore, framework conditions are not seen as direct drivers of entrepreneurial attitudes, abilities, and aspirations, but rather, as institutional and contextual regulators.

REDI is a systemic tool, in the sense that the system components are thought to "co-produce" system-level outcomes. In practice, this property is operationalized through the penalty for bottleneck (PFB) algorithm, which "penalizes" strong pillars for gaps—or bottlenecks—in pillar-level performance. This means that the REDI methodology is potentially useful for profiling entrepreneurial ecosystems, where a similar co-production dynamic is thought to be in operation (Autio et al., 2018; Autio & Levie, 2017). As the REDI methodology is able to highlight gaps in the entrepreneurial dynamic, it also provides a potentially useful template to guide policy action. The first version of REDI has been developed under the professional supervision of DG REGIO,[3] and its importance is demonstrated by the fact that both the index itself and the results of the regional investigation have been included in the EU's 6th Cohesion Report (European Commission, 2014b).

Table 1 illustrates the structure of the REDI: (i) sub-indicators; (ii) indicators; (iii) variables; (iv) pillars; (v) sub-indices; and, finally, (vi) the super-index. While the GEM-based individual indicators are simple formations, some institutional indicators are complex creations by themselves, comprising 76 sub-indicators in total. The most important building blocks are the 14 pillars which contain, simultaneously, 36 regional individual, regional and country-level institutional variables. As compared to the Global Entrepreneurship Index (GEI) the institutional variable components of REDI are much richer. Regional level variables aim to reflect the local spillover effects of agglomeration (size of the region, market potential), connectivity, networking/clustering, social capital, education systems, human capital, the effects of knowledge spillover and innovation, the role of regulation, the quality of governance and also of finance. Each pillar was created as a product of individual- and institutional-level variables. Careful scrutiny of the relative differences between individual pillars, both within a given region and across benchmark regions, can provide good initial guidance for the search for prospective strengths and weaknesses across regions from a benchmarking perspective.

[3]This report and the associated research was financed by the European Union represented by the European Commission Directorate-General Regional and Urban Policy under contract number NO 2012.CE.16.BAT.057. http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/regional_entrepreneurship_development_index.pdf

**TABLE 1** The structure of the regional entrepreneurship and development index

| Structure of the REDI 3 sub-indexes/14 pillars | | National and regional institution variables | Regional level individual variables |
|---|---|---|---|
| Entrepreneurial *Aspiration* Sub-index | Financing | FINANCIAL INSTITUTIONS | INFORMAL INVESTMENT |
| | Globalization | CONNECTIVITY | EXPORT |
| | High Growth | CLUSTERING | GAZELLE |
| | Process Innovation | TECHNOLOGY DEVELOPMENT | NEW TECHNOLOGY |
| | Product Innovation | TECHNOLOGY TRANSFER | NEW PRODUCT |
| Entrepreneurial Ability Sub-index | Competition | BUSINESS STRATEGY | COMPETITORS |
| | Human Capital | EDUCATION AND TRAINING | EDUCATION LEVEL |
| | Technology Sector | ABSORPTIVE CAPACITY | TECHNOLOGY LEVEL |
| | Opportunity Start-up | BUSINESS ENVIRONMENT | OPPORTUNITY MOTIVATION |
| Entrepreneurial *Attitudes* Sub-index | Cultural Support | OPEN SOCIETY | CARRIER STATUS |
| | Networking | SOCIAL CAPITAL | KNOW ENTREPRENEURS |
| | Risk Acceptance | BUSINESS RISK | BUSINESS ACCEPTANCE |
| | Start-up Skills | QUALITY OF EDUCATION | SKILL PERCEPTION |
| | Opportunity Perception | MARKET AGGLOMERATION | OPPORTUNITY RECOGNITION |

*Source*: authors' own construction.

These pillars comprise three sub-indices: entrepreneurial attitudes (5 pillars); abilities (4 pillars); and aspirations (5 pillars).[4]

The entrepreneurial attitude (ATT) sub-index aims to identify the attitudes of a region's population as they relate to entrepreneurship. Opportunity recognition, start-up skills, risk acceptance, networking building potential, and cultural perceptions formulate these attitudes. The entrepreneurial abilities (ABT) sub-index is principally concerned with measuring certain important characteristics of both the entrepreneur and the start-ups with high growth perspectives such as start-up motivation, human capital, technology-absorption potential, and market niche-identification capabilities. The entrepreneurial aspiration (ASP) sub-index refers to the distinctive, qualitative, strategy-related nature of entrepreneurial start-up activity. Product and process innovation, growth strategy, cluster formation, internationalization, and finance frame these aspirations.

## 3.2 | REDI as a policy tool

A key feature of the REDI is its unique methodology based upon the Penalty for Bottleneck (PFB) method that makes it possible to incorporate the system-perspective to the calculation method. Practically it means that the value of each pillar in a region is penalized by linking it to the score of the pillar with the weakest performance in that region. This simulates the notion of a bottleneck, and if the weakest pillar were improved, the particular sub-index and ultimately the whole REDI would show a significant improvement. On the contrary, improving a relatively high pillar value will primarily enhance only the value of the pillar itself, and in this case, a much smaller increase of the whole REDI index can be anticipated. Moreover, the penalty is higher if differences between the bottleneck and the actual pillars are higher (Acs et al., 2014). This idea reflects the classical notion of public policy

[4]For more details about the methodology see Szerb, Vörös, Komlósi, Acs, Páger, & Rappai (2017) report.

where the aim is to correct for market failures (Bator, 1958; Stiglitz, 1989) and also the growth policy notion of the "second-best" targeting to improve the most binding constraints of development (Hausmann, Rodrik, & Velasco, 2008). Moreover, region-specific bottlenecks can also be interpreted as restraints in the entrepreneurial discovery process. Here, the main aim of public/entrepreneurship policy is to correct for entrepreneurship ecosystem failures.

The advantage of REDI, as compared to other indices, is its capability to incorporate both the individual and institutional contexts in one model. Emphasizing both angles the REDI acknowledges the multidimensional nature of entrepreneurship (Wennekers & Thurik, 1999), against those measures which are still one-dimensional and frequently using start-up, self-employment or business density rates (Iversen, Jorgensen, & Malchow-Moller, 2008). These output measures are problematic because they mix together many different types and qualities of start-ups or business organizations from "muppets" to "gazelles" (Nightingale & Coad, 2013). Recent conceptual developments of the "entrepreneurial ecosystem" represent the latest evolution about the measurement of entrepreneurship (Autio et al., 2018; Pitelis, 2012; Spigel, 2017) and the REDI provides the most structured and comprehensive approach to entrepreneurial ecosystem measurement, up to now.

In terms of the possible limitations of REDI, one of the fundamental restrictions is that any regional regulating context behind entrepreneurship ecosystems might be more complex than an index such as the REDI could fully capture. Understanding the REDI index outcomes is less straightforward than in the case of one-dimensional measures (using only one variable), but a potential criticism of our method—as with any other index—might be the apparently arbitrary selection of indicators and the neglect of other important ones. In order to limit this risk, in all cases, we aimed to collect and test alternative individual/institutional factors before making our selection. Of course, our choice is constrained by the limited availability of data.

The REDI methodology also makes several simplifying assumptions. First, in assigning equal weights to each pillar, it thereby assumes that all pillars always contribute equally to the outcomes of the entrepreneurial dynamic. In so doing, the method also assumes that one best configuration for the entrepreneurial system exists—one in which all elements are maximized and in balance. Second, is the arbitrary selection of the magnitude of the penalty that is based on a "rule of thumb" 10% penalty on the average. The other problem is that we cannot exclude fully the potential that a particularly good feature can have a positive effect on the weaker performing features. While this could also happen, many of the entrepreneurship policy experts hold that policy should be based on the correction of market failures (Acs, Audretsch, Lehmann, & Licht, 2016; Audretsch, Grilo, & Thurik, 2007; Lundström & Stevenson, 2006). The identification and the correction of the weak links is also the main focus of the efficient operation of the entrepreneurship ecosystem (Mason & Brown, 2014; Stam, 2015). The REDI focus on system bottlenecks tends to focus attention to fixing gaps, which potentially may come at the cost of maximizing system strengths. An important novelty of our index-building is the way the pillars are combined (aggregated) into subindices. Most indices simply use the (weighted) average of the pillars; others apply a dimension reduction methodology, such as factor analysis. We provide a different approach. The basic assumptions of our methodology are that the performance of the system is determined by its weakest performing part and the pillars can only be partially substitutable with one another. The PFB relates the pillar values to the lowest pillar value. The penalty depends on the magnitude of the differences; for greater deviation, the penalty is greater. The PFB provides valuable policy suggestions for enhancing entrepreneurship by improving the weakest pillar in the system. Altogether, we claim that the PFB methodology is theoretically better than the arithmetic average calculation. The average method has no any theoretical/conceptual basis by assuming equal weights to all the components. PFB based weighting addresses directly the system failure and provides a theoretical basis to policy suggestions. However, the PFB adjusted REDI is not necessarily an optimal solution since the magnitude of the penalty is unknown.

