The Regional Entrepreneurship and Development Index: Structure, Data, Methodology and Policy Applications

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List of Abbreviations

ABT	Entrepreneurial Abilities sub-index
ANOVA	Analysis of variance
ASP	Entrepreneurial Aspirations sub-index
ATT	Entrepreneurial Attitudes sub-index
c-alpha	Cronbach Coefficient Alpha
EC	European Commission
EEA	European Economic Area
EIS	European Innovation Scoreboard
EQI	European Quality of Government Index
ESPON	European Observation Network for Territorial Development and Cohesion
GCI	Global Competitiveness Index
GEDI	Global Entrepreneurship and Development Index
GEI	Global Entrepreneurship Index
GEM	Global Entrepreneurship Monitor
GERD	Gross Domestic Expenditure on R&D
GII	Global Innovation Index
MRC	Marginal Rate of Compensation
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
OWA	Ordered Weighted Averaging
PFB	Penalty for Bottleneck
PISA	Programme for International Student Assessment
QoG	Quality of Government Index
R&D	Research and Development
RCI	Regional Competitiveness Index
REDI	Regional Entrepreneurship and Development Index
RII	Regional Innovation Index
RIS	Regional Innovation Scoreboard
SE	System of Entrepreneurship
TEA	Total Early-Stage Entrepreneurial Activity
Tukey HSD	Tukey's Honest Significance Difference
VC	Venture Capital
WEF	World Economic Forum

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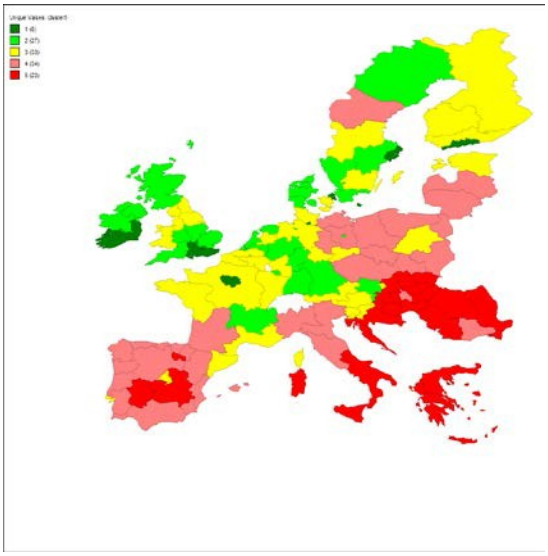
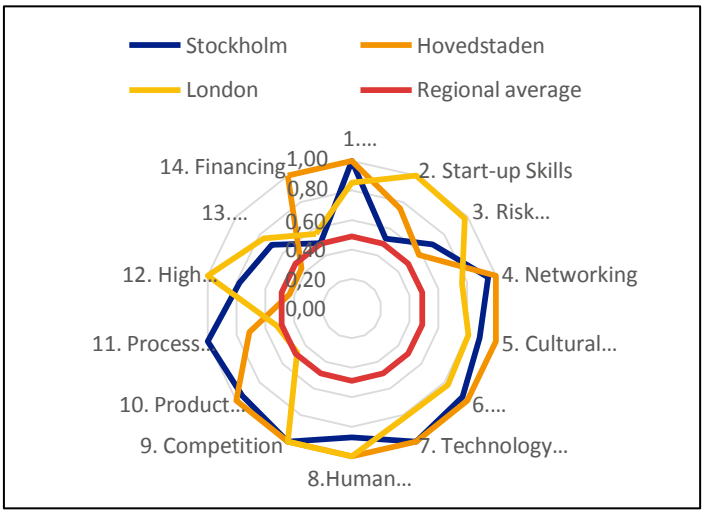
Executive summary

In this technical report, we deliver a full description of the new Regional Entrepreneurship and Development Index (REDI) dataset, and of the calculation methodology. This report is an amended and renewed version of the previous REDI report (Szerb et al., 2014). After a general introduction of the index the report goes into the technical details of data collection and manipulation before presenting the index for 125 NUTS 1-2 regions in 24 EU member states.

The policy relevance of the index is then illustrated in a policy simulation in which we investigate where regions should prioritize their policy efforts to improve the quality of their entrepreneurial ecosystem. Although our index is no substitute for common sense and results should always be treated with the appropriate caution, the REDI-index clearly points policy makers at the EU-, the national and the regional level to the weaknesses they should address with priority to make the transition to a more Entrepreneurial Society. The map below, reproduced from the report, clearly shows the pattern of entrepreneurial system quality in Europe. It closely matches the well-known core-periphery pattern in the EU, but by zooming in on regions, we can also see that islands of high quality entrepreneurial ecosystems do exist in the South and East, concentrated on major urban centers.