The most important message for economic development policy is that improvement can only be achieved by abolishing the weakest link of the system which has a constraining effect on other pillars, and consequently on the EE as a whole.

### 3.3 | The REDI dataset

Our index incorporates both individual-level and institutional variables. The former is based on indicators from the Global Entrepreneurship Monitor (GEM) Adult Population Survey dataset, and for the present purposes, we have used the 2012–2014 pooled GEM data.[5] For 24 countries in the European Union, except Bulgaria, Cyprus, Malta, and Luxemburg, it was possible to create the regional representation of the GEM dataset. In the case of 10 countries, GEM data were regionalized at NUTS1 level (Austria, Belgium, Greece, France, Germany, Italy, the Netherlands, Poland, Romania, and the United Kingdom). For four additional countries, the country level classification was equal to the NUTS1 level classification. These are the Czech Republic, Latvia, Lithuania, and Estonia. For the remaining 10 countries, GEM data were calculated at NUTS 2 level (Croatia, Denmark, Finland, Hungary, Ireland, Portugal, Spain, Slovenia, Slovakia, and Sweden). In the case of Portugal, only those five NUTS 2 level data were available which belong to the *Continente* NUTS1 region. For Spain, the two small African continent NUTS1 regions, Ceuta and Melilla were also excluded. Thus, we have calculated the REDI for 24 countries which altogether contain a mix of 125 NUTS1 and NUTS2 regions.

It should be noted that most of the countries participated in GEM all three years between 2012 and 2014. Austria and Denmark took the survey in 2012 and 2014 while the Czech Republic joined the assessment network only for 2013. For most of the regions, satisfactory sample size was achieved. For 79 out of the 125 regions, the sample size exceeded 1,000 individuals. For Algarve (Portugal), Bremen and Saarland (Germany) the GEM data should be taken with care as it is based on sample sizes lower than 300 cases. There are another 11 regions with relatively limited coverage; a sample size below 500. The individual sample distribution over countries and years can be found in Table 2. Individual variables are described in detail in Appendix Table A1.

Since the GEM dataset lacks the necessary institutional variables, we complemented it for the index with other widely-used and relevant data derived from a variety of available sources. For a detailed description and sources of institutional data see Appendix Table A2. An important note is that the benchmarks were calculated by taking into account the previous 2007–2011 time period data for the same 125 regions. Here, we only analyse and report the 2012–2014 time period results.

## 4 | REDI AND ITS CONTRIBUTION TO SMART SPECIALIZATION STRATEGIES: A PRACTICAL APPLICATION

In this section, we present how REDI could contribute to S3 policy implementation by providing a solution to the following four S3 policy caveats emphasized by the literature. The sharpest critique regarding the S3 concept that it does not emphasize enough (at least in the beginning) that the success of the S3 strategies is largely determined by the *institutional setup* in which nations or regions are embedded. Capello and Kroll (2016, p. 1396) call attention the fact that nations and regions characterized by diverse institutional capacity have to face and handle various challenging place-based situations, and therefore they argue that "smart specialization could provide a common political rationale." The notion of institutional capacity refers to the ability of nations/regions supporting or hampering the absorption of those new aspects, ideas which continuously attack their institutional arrangement.

The limitations of the S3 concept are particularly apparent for less developed regions (LDRs), which struggle with the phenomenon of regional innovation paradox (Oughton, Landabaso, & Morgan, 2002). It means that LDRs are deficit regarding their institutional capacity (Rodríguez-Pose, 2013), and therefore they have to face many "atypical obstacles", such as lack of creativity, limited marked opportunities, top-down style of governance lieu of regional

[5]See detailed description about the calculation of regionalized GEM data: Szerb et al. (2014, p. 31). http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/regional_entrepreneurship_development_index.pdf

**TABLE 2** The sample size and the distribution of the Global Entrepreneurship Monitor (GEM). based individual data by countries and years

| | | REDI 2017 | | | |
|---|---|---|---|---|---|
| Country | | Sample size | Years included | Basic Class. | No. of regions |
| AT | Austria | 9,102 | 2012; 2014 | NUTS 1 | 3 |
| BE | Belgium | 6,015 | 2012–2014 | NUTS 1 | 3 |
| HR | Croatia | 6,000 | 2012–2014 | NUTS 2 | 3 |
| CZ | Czech Republic | 4,967 | 2013 | NUTS 1 | 1 |
| DK | Denmark | 4,225 | 2012; 2014 | NUTS 2 | 5 |
| EE | Estonia | 6,365 | 2012–2014 | NUTS 2 | 1 |
| FI | Finland | 6,043 | 2012–2014 | NUTS 2 | 5 |
| FR | France | 8,010 | 2012–2014 | NUTS 1 | 8 |
| DE | Germany | 14,607 | 2012–2014 | NUTS 1 | 16 |
| EL | Greece | 6,000 | 2012–2014 | NUTS 1 | 4 |
| HU | Hungary | 6,003 | 2012–2014 | NUTS 2 | 7 |
| IE | Ireland | 5,801 | 2012–2014 | NUTS 2 | 2 |
| IT | Italy | 6,052 | 2012–2014 | NUTS 1 | 5 |
| LV | Latvia | 4,000 | 2012–2013 | NUTS 2 | 1 |
| LT | Lithuania | 6,003 | 2012–2014 | NUTS 2 | 1 |
| NL | Netherlands | 8,730 | 2012–2014 | NUTS 1 | 4 |
| PL | Poland | 6,004 | 2012–2014 | NUTS 1 | 6 |
| PT | Portugal | 6,009 | 2012–2014 | NUTS 2 | 3 |
| RO | Romania | 6,007 | 2012–2014 | NUTS 1 | 4 |
| SK | Slovak Republic | 5,987 | 2012–2014 | NUTS 2 | 4 |
| SI | Slovenia | 6,016 | 2012–2014 | NUTS 2 | 2 |
| ES | Spain | 70,300 | 2012–2014 | NUTS 2 | 17 |
| SE | Sweden | 7,477 | 2012–2014 | NUTS 2 | 8 |
| UK | United Kingdom | 15,024 | 2012–2014 | NUTS 1 | 12 |
| Total | | 230,747 | | | 125 |

Source: authors' own construction.

autonomy, heavy reliance on external resources etc. (see in detail Krammer, 2017). While particularly the LDRs have a greater need for strategic reshape of their policies and innovation-related institutional setup to avoid the danger of stalling in regional "lock-in situations" (Capello & Kroll, 2016; McCann & Ortega-Argilés, 2016a). The S3 requires less developed regions to get rid of their old unfavourable institutional setup and introduce novel institutional arrangement. Therefore, as Morgan (2017, p. 17) indicates "the detrimental power of policy path dependence" should be seriously considered as well. (p. 17).

According to Capello and Kroll (2016), the success of the S3 strategies is largely determined by the *institutional capacity*, which refers to the ability of regions supporting or hampering the absorption of those new aspects and ideas that continuously challenge their existing institutional arrangement. In fact, regions are characterized by diverse institutional capacity and have to face and handle various challenging place-based situations. It is doubtful that smart specialization "could provide a common political rationale" (Capello & Kroll, 2016, p. 1396) but it does offer real

opportunities for institutional learning and the upgrading of governance capabilities (McCann & Ortega-Argilés, 2016b).

Grillitsch (2016, p. 29–30) emphasizes the importance of "institutional harmony" by stressing that conflicting institutions can discourage trust among different stakeholders. Regions lacking institutional harmony can "fall into an institutional conflict trap that might not only dissipate collective efforts but also impede trust-based social relations or prevent them from being built" (Sotarauta, 2018, p. 6.).

S3 needs to ensure the continuous character of the entrepreneurial discovery process. The process should avoid reducing EDP to a mere consultation on top-down choices, based on ex cathedra analysis. Instead, stakeholders should be present at the creation (Kyriakou, 2017, p. 5).Next, we present how REDI could contribute to these S3 policies related to caveats. We follow the four points listed at the beginning of this section. All sub-sections finish with a proposition and we also note some potential caveats.

## 4.1 | Smart specialization strategies in less developed regions

The first point refers to a typical practical problem of the application of S3 policy in less developed regions (LDRs). It seems that some development of the individual and institutional capabilities are required for the successful specialization policy. If basic requirements are missing then there is no place for industry specialization. REDI is able to measure the level of the entrepreneurship ecosystem on a 0–100 point scale; hence providing an overall picture about the level of existing preconditions for specialization. Table 3 contains the REDI scores for each of the 125 regions.

As can be seen Table 3, it is clear that the differences in EE are significant in the European Union regions: The difference between the first Stockholm (REDI = 78.3) and the last Hungarian Dél Alföld (REDI = 17.7) is huge, 4.5 fold. There is a close relationship between the EE and the development of the region (measured by the *per capita* GDP), the Spearman correlation coefficient is 0.77. Rich and mainly highly agglomerated Scandinavian (Swedish, Danish, Finnish) and UK regions lead the ranking together with the best Irish (Southern and Eastern), French (Ile de France), German (Hamburg) and Belgian (Bruxelles-Capitale) regions. West German, Dutch, Belgian, French, Austrian regions dominate the first half of the ranking together with some highly agglomerated capital city regions like Madrid, Lisbon, and Bratislava. The less-developed German, Spanish, Portugal, Polish, Czech, Baltic country regions can be found in the second half of the ranking. Finally, Greek, Italian, Slovakian, Romanian, Croatian and Hungarian regions are at the bottom of the ranking.

While REDI is a measure of EE, it could also be viewed as a proxy of the overall development capabilities. Based on this assumption we can formulate our first proposition:

**Proposition 1** Low REDI score regions should focus more on EE improvement while high REDI score regions should develop S3 focused prioritization strategies.

**Caveat** We do not know what is the minimum level of REDI score, representing the development of local EE required as a precondition for S3 policy application. For example, if a region chooses to implement S3, then later the *ex post* evaluation of the implementation will obviously reveal the effectiveness of this strategy. If it was unsuccessful, it is a clear sign for the region that its EE is still not ready for the proper for the execution of S3 strategies, while basic regional conditions are still missing.

## 4.2 | Institutional and individual development

The second critical points referred to the problem of identifying the deficits in the local institutional capacity. While the focus of S3 is the identification of individual strengths supporting the EDP, REDI considers not only individual

**TABLE 3** The REDI rank of the 125 EU regions

| Rank | Region name | REDI | Rank | Region name | REDI | Rank | Region name | REDI |
|---|---|---|---|---|---|---|---|---|
| 1 | Stockholm | 78.3 | *43* | North West (UK). | 50.4 | *85* | Illes Balears | 34.3 |
| 2 | Hovedstaden | 76.6 | *44* | Région wallonne | 50.3 | *86* | Region Pólnocno-Zachodni | 34.2 |
| 3 | London | 75.5 | *45* | Niedersachsen | 50.3 | *87* | Region Pólnocny | 33.7 |
| 4 | Southern and Eastern | 71.3 | *46* | Zahodna Slovenija | 50.0 | *88* | Centro (IT). | 33.5 |
| 5 | Île de France | 70.8 | *47* | Schleswig-Holstein | 49.8 | *89* | Nord-Ovest | 33.5 |
| 6 | Helsinki-Uusimaa | 70.0 | *48* | Westösterreich | 49.0 | *90* | Andalucía | 33.2 |
| 7 | South East (UK). | 69.6 | *49* | Länsi-Suomi | 48.9 | *91* | Lithuania | 32.8 |
| 8 | Hamburg | 69.5 | *50* | Sjalland | 48.4 | *92* | Cantabria | 32.7 |
| 9 | Sydsverige | 65.8 | *51* | Lisboa | 48.1 | *93* | Centro (PT). | 32.7 |
| 10 | West-Nederland | 63.5 | *52* | Südösterreich | 47.6 | *94* | Nord-Est | 32.6 |
| 11 | Bruxelles/Brussels | 63.2 | *53* | Ouest (FR). | 46.6 | *95* | Aragón | 31.9 |
| 12 | Berlin | 62.4 | *54* | Nord - Pas-de-Calais | 46.4 | *96* | Region Wschodni | 31.8 |
| 13 | South West (UK). | 62.3 | *55* | Smaland med öarna | 45.6 | *97* | Közép-Magyarország | 31.1 |
| 14 | Baden-Württemberg | 62.0 | *56* | Est (FR). | 45.5 | *98* | Principado de Asturias | 30.3 |
| 15 | Syddanmark | 61.6 | *57* | Norra Mellansverige | 45.5 | *99* | Macroregiunea trei | 29.9 |
| 16 | Bayern | 60.6 | *58* | Méditerranée | 45.4 | *100* | Galicia | 29.5 |
| 17 | Scotland | 60.5 | *59* | Estonia | 45.3 | *101* | Región de Murcia | 29.3 |
| 18 | Border, Midland and Western | 60.4 | *60* | Rheinland-Pfalz | 44.6 | *102* | Canarias (ES). | 29.2 |
| 19 | Östra Mellansverige | 59.9 | *61* | North East (UK). | 44.3 | *103* | Attiki | 28.3 |
| 20 | Vastsverige | 59.8 | *62* | Bratislavsky kraj | 44.2 | *104* | La Rioja | 28.2 |
| 21 | Hessen | 58.9 | *63* | Bassin Parisien | 44.1 | *105* | Západné Slovensko | 26.7 |
| 22 | East of England | 58.7 | *64* | Pohjois- ja Ita-Suomi | 43.2 | *106* | Isole | 26.7 |
| 23 | Centre-Est (FR). | 58.5 | *65* | Vzhodna Slovenija | 43.0 | *107* | Stredné Slovensko | 26.5 |
| 24 | Midtjylland | 58.2 | *66* | Region Centralny | 43.0 | *108* | Extremadura | 26.1 |
| 25 | East Midlands (UK). | 57.9 | *67* | Thüringen | 41.1 | *109* | Macroregiunea unu | 26.1 |
| 26 | Zuid-Nederland | 57.6 | *68* | Cataluna | 40.9 | *110* | Vychodné Slovensko | 26.0 |

**TABLE 3** (Continued)

| Rank | Region name | REDI | Rank | Region name | REDI | Rank | Region name | REDI |
|---|---|---|---|---|---|---|---|---|
| 27 | Bremen | 57.1 | *69* | Region Poludniowy | 40.5 | *111* | Sud | 25.7 |
| 28 | Ostösterreich | 56.9 | *70* | Mecklenburg-Vorpommern | 40.2 | *112* | Kontinentalna Hrvatska | 25.6 |
| 29 | Saarland | 56.7 | *71* | Mellersta Norrland | 39.9 | *113* | Castilla-la Mancha | 24.7 |
| 30 | Nordjylland | 56.5 | *72* | País Vasco | 38.8 | *114* | Jadranska Hrvatska | 23.5 |
| 31 | Noord-Nederland | 55.3 | *73* | Czech Republic | 38.8 | *115* | Macroregiunea patru | 22.3 |
| 32 | Northern Ireland (UK). | 55.0 | *74* | Sachsen-Anhalt | 38.2 | *116* | Voreia Ellada | 22.0 |
| 33 | Nordrhein-Westfalen | 54.8 | *75* | Sud-Ouest (FR). | 37.6 | *117* | Nyugat-Dunántúl | 21.7 |
| 34 | Övre Norrland | 54.8 | *76* | Alentejo | 37.1 | *118* | Macroregiunea doi | 21.4 |
| 35 | West Midlands (UK). | 54.0 | *77* | Latvia | 36.7 | *119* | Nisia Aigaiou, Kriti | 21.3 |
| 36 | Etelä-Suomi | 52.4 | *78* | Region Poludniowo-Zachodni | 36.7 | *120* | Kentriki Ellada | 20.0 |
| 37 | Oost-Nederland | 51.8 | *79* | Comunidad Foral de Navarra | 36.2 | *121* | Dél-Dunántúl | 19.8 |
| 38 | Yorkshire and The Humber | 51.8 | *80* | Algarve | 35.4 | *122* | Észak-Magyarország | 18.9 |
| 39 | Vlaams Gewest | 51.3 | *81* | Brandenburg | 35.1 | *123* | Közép-Dunántúl | 18.8 |
| 40 | Comunidad de Madrid | 51.1 | *82* | Comunidad Valenciana | 34.9 | *124* | Észak-Alföld | 18.2 |
| 41 | Sachsen | 50.5 | *83* | Castilla y León | 34.6 | *125* | Dél-Alföld | 17.7 |
| 42 | Wales | 50.4 | *84* | Norte | 34.3 | | | |

*Source*: authors' own construction.

but also the widely interpreted institutional features. Although, REDI pillars are created as the interaction of the various individual initiations and institutional contexts it is possible to separate them. For doing it, we have followed the REDI score calculation methodology and used the non-penalized institutional and individual components scores (in details see Szerb et al., 2017). By calculating the share of institutional scores to individual (SII) ones for every region we can identify if a specific region is relatively weak in the institutional component (share is lower than 1) or in the individual features (share is higher than 1). Figure 1 presents the connection between the SII and REDI scores.