There is more to the index than just the overall score. We can illustrate how to use and interpret the REDI-index by looking at figure 5, reproduced below. In this figure, it is shown that Stockholm's weakest links in the entrepreneurial system are found on pillars Startup Skills and Financing, whereas Hovedstaden (Copenhagen) in contrast lacks in Risk Acceptance, Globalization and High Growth, while London seems relatively weak in Product and Process Innovation. Of course, graphically depicting all 125 regions does not generate useful results, but more sophisticated statistical analysis can be used to identify EU, national and region specific policy priorities. The analysis in the report contains too much detail and richness to be captured in general terms in an executive summary. The main conclusion one should draw at this point is that the index presented in this report is a vital tool in developing and evaluating tailor made entrepreneurship policies for EU-regions.



1. Introduction

The most important aim of this report is to justify the rationale behind the Regional Entrepreneurship and Development Index (REDI) and illustrate its usability for policy planning and actions. The report devotes attention to the description of the related methodological issues and the data used as well.

Following Acs et al. (2014), we define the System of Entrepreneurship as follows: *"A System of Entrepreneurship (SE) is the 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"* (Acs et al., 2014, p. 480). REDI was developed to assess the SE at the regional level (Szerb et al., 2014). The definition above implies that REDI conceptualizes entrepreneurship as a trial-and-error process of knowledge spillovers and resource allocation which is driven by individuals and regulated by context and which drives the allocation of resources towards productive use in the economy (Qian et al., 2013).

To compose the REDI index we collected a large scale of relevant data and combined it in a unique way to assess the quality of SE by region. According to our knowledge, REDI is the only index which can serve as an instrument to evaluate and compare the state of European entrepreneurial ecosystems at the regional level. Apart from identifying the strengths and weaknesses of a particular geographical unit, the novel index building approach that we applied makes it possible to provide tailor-made rather than uniform solutions to the problem of how to develop entrepreneurship as well.

EU policies related to SMEs and entrepreneurship, including those emerging from EU Cohesion Policy, are at the core of Europe 2020 economic growth strategy, under the objective of Smart Growth (McCann and Ortega-Argilés, 2016). From this broader umbrella emerges the Entrepreneurship 2020 Action Plan which is a blueprint for decisive action to reignite the entrepreneurial spirit in Europe. It is built on three main pillars: entrepreneurial education and training to support growth and business creation; strengthening framework conditions for entrepreneurs by removing the existing structural barriers and supporting them at different stages of their business lifecycle; and dynamising the culture of entrepreneurship in Europe by nurturing the new generation of entrepreneurs, additionally reaching out to specific groups whose entrepreneurial potential is not being tapped to its fullest extent or who are not reached by traditional outreach for business support is also under their priorities (European Commission, 2012).

The reforms to European Cohesion Policy have sought to place entrepreneurship center-stage via the introduction of the 'smart specialization' strategy (European Commission, 2012; McCann and Ortega-Argilés 2013, 2015, 2016). Entrepreneurship, and in particular its role on fostering innovation, is now seen as being key to the new EU smart growth and development agenda. All European regions and member states, and the richer regions in particular, are required to use the lion's share of their EU Cohesion Policy resources for enhancing entrepreneurship and upgrading the performance of SMEs (Foray et al., 2012; European Commission, 2013). Indeed, the 'smart specialization conditionality' is now a legal requirement which must be adhered to by regions in order to draw on

the Cohesion funds from Brussels and this requires local and regional policy-makers, working alongside entrepreneurs and businesses, to develop tailored policy settings aimed at maximizing local entrepreneurial search processes (European Commission, 2014; McCann and Ortega-Argilés 2013, 2015, 2016).

In order to design tailor-made policies, it is essential to use the best available evidence to develop appropriate data baselines on which targets can be set and policies can be developed. Therefore, the knowledge of specific strengths and weaknesses of the individual regional entrepreneurial system is essential. In terms of the various possible facilitating or inhibiting influences on entrepreneurship, EU regions are seen to vary enormously according to many different characteristics. The specific knowledge required to build tailored policy settings cannot be gained simply by using cross-region or cross-country entrepreneurship, innovation or competitiveness league-tables, but rather needs to be constructed on the basis of the specific features and elements evident in the local entrepreneurial system. Moreover, approaches to analyzing regional entrepreneurship which focus on various influences without considering the systemic and contextual nature of entrepreneurship will fail to provide the relevant information and evidence on which tailored policy-settings can be built. As such, in Europe the need for the type of empirical approach offered by REDI is very pressing.