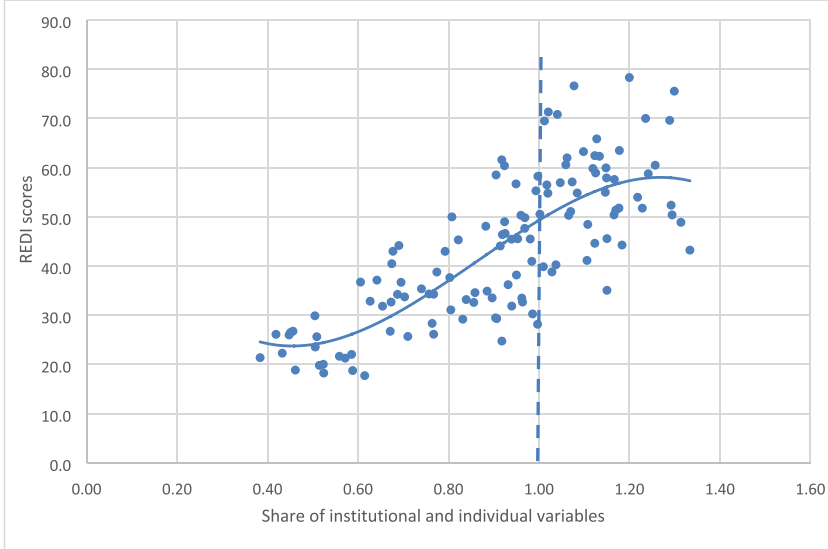
In Figure 2, we highlighted the 1.00 SII score with a dotted line, as an optimal share. SII scores range from 0.38 (Macroregion doi, Romania) to 1.33 (Pohjois-ja Ita-Suomi, Finland). The third-degree polynomial line in Figure 2 implies that REDI scores are determined mostly by the institutional quality that is along the line of the institutional economics claim.

If SII is lower than 1 then a certain region has a weakness in its institutional setup, so its policy should aim to alleviate these institutional deficiencies. This is the case in many regions of less developed countries. If SII is higher than 1, then the policy focus should be the improvement of individual skills (population attitudes, entrepreneur's abilities or startup aspirations). Many higher developed regions have relatively developed institutions while their inhabitants cannot fully exploit the potential of this development. Individual capability improvement can be considered as strengthening the potential of bottom-up initiation. Institutional enhancements most of the times are coming from the top.

**Proposition 2a** Regions with relatively higher institutional development should improve their individual capabilities.

**Proposition 2b** Regions with relatively higher individual development should improve their institutional features.

**Caveat** As REDI is determined more by institutional factors as compared to individual ones, the selected optimal share of one may not be appropriate. Further research is necessary to search for an optimal share of institutional and individual variables.




Source: authors' own construction.

**FIGURE 2** The connection between the share of the individual and institutional variables and REDI scores

## 4.3 | Harmonization of the components

Regarding the institutional harmony, the REDI methodology is based on the harmonization of its 14 pillars, therefore it is particularly suitable for identifying the potential conflict trap domain. REDI measures not only the level of regional institutional capacity but also the interconnected effect of the individual and the institutional factors. Differences in EE are clear when we classify the countries according to the 14 pillars of entrepreneurship (Table 4).

EU regions are different not only in the level of REDI scores but also in the configurations of the 14 pillars. Same country regions tend to cluster together: Danish, Dutch, Finnish, Irish, Swedish, UK regions can be found in clusters 1 and 2. Austrian, Belgian, French and German regions occupy clusters 1 and 3. Some better Italian, Portugal, Spanish and Central Eastern European regions are in cluster 4. Cluster 5 contains Croatian, Greek, Hungarian, Latvian, Lithuanian, and Romanian regions.

Cluster 1 regions are the best in 10 out of 14 pillars, except risk perception, networking, cultural support, and opportunity startup. Cluster 2 regions lack aspiration related pillars of high growth, globalization, and financing. Cluster 3 regions are excellent in competition but relatively weak in High Growth and in some attitude pillars. Cluster 4 regions are relatively well-balanced over the 14 pillars, however, on a low level. High growth and globalization are relatively high in cluster 5; however, they are the worst regions in all other cases. In particular, cultural support is badly missing. Countries with similar weaknesses and level of development can learn from each other as well as from

**TABLE 4** The grouping of the EU 125 regions based on the 14 pillars (K-means cluster).

| Pillars/clusters | 1 | 2 | 3 | 4 | 5 | Average |
|---|---|---|---|---|---|---|
| Opportunity perception | 0.75 | 0.74 | 0.45 | 0.32 | 0.29 | 0.48 |
| Strat-up skills | 0.74 | 0.47 | 0.54 | 0.51 | 0.22 | 0.50 |
| Risk perception | 0.58 | 0.75 | 0.44 | 0.36 | 0.30 | 0.47 |
| Networking | 0.67 | 0.76 | 0.51 | 0.36 | 0.18 | 0.49 |
| Cultural support | 0.69 | 0.85 | 0.60 | 0.35 | 0.06 | 0.50 |
| Opportunity startup | 0.70 | 0.84 | 0.57 | 0.30 | 0.15 | 0.49 |
| Technology absorption | 0.84 | 0.63 | 0.59 | 0.40 | 0.30 | 0.53 |
| Human capital | 0.72 | 0.70 | 0.47 | 0.35 | 0.32 | 0.49 |
| Competition | 0.86 | 0.71 | 0.73 | 0.31 | 0.23 | 0.54 |
| Product innovation | 0.75 | 0.52 | 0.50 | 0.53 | 0.34 | 0.52 |
| Process innovation | 0.80 | 0.54 | 0.54 | 0.48 | 0.29 | 0.52 |
| High growth | 0.79 | 0.45 | 0.44 | 0.29 | 0.63 | 0.47 |
| Globalization | 0.68 | 0.35 | 0.64 | 0.31 | 0.43 | 0.46 |
| Financing | 0.62 | 0.39 | 0.61 | 0.40 | 0.31 | 0.46 |
| REDI score (average). | 65.4 | 53.6 | 48.8 | 33.2 | 24.4 | 43.5 |
| Number of regions | *17* | *24* | *27* | *38* | *19* | *125* |

*Notes*:
Cluster 1: BE1, DE1, DE2, DE3, DE5, DE6, DK01, FI1B, FR1, FR7, IE02, NL3, SE11, SK01, UKH, UKI, UKJ;
Cluster 2: DK02, DK03, DK04, DK05, FI19, FI1C, FI1D, IE01, SE12, SE21, SE22, SE23, SE31, SE32, SE33, UKC, UKD, UKE, UKF, UKG, UKK, UKL, UKM, UKN;
Cluster 3: AT1, AT2, AT3, BE2, BE3, DE4, DE7, DE8, DE9, DEA, DEB, DEC, DED, DEE, DEF, DEG, ES30, FR2, FR3, FR4, FR5, FR8, NL1, NL2, NL4, PT17, SI02;
Cluster 4: CZ, EE, EL1, EL3, EL4, ES11, ES12, ES13, ES21, ES22, ES23, ES24, ES41, ES42, ES43, ES51, ES52, ES53, ES61, ES62, ES70, FR6, ITC, ITF, ITG, ITH, ITI, PL1, PL2, PL3, PL4, PL5, PL6, PT11, PT15, PT16, PT18, SI01;
Cluster 5: EL2, HR03, HR04, HU10, HU21, HU22, HU23, HU31, HU32, HU33, LT, LV, RO1, RO2, RO3, RO4, SK02, SK03, SK04.

more successful regions in that particular feature. The EU's best practices could be helpful to look for practical solutions.[6]

Differences across regions are even higher if we examine individual regions and not clusters. Region-specific obstacles as bottlenecks, that is, lower score pillars can be identified both in higher developed regions and LDRs.

**Proposition 3** EE is optimal when the 14 pillars of REDI are harmonized. The region-specific policy should focus on increased balance of the 14 pillars of EE. Without the harmonization of the components, the EE cannot fully exploit its potential opportunities, resources are wasted, and the whole EDP is inhibited.

**Caveat 3** While classical public policy intervention is based on the alleviation of market, in this case system failures, we cannot rule out the possibility that higher-performing components could counterbalance weakly performing elements of the system.

## 4.4 | Policy optimization

While early S3 policy suggestions centered on bottom-up policies, over time, a more realistic top-down and bottom-up mix approaches have gained space (Foray, 2017, 2019). As a systemic index for entrepreneurial ecosystems underpinnings of S3, the REDI provides an opportunity for enhancing the EE by alleviating the bottlenecks and optimizing the additional resources. The PFB algorithm penalizes system pillars according to gaps exhibited by the most poorly performing pillar or pillars, that is, the bottleneck pillar(s). As explained above, the idea is that systems with strong weaknesses cannot fully leverage their strengths, or to put it another way, weakly performing bottleneck pillars hold back entrepreneurial ecosystems performance in situations where system pillars coproduce system performance. A corollary implication of this assumption is that entrepreneurship policy efforts supporting EE can work most effectively when it seeks to alleviate systemic bottlenecks. A notable advantage of REDI is its capability to show the relative size and magnitude of the bottleneck(s). Instead of further enhancing systemic strengths, it may be more effective to alleviate the bottlenecks that prevent the system from fully leveraging its strengths.

Using the logic above, we performed a set of simulations exploring the effect of regional entrepreneurship policies designed to alleviate systemic bottlenecks.

The PFB method calculation implies that the greatest improvement in system performance can be achieved by alleviating the weakest performing pillar—the bottleneck pillar. In the simulation, each bottleneck pillar is alleviated to a point where it ceases to be a bottleneck. At this point, any further effort is allocated to the second-most binding constraint within the system, again up to a point where this constraint is no longer the most binding constraint within the system. By successively alleviating most binding constraints, our simulation therefore provides an idea of how policy effort should be allocated to achieve an "optimal" outcome, defined as the largest possible increase in the REDI index score.

Our simulations seek to identify the benchmark allocation of policy effort that targets to increase the REDI index score each of the 125 EU regions by 5 REDI points.

Table 5 shows the result of our optimization exercise for the selected country regions of Denmark, Estonia, France, and Hungary. In this case, the additional units are distributed across constraining pillars until a 5-point increase in the REDI index score has been achieved in each region. The percentages indicate the distribution of additional policy effort across the constraining pillars, reflecting the relative severity of the pillars in the respective region. In Table 5 Total effort represents all the amount of the inputs that the region is spending for entrepreneurship

[6]See for eample the Entreprenurship and Innovation Programme (https://ec.europa.eu/cip/eip/index_en.htm).

**TABLE 5** Simulation of the policy allocation to increase the REDI score by some selected EU regions

| Region | DK01 | DK02 | DK04 | EE | FR1 | FR6 | FR7 | HU10 | HU21 | HU31 |
|---|---|---|---|---|---|---|---|---|---|---|
| REDI | 76.6 | 48.4 | 58.2 | 45.3 | 70.8 | 37.6 | 58.5 | 31.1 | 18.8 | 18.9 |
| Total Effort | 11.92 | 8.9 | 10.71 | 7.25 | 10.76 | 6.52 | 9.4 | 5.29 | 2.85 | 2.94 |
| Total Additional Effort | 0.231 | 0.171 | 0.099 | 0.292 | 0.286 | 0.145 | 0.144 | 0.214 | 0.508 | 0.493 |
| Opportunity Perception | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 1.80% | 2.40% |
| Startup Skills | 0.00% | 0.00% | 0.00% | 0.00% | 9.40% | 0.00% | 100.00% | 0.00% | 6.90% | 11.20% |
| Risk Perception | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 25.20% | 17.10% | 14.20% |
| Networking | 0.00% | 0.00% | 0.00% | 0.00% | 47.20% | 0.00% | 0.00% | 2.30% | 7.50% | 9.10% |
| Cultural Support | 0.00% | 0.00% | 0.00% | 46.90% | 28.30% | 0.00% | 0.00% | 70.10% | 33.10% | 32.30% |
| Opportunity Startup | 0.00% | 0.00% | 0.00% | 0.00% | 15.00% | 0.00% | 0.00% | 2.30% | 0.00% | 0.00% |
| Technology Absorption | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Human Capital | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Competition | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 6.10% |
| Product Innovation | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 7.90% | 21.70% |
| Process Innovation | 0.00% | 59.10% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 12.00% | 0.00% |
| High Growth | 50.20% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Globalization | 49.80% | 40.90% | 100.00% | 12.70% | 0.00% | 100.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Financing | 0.00% | 0.00% | 0.00% | 40.40% | 0.00% | 0.00% | 0.00% | 0.00% | 13.80% | 3.00% |

*Notes*:
DK01, DK02, DK04 = Danish NUTS2 regions, EE = Estonia, FR1, FR6, FR7 = French NUTS1 regions, HU10, HU21, HU31 = Hungarian NUTS2 regions.
Due to the manuscript length limit, we cannot present the results of the simulation to all 125 regions. In order for an illustrative demonstration, some regions of four countries at different levels of development were selected.
*Source*: own calculation.

in natural units.[7] It is the sum of the average normalized values of the 14 pillars. The percentage numbers under the pillar names are the unit (amount) of inputs necessary to add to the particular pillar value in order to reach the required alleviation of the pillar constraint. Zero value indicates that no additional input is needed, as the pillar is currently not a binding constraint. The total additional effort column provides the overall sum of the required additional units. Larger numbers indicate that more inputs are necessary for overall performance improvement in a given region, as compared to regions with lower scores. More uneven profiles are ones where significant relative differences exist across different pillars—in particular, where some pillars exhibit significantly lower values than other pillars. Thus, a more uneven profile signals the existence of more pressing constraints. In addition, an uneven profile also means that greater benefit can be achieved by focusing most of the additional policy effort into a small number of bottleneck pillars because bottleneck alleviation enables the system to more fully utilize its existing strengths. The most efficient outcome can be achieved in regions where there is one single pressing bottleneck, which is able to absorb all of the additional policy effort required to produce a five-point increase in the REDI index value.

According to Table 5, there are huge differences in the allocation of the inputs. For example, in the case of Midtjyland (DK04), the five-point increase can be produced by alleviating the *Globalization* bottleneck alone. This is reflected in the relatively small additional input allocation required (0.009 units). Other Danish regions also have such an 'uneven' profile requiring additional inputs in *Globalization*, *Finance*, *Process Innovation*, and *High growth*. In contrast, Estonia has a relatively "even" profile, and the simulation suggests that additional policy effort needs to be distributed relatively evenly across *Cultural support*, *Globalization*, and *Finance* pillars. This also means that there are few pressing bottlenecks in the Estonian region – the implication is that greater additional inputs are required to achieve a five-point increase in the Estonian entrepreneurship system performance (0.292 units). French regions show larger differences in EE as compared to Danish ones: Île de France (FR1) is one of the leading regions with well-balanced pillars. Sud-Ouest (FR6)—similar to DK4 has only one bottleneck that is *Globalization*. Centre-Est (FR7) also needs to improve only one pillar, in particular, *Startup skills*. Hungarian regions are at the bottom of the ranking, but the entrepreneurship system profiles of the country's regions show a relatively well-balanced performance. As a consequence, a high amount of additional inputs is necessary to reach a five-point increase in the REDI scores (0.214–0.520). In addition, multiple pillars need to develop in the Hungarian regions, mostly *Cultural support*, *Risk perception*, and *Financing*.