The most important benefit of REDI is in drawing attention to and highlighting system dynamics in Regional Systems of Entrepreneurship. As a systemic index, REDI combines information on 14 pillars that support a regional entrepreneurship system. This permits the introduction of experimentation in policy design by the exploration of different policy scenarios. Because of the Penalty for Bottleneck (PFB) algorithm, one tempting use of the REDI index is in exploring alternative scenarios for enhancing the entrepreneurial performance of the Regional System of Entrepreneurship – as captured by the REDI index. This is because the PFB algorithm penalizes system pillars according to gaps exhibited by the most poorly performing pillar – i.e. the bottleneck pillar. The idea is that systems with strong weaknesses cannot fully leverage their strengths: to put another way, weakly performing bottleneck pillars hold back system performance in situations where system pillars coproduce system performance. A corollary implication of this assumption is that policy effort is allocated most effectively when it seeks to alleviate systemic bottlenecks. Instead of further enhancing systemic strengths, it may be more effective to alleviate the bottlenecks that prevent the system from fully leveraging its strengths. This reinforces a systemic perspective to policy analysis and design over a traditional, siloed standpoint.

Index-building is a complex task that faces several potential pitfalls, starting with the vague and various definitions of a concept like entrepreneurship. Our approach to measuring entrepreneurship is based on three important premises which provide an appropriate platform for analyzing entrepreneurial ecosystems. Firstly, entrepreneurship is fundamentally action undertaken and driven by agents – and so individual level data is needed to show the dynamics of an entrepreneurial ecosystem. Secondly, individual action is controlled by an institutional framework for entrepreneurship – and so relevant institutional level data are also needed for the same purpose. Thirdly, such ecosystems are complex, multifaceted structures in which many elements interact to enable the systems to function, and so the index method needs to allow these elements to interact.

Moreover, REDI is a regional level index. Recent research reinforces the view that the distribution of entrepreneurial activity and entrepreneurship are spatially unbalanced (Acs, 2010; Audretsch and Fritsch, 2002; Fritsch and Schmude, 2006; Feldman, 2001; Sternberg, 2012). Our emphasis on the controlling influence of the institutional context implies that entrepreneurship is best studied at levels which transcend the individual decision to involve oneself in such activity. Whilst many rules and regulations may exist at national level, there are other related contexts such as human capital, finance, education, networking/clustering, innovation etc., in which a level below the national is more appropriate (Feldman, 2001; Stam, 2007; Sternberg, 2012; Henrekson and Johansson, 2011; Westlund and Bolton, 2003; Kerr and Nanda, 2009). The Regional Entrepreneurship and Development Index (REDI) methodology is based on the Global Entrepreneurship Index (GEI), which measures the entrepreneurial system at the country-level. To create the REDI indicators, the GEI data had to be modified to reflect regional conditions. So, in addition to country-level data, the indicators now also include regional institutional and individual variables. REDI is now implemented to measure the entrepreneurial performance of a mixture of 125 NUTS1 and NUTS2 EU regions, a process which includes changes to the environmental and institutional variables to reflect the regional forces of agglomeration, connectivity and clustering (Komlósi et al., 2015).

Thus, with the creation of the REDI index, our main objectives were (1) to identify the crucial regional drivers of the entrepreneurial "discovery" process, (2) to emphasize the system-characteristics of these identified drivers, (3) to find adequate regional (or country-level) variables and proxies, and (4) to provide a useful tool to analyze alternative entrepreneurship policy scenarios. A careful review of the literature [2] and the available data has shown that in fourteen pillars we can cover the most relevant aspects of the SE and reach these objectives Each pillar is created as a combination of individual- and institutional-level data. A careful scrutiny of the relative differences between individual pillars, both within a given region and across benchmark regions, should provide good initial guidance for the search for prospective strengths and weaknesses across regions.

The variables or indicators of complex indices are generally selected by integrating experts' judgment, data availability and checks on statistical consistency. So it is the situation with the REDI. To create the REDI index, we took all relevant variables in GEM that measure or relate to the entrepreneurship we are interested in and regionalized that data to NUTS 1 and NUTS 2 regions of 24 EU countries. Then, we matched those with fitting institutional variables available following the below selection procedure:

1. The potential to link logically to the particular entrepreneurship variable;
2. The clear interpretation and explanatory power of the selected variable; for example, we have had interpretation problems with the taxation variables;
3. Avoiding the appearance of the same factor more than once in the different institutional variables[3]; and
4. The pillar created with the particular variable should in the end positively correlate to the overall REDI-score.

[2] For more details about the literature see section 3.3.