While REDI cannot mobilize local players the analysis of the individual and institutional components of the REDI pillars makes it possible to identify the lack of vital local individual and/or institutional features of the EE that could negatively affect EDP.

**Proposition 4** REDI provides a methodology on the optimal allocation of additional resources to improve regional EE. This region-specific policy mix could contribute to increased EDP and the emergence of high growth, innovative startups, and ultimately regional growth.

**Caveat 4a** REDI, by itself, is not appropriate to offer assistance on sectoral/industry specialization.

**Caveat 4b** REDI cannot provide guidance on how to promote the learning process or a solution on how to make local players involved in S3. REDI only detects the lack or the presence of particular local factors influencing EDP. If many factors are missing in the particular region then it is worth thinking about a more appropriate development strategy for S3.

[7]We use the term natural unit while it can be expressed in purchasing power parity *per capita* euro form. However, the exchange of one unit to a monetary form is unknown. This is the reason why we use the natural unit form.

## 5 | SUMMARY AND CONCLUSION

Moving away from traditional, top-down and largely uniform innovation policies, the EU has turned to a more bottom-up, region-specific, place-based policy, spearheaded by the Regional Research and Innovation Strategies for Smart Specialisation (RIS3) or simply the S3 agenda. By the mid-2010s, all EU regions have developed their own S3 priorities, although the practical implementation of S3 is still only partially successful. This has encouraged researchers and politicians to further develop S3 both from the theoretical and from the practical, policy-action sides. S3 includes industry prioritization and reliance on the entrepreneurial discovery process (EDP). While early S3 experiences focused on the industry prioritization and neglect EDP, here we aim the spotlight on EDP. While EDP is a self-governed process itself based on trials and errors, its functioning is determined by the entrepreneurship ecosystem development of the particular region. Hence, the improvement of EE could contribute to more successful EDP and therefore of the overall S3 process.

In this paper we present the Regional Entrepreneurship and Development Index (REDI), as a holistic measure of EE. Our methodology is based on a systemic and multidimensional approach, and we demonstrate how the REDI could contribute to S3 policy implementation by providing some improved solutions to four S3 policy caveats. First, we provide a measure of the entrepreneurship ecosystem for a mix of 125 NUTS 1 and NUTS2 European Union regions. If basic conditions are missing then policies should focus more on improving the entrepreneurial discovery process rather than trying to specialize. Second, REDI is able to identify institutional and individual weaknesses at local levels. Third, REDI methodology provides a comprehensive view of the harmonization of the 14 pillars of the entrepreneurship ecosystem for each region, hence able to identify potential policy domains. Fourth, with the help of the penalty for bottleneck methodology REDI presents some simulations on how additional policy efforts could be optimized over the 14 pillars to improve the REDI scores and enhance EDP. REDI based suggestions are place-based and they are parallel to the tailor-made policy nature of S3. While S3 industry prioritization is based on the identification of local strengths, REDI improvement can achieved by improving the weak features of the EE. We found that without optimizing the entrepreneurial ecosystem, the industry prioritization alone may not be successful because of the inability of the ecosystem to be able to nurture high growth potential ventures.

Even if the assumptions are restrictive it should be kept in mind that the policy portfolio simulation offers many benefits that go above and beyond what traditional indices can offer. The most important benefit is in drawing attention and highlighting system dynamics in regional EEs. This reinforces a systemic perspective to policy analysis and design over a traditional, siloed standpoint, exactly as is argued for in the smart specialization agenda. A policy scenario simulation, which highlights interconnections within the system, forces policy analysts and policy-makers to think outside individual policy silos and consider the system performance as a whole. This, then, should help smart specialization policy-makers also to think about trade-offs between different allocations of policy effort and to judge their effectiveness against a system-level performance benchmark. If correctly used, therefore, a policy portfolio simulation should facilitate agreement on system-level policy priorities for driving smart specialization by promoting awareness of different policy scenarios.

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## APPENDIX A

**TABLE A1** The description of the individual variables and indicators used in the REDI

| Individual variable | Description | Source of data |
|---|---|---|
| *Opportunity Recognition* | The percentage of the 18–64 aged population recognizing good conditions to start business next 6 months in area he/she lives, | GEM 2012–2014 |
| *Skill Perception* | The percentage of the 18–64 aged population claiming to possess the required knowledge/skills to start business | GEM 2012–2014 |
| *Risk Acceptance* | The percentage of the 18–64 aged population stating that the fear of failure would not prevent starting a business | GEM 2012–2014 |
| *Know Entrepreneurs* | The percentage of the 18–64 aged population knowing someone who started a business in the past 2 years | GEM 2012–2014 |
| *Career* | The percentage of the 18–64 aged population saying that people consider starting business as good career choice | GEM 2012–2014 |
| *Status* | The percentage of the 18–64 aged population thinking that people attach high status to successful entrepreneurs | GEM 2012–2014 |
| *Career Status* | The status and respect of entrepreneurs calculated as the average of Career and Status | GEM 2012–2014 |

(Continues)

**TABLE A1** (Continued)

| Individual variable | Description | Source of data |
|---|---|---|
| *Opportunity Motivation* | Percentage of the TEA businesses initiated because of opportunity start-up motive (rather than necessity). | GEM 2012–2014 |
| *Technology Level* | Percentage of the TEA businesses that are active in technology sectors (high or medium). and belong to the creative sector | GEM 2012–2014 |
| *Educational Level* | Percentage of the TEA businesses owner/managers having participated over secondary education | GEM 2012–2014 |
| *Competitors* | Percentage of the TEA businesses started in those markets where not many businesses offer the same product | GEM 2012–2014 |
| *New Prod* | Percentage of the TEA businesses offering products that are new to at least some of the customers | GEM 2012–2014 |
| *New Tech* | Percentage of the TEA businesses using new technology that is less than 5 years old average (including 1 year). | GEM 2012–2014 |
| *Gazelle* | Percentage of the TEA businesses having high job expectation average (over 10 more employees and 50% in 5 years). | GEM 2012–2014 |
| *Export* | Percentage of the TEA businesses where at least some customers are outside country (over 1%). | GEM 2012–2014 |
| *Informal Investment Mean* | The mean amount of 3 year informal investment | GEM 2012–2014 |
| *Business Angel* | The percentage of the 18–64 aged population who provided funds for new business in past 3 years excluding stocks & funds, average | GEM 2012–2014 |
| *Informal Investment* | The amount of informal investment calculated as INFINVMEAN* BUSANG | GEM 2012–2014 |

**TABLE A2** The description and source of the institutional variables and indicators used in the REDI indices 2017 and 2013

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| **Market Agglomeration** | Simple average of the indicators. | **Population growth** | regional | The inhabitants of a given area on 1 January of the year in question (or, in some cases, on 31 December of the previous year). . The population is based on data from the most recent census adjusted by the components of population change produced since the last census, or based on population registers. | Eurostat |
| | | **Urbanization** | country/ regional | Percentage of population living in urban areas. | World Urbanization Prospects: The 2011 Revision, Population of Urban and Rural areas and Percentage Urban; Cluster Observatory - Degree of urbanization |
| | | **Accessibility** | regional | **GDP:** It reflects the total value of all goods and services produced less the value of goods and services used for intermediate consumption in their production. Expressing GDP in PPS (purchasing power standards). eliminates | Eurostat |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | differences in price levels between countries. Calculations on a per inhabitant basis allow for the comparison of economies and regions significantly different in absolute size. | |
| | | | regional | **Total land area:** For calculation of population density, the land area (excluding inland water bodies like lakes or rivers). should be used when available. In several countries the total area, including area of lakes and rivers, is used because it is the only aspect for which data are available. | Eurostat |
| | | **Business Freedom** | country | A quantitative measure of the ability to start, operate, and close a business that represents the overall burden of regulation as well as the efficiency of government in the regulatory process. | Heritage Foundation |
| | | **Property Rights** | country | *The property rights component is a qualitative assessment of the extent to which a country's legal framework allows individuals to freely* | Heritage Foundation |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | *accumulate private property, secured by clear laws that are enforced effectively by the government*. | |
| **Quality of Education** | The average of the three PISA variables was subtracted from 100. It was multiplied with the value of Creative Class. | **PISA** | country | Low achievers in Reading of 15-year-olds.<br>Low achievers in Science of 15-year-olds.<br>Low achievers in Math of 15-years-olds. | OECD |
| | | **Creative Class** | regional | Employment in creative industries/1000 population. | Cluster Observatory |
| **Business Risk** | | **Business Extent of Disclosure Index** | country | Disclosure index measures the extent to which investors are protected through disclosure of ownership and financial information. The index ranges from 0 to 10, with higher values indicating greater disclosure, (0 = least disclosure to 10 = greatest disclosure). , for year 2012.<br>The indicators distinguish three dimensions of investor protections: transparency of related-party transactions (extent of disclosure index). , liability for self-dealing (extent of director liability index). and shareholders' ability to sue | World Bank, World Development Indicator |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | officers and directors for misconduct (ease of shareholder suits index). . The data come from a survey of corporate and securities lawyers and are based on securities regulations, company laws, civil procedure codes and court rules of evidence. | |
| **Social Capital** | The re-scaled (converted to a scale of 0 to 10). Social Capital data were multiplied with the simple average of the three indicators of Technological Readiness. | **Social Capital sub-index** | country | The sub-index measures countries' performance in two areas: social cohesion and engagement; and community and family networks. This sub-index evaluates how factors such as volunteering, helping strangers, and donating to charitable organizations impact economic performance and life satisfaction. It also measures levels of trust, whether citizens believe they can rely on others, and assesses how marriage and religious attendance provide support networks beneficial to wellbeing. | Legatum Prosperity |
| | | **Technological Readiness** | regional | Households with access to broadband. | Eurostat |
| | | | regional | | Eurostat |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | Individuals who ordered goods or services over the Internet for private use. | |
| | | | regional | Households with access to Internet. | Eurostat |
| **Open Society** | The re-scaled (converted to a scale of 0 to 10). Corruption data was multiplied with re-scaled (converted to a scale of 0 to 10). Personal Freedom data. | **Personal Freedom** | country | The Personal Freedom sub-index measures countries' performance in two areas: individual freedom and social tolerance. The Personal Freedom sub-index captures the effects of freedom of choice, expression, movement, and belief, on a country's *per capita* GDP and the subjective wellbeing of its citizens. It also assesses how levels of tolerance of ethnic minorities and immigrants impact countries' economic growth and citizens' life satisfaction. Societies that foster strong civil rights and freedoms have been shown to enjoy increases in levels of satisfaction among their citizens. When citizens' personal liberties are protected, a country benefits from higher levels of national income. | Legatum Prosperity |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | **Corruption** | regional | Data based on a standardized variable combining education (*EdCor*: region's aggregated score from survey question on the extent to which corruption persists in the education system in the region/area). , health (*HelCor*: region's aggregated score from survey question on the extent to which corruption persists in the health care system in the region/area, and general public corruption (*OtherCor*: egion's aggregated score from survey question on the extent to which respondents felt other citizens in the region/area use bribery to obtain public services). in addition to law enforcement (*LawCor*: region's aggregated score from survey question on the extent to which corruption persists in the law enforcement in the region/area). and the payment of bribes (*HelBribe*: region's aggregated score from survey question asking whether the respondents | EU QoG Corruption Index (EQI). |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | were forced to pay a bribe in the last 12 months to obtain any health care in the region/area. | |
| **Business Environment** | | **Quality of Governance** | regional | Data shows quality of government. Data based on a study on regional variation in quality of government within the EU. The dataset covers all 27 EU countries as well as 172 NUTS 1 and NUTS 2 regions within 18 of the 27 countries, thus the data is given for 181 separate units. The data for region ns was collected via a large survey of roughly 34,000 respondents in Europe. The national level estimates are taken from the World Bank Governance Indicators. The regional estimates are comprised of 16 separate indicators. | EU QoG Index (EQI). |
| | | ***Taxation*** | country | *Taxation records the taxes and mandatory contributions that a medium-size company must pay in a given year as well as the administrative burden of paying taxes and contributions.* | Doing Business |
| | | | country | | WEF |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| **Absorptive Capacity** | Firm-level Technology Absorption variable was multiplied with the average of variables related to employment in Knowledge and high-Technology Sectors. | **Firm-level Technology Absorption** | | *Technological readiness* is the 9th pillar of the Global Competitiveness Index (GCI). . The pillar contains two sub-indicators: (1). *Technological adoption* and (2). *ICT use*. The variable of *Firm-level technology absorption* is a part of the Technological readiness pillar. The variable answer the question to what extent do businesses in a country absorb new technology (1 = not at all; 7 = aggressively absorb). . | |
| | | **Employment in Knowledge and High-Tech Sectors** | regional | Employment in high-Technology Adoptions (high-tech manufacturing and knowledge-intensive services). . | Eurostat |
| | | | regional | Employment in technology and knowledge-intensive sectors. | Eurostat |
| | | | regional | Researchers, % of total employment. | Eurostat |
| | | | regional | Annual data on Human resources in science and technology (HRST). . | Eurostat |
| **Education &Training** | | **Higher Education&** | regional | Share of population aged 25–64 years with higher educational attainment. | Eurostat |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | **Training and LLL** | regional | Share of population aged 25–64 years participating in education and training. | Eurostat |
| | | ***Labour Freedom*** | country | *The labour freedom component is a quantitative measure that considers various aspects of the legal and regulatory framework of a country's labour market, including regulations concerning minimum wages, laws inhibiting layoffs, severance requirements, and measurable regulatory restraints on hiring and hours worked, plus the labour force participation rate as an indicative measure of employment opportunities in the labour market.* | Heritage Foundation |
| **Business Strategy** | The Nature of competitive advantage was multiplied with the unweighted average of the three indicators of the Business Sophistication variable. | **Nature of Competitve Advantage** | country | This data is taken from the WEF Global Competitiveness Report. *Business sophistication* is the 11th pillar of the Global Competitiveness Index (GCI). . There is no doubt that sophisticated business practices are conducive to higher efficiency in the production of goods and services. Business sophistication concerns two | WEF |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | elements that are intricately linked: the quality of a country's overall business networks and the quality of individual firms' operations and strategies. These factors are particularly important for countries at an advanced stage of development when, to a large extent, the more basic sources of productivity improvements have been exhausted. The quality of a country's business networks and supporting industries, as measured by the quantity and quality of local suppliers and the extent of their interaction, is important for a variety of reasons. When companies and suppliers from a particular sector are interconnected in geographically proximate groups, called clusters, efficiency is heightened, greater opportunities for innovation in processes and products are created, and barriers to entry for new firms are reduced. Individual firms' advanced operations and strategies (branding, | |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | marketing, distribution, advanced production processes, and the production of unique and sophisticated products). spill over into the economy and lead to sophisticated and modern business processes across the country's business sectors. The variable of *Nature of competitive advantage* is a part of the Technological readiness pillar. The data captures answers to the question: "What is the nature of competitive advantage of your country's companies in international markets based upon?" (1 = low-cost or natural resources; 7 = unique products and processes). . | (Continues) |
| | | **Employment, K-N sector** | regional | Employment in the "Financial, real estate, professional, scientific and support activities" sectors (K-N). as % of total employment. | Eurostat |
| | | **GVA, K-N sector** | regional | GVA in the "Financial, real estate, professional, scientific and support activities" sectors (K-N). as % of total GVA. | EU Regional Competitiveness Report |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | **Foreign control of enterprises** | country | Foreign control of enterprises by economic activity and a selection of controlling countries (number of enterprises/population). . | Eurostat |
| **Technology Transfer** | Unweighted average of the five innovation related indicators. | **Total patent applications** | regional | Patent applications to the EPO. Number of applications per one million inhabitants. | Eurostat |
| | | **Scientific publication** | regional | Publications per one million inhabitants (Thomson Reuters Web of Science & CWTS database (Leiden University). . | EU Regional Competitiveness Report |
| | | **High-tech inventors** | regional | High-tech patent applications to the EPO. Number of applications per one million inhabitants. | Eurostat |
| | | **ICT inventors** | regional | PCT patent applications (fractional count by inventor and priority year). in ICT. | Eurostat |
| | | **Biotechnology inventors** | regional | PCT patent applications (fractional count by inventor and priority year). in biotech. | |
| **Technology Development** | | **GERD** | regional | Gross Domestic Expenditure in Research & Development (GERD). as a percentage of GDP. | Eurostat |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | **Researchers and R&D employees in higher education sector** | regional | Researchers and R&D employees in higher education sector (% of active population). . | Eurostat |
| **Clustering** | | **Cluster Observatory Star Rating** | regional | | DG Regio |
| | | **State of cluster development** | country | In your country, how widespread are well-developed and deep clusters (geographic concentrations of firms, suppliers, producers of related products and services, and specialized institutions in a particular field). ? [1 = nonexistent; 7 = widespread in many fields] | WEF GCI |
| | | **Venture Capital Availability** | country | In your country, how easy is it for entrepreneurs with innovative but risky projects to find venture capital? [1 = extremely difficult; 7 = extremely easy] | WEF GCI |
| **Connectivity** | | **Infrastructure Sub-index** | regional | - Motorway density (average pop/area). . EU27 = 100, Eurostat/ | EU Regional Competitiveness Report |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | DG TREN/ EuroGeographics/ National Statistical Institutes.<br>- Railway density (average pop/area). , EU27 = 100, Eurostat/DG TREN/ EuroGeographics/National Statistical Institutes.<br>- Number of passenger flights, daily number of passenger flights (accessible within 90-minute drive). , Eurostat/ EuroGeographics/National Statitical Institutes. | |
| | | **Economic complexity index** | country | The ECI reflects to the knowledge accumulated in a country and it is captured by the country's industrial composition. Hence, ECI combines together the metrics of the diversity of countries and the ubiquity of products to create measures of the relative complexity of a country's exports. | Hidalgo - Hausmann |
| **Financing** | Depth of Capital Market country level data were multiplied with the Concentration of Financial Services variable. | **Depth of Capital Market** | country | The Depth of Capital Market is one of the six sub-indices of the Venture Capital and Private Equity index. This variable is a complex measure of the size and | The Global Venture Capital and Private Equity Country Attractiveness Index (2013). |

**TABLE A2** (Continued)

| Institutional variable | Calculation | Indicators | Level | Description | Original source |
|---|---|---|---|---|---|
| | | | | liquidity of the stock market, level of IPO, M&A and debt and credit market activity | |
| | | **Concentration of Financial Sector** | regional | Regional employment in financial services sector as percentage of total regional employment. | Cluster Observatory |

**TABLE A2** Continued

| Institutional variable | REDI 2013 | REDI 2017 | Data availability | Notes |
|---|---|---|---|---|
| Market Agglomeration | 2005–2012 | 2013–2015 | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | 2011; 2010–2011 | 2014 (for countries). ,2011 (for regions). | http://www.clusterobservatory.eu/index.html http://esa.un.org/unpd/wup/CD-ROM/ | |
| | million EUR, 2010 | 2011–2013 | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | 2010 | 2011–2015 | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | 2013 | average 2014–2015 | http://www.heritage.org/index/download | |
| | average of 2007–2011 | average of 2012–2016 | http://www.heritage.org/index/property-rights | |
| Quality of Education | 2006 | 2012 | http://gpseducation.oecd.org/IndicatorExplorer? | http://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/33690591.pdf<br>http://stats.oecd.org/#<br>https://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/34002216.pdf |
| | 2005–2011 | *2005–2011* | http://www.clusterobservatory.eu/index.html#!view=mainMenu | |
| Business Risk | 2012 | 2013–2015 | http://data.worldbank.org/indicator/IC.BUS.DISC.XQ | |
| Social Capital | 2011 | 2012–2015 | http://www.prosperity.com/#!/?opts=2Ekxmx-Ulx3y1 | |
| | 2011 | 2012–2015 | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | 2011 | 2012–2015 | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | 2011 | 2012–2015 | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| Open Society | 2011 | 2012–2015 | | |

**TABLE A2** (Continued)

| Institutional variable | REDI 2013 | REDI 2017 | Data availability | Notes |
|---|---|---|---|---|
| | | | http://www.prosperity.com/#!/?opts=2Ekxmx-Ulx3y1 | |
| | 2010 | 2013 | http://qog.pol.gu.se/data/datadownloads/qogeuregionaldata | RO3 = instead of 0 (technical). 0,05 |
| Business Environment | 2010 | 2013 | http://qog.pol.gu.se/data/datadownloads/qogeuregionaldata | NL, FR, IT, RO, AT, PL = only available for NUTS2, calculated population weighted average; HU, SE = only available for NUTS1, SI = only available for NUTS0; ITH = instead of 0 (technical). 0,05; rescaled 0–10 scale |
| | average of 2010–2012 | average of 2013–2016 | http://www.doingbusiness.org/data/distance-to-frontier | |
| Absorptive Capacity | GCI Report 2012/2013 | GCR Reports 2013–2014 and 2014–2015 | http://reports.weforum.org/global-competitiveness-report-2015-2016/ | Average of 2012–2013 weighted average and 2013–2014 weighted average data, 2014–2015 weighted average data = 2013–2014 weighted average data |
| | 2007–2008 | 2009–2013 (% of total employment). | http://appsso.eurostat.ec.europa.eu/nui/show.do | PT15 missing |
| | 2011 | 2014 (% of total employment). | http://appsso.eurostat.ec.europa.eu/nui/show.do | PT15 missing |
| | 2009 | 2010–2013 (% of active population). | http://appsso.eurostat.ec.europa.eu/nui/show.do | EL1, EL2, FR1–8 = missing |
| | 2011 | 2012–2014 average (% of population). | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| Education &Training | 2011 | 2012–2014 (%). | http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tgs00109&plugin=1 | |
| | 2011 | 2012–2014 (%). | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | average of 2007–2011 | average of 2012–2016 | http://www.heritage.org/index/labour-freedom | |
| Business Strategy | GCI Report 2012/2013 | GCR Reports 2013–2014, 2014–2015, 2015–2016 | http://reports.weforum.org/global-competitiveness-report-2015-2016/ | average of 2012–2013 weighted average and 2013–2014 weighted averag data and 2014–2015 weighted average data |

(Continues)

**TABLE A2** (Continued)

| Institutional variable | REDI 2013 | REDI 2017 | Data availability | Notes |
|---|---|---|---|---|
| | 2011 | 2012–2015 | | eariler variable contained only J_K secotrs |
| | 2007 | 2010 | | eariler variable contained only J_K secotrs |
| | 2008–2011 (% of population). | 2008–2013 (% of population). | | earlier variable: New foreign firms per (mill.). inhabitants (EU Regional Competitiveness Report). (no further data). |
| Technology Transfer | 2008–2009 | 2010–2012 (per million inhabitants). | http://appsso.eurostat.ec.europa.eu/nui/show.do | |
| | 2010 | 2008–2010 (per one million inhabitants). | http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/6th_report/rci_2013_report_final.pdf | |
| | 2008–2009 | 2010–2012 (per one million inhabitants). | http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do | HR03 = missing |
| | 2010 | 2011–2012 (per one million inhabitants). | http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=pat_ep_rict&lang=en | ES23, PT15, HR03 = missing |
| | 2010 | 2011–2012 (per one million inhabitants). | http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do | Missing: ES42, HU22, HU23, RO2, RO3, IE01, HR03, SK03; earlier version: OECD, but available only 2011 |
| Technology Development | 2009 | 2010–2013 (% of GDP). | http://appsso.eurostat.ec.europa.eu/nui/show.do | earlier version: OECD, but available only 2011 |
| | average of 2007–2011 | average of 2012–2013 | http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tgs00043&plugin=1 | |
| Clustering | no data | 2011 | | http://ec.europa.eu/DocsRoom/documents/17982 HR, SI, IE, FI1B, FI1C = missing |
| | average of 2007–2011 | average of 2012–2015 | http://reports.weforum.org/global-competitiveness-report-2015-2016 | |
| | 2007–2012 | 2012–2016 | http://reports.weforum.org/global-competitiveness-report-2015-2016/ | |
| Connectivity | 2010 | 2013 | | |

**TABLE A2** (Continued)

| Institutional variable | REDI 2013 | REDI 2017 | Data availability | Notes |
|---|---|---|---|---|
| | | | http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/6th_report/rci_2013_report_final.pdf | |
| | **2007–2011** | **2012–2014** | http://atlas.media.mit.edu/en/ | |
| **Financing** | **2013** | **2015** | http://blog.iese.edu/vcpeindex/ | |
| | **2005–2011** | **2012–2014 (Eurostat data).** | http://appsso.eurostat.ec.europa.eu/nui/show.do | PT15 = missing |