[3] There is only one duplication in the data set we could not avoid: The corruption appears in the Corruption in the Social capital institutional variable and also in the EU QoG INDEX.

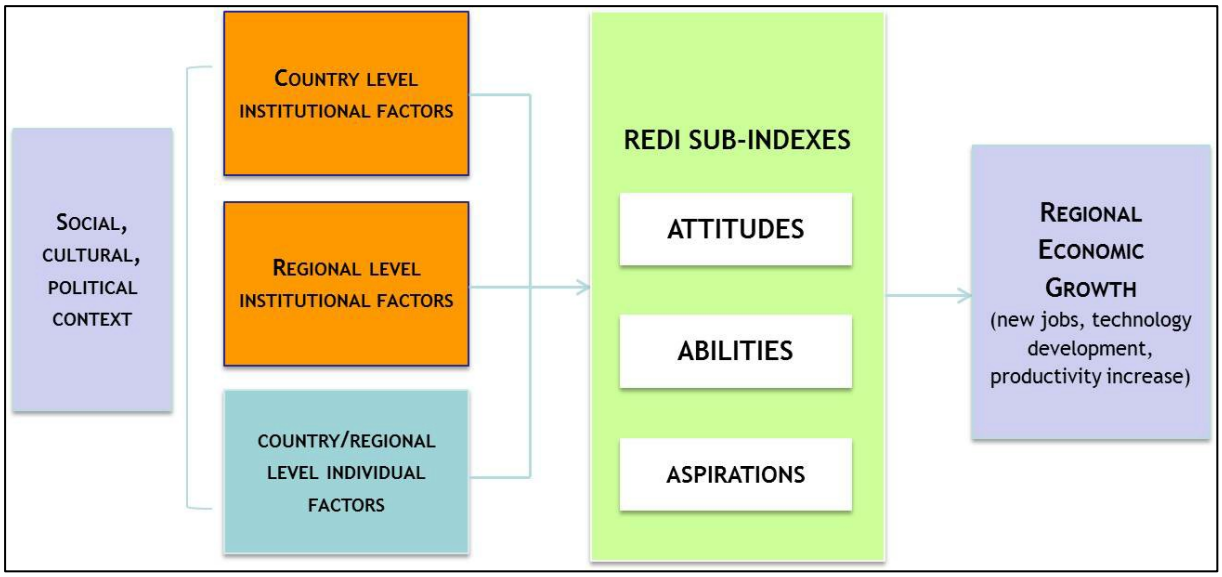
This method inevitably involved a degree of arbitrariness and expert judgement, but we have carefully reduced that by discussing the choices made in a wide circle of experts and doing robustness analyses including the calculation of the REDI scores by different combinations of the individual and institutional data.

After this introduction, we present the structure of the REDI index in detail and summarize the most important steps of our index creation. We also provide a detailed description of and the rationale behind the 76 sub-indicators and 14 pillars we used to calculate the REDI scores for the mix of 125 NUTS 1 and NUTS 2 regions of 24 European Union countries. In the analytical part of the report we present the REDI index scores and rankings followed by the technical investigation of the sub-indices, pillars and different combinations of the data. Later, the REDI index scores are compared to various regional indicators. Finally, we illustrate how the REDI can be used to evaluate different policy scenarios.

2. The structure of the Regional Entrepreneurship and Development Index

The Regional Entrepreneurship and Development Index (REDI) captures the contextual dimensions of regional entrepreneurship. The Regional Entrepreneurship and Development Index (REDI) methodology is based on the Global Entrepreneurship Index (GEI), which measures entrepreneurship at country-level (see Acs et al, 2013; Acs et al., 2014). To create the REDI, the institutional and individual indicators of the GEI data had to be adapted to reflect regional conditions. Therefore, besides the county-level data the indicators are amended with regional institutional and regionalized individual variables (*Figure 1*).

Figure 1. The Regional Entrepreneurship and Development Index (REDI) conceptual model



Source: own editing.

Compared to its last version (Szerb et al., 2014), the index building methodology and the organization principle of the REDI index have not been changed. The datasets were updated and some of the institutional variables, indices and sub-indices were modified or based on different data (see next chapter for more details).

Based on the definition of entrepreneurship and the conceptual model we proposed, we keep the six level index-building approach: (1) sub-indicators, (2) indicators, (3) variables, (4) pillars, (5) sub-indices, and, finally, (6) the REDI index. The three sub-indexes of attitudes, abilities, and aspirations constitute the entrepreneurship super-index, which we call the Regional Entrepreneurship and Development Index (REDI). The sub-indices are composed of the pillars. Pillars are the most important layers in the index structure because they provide the basis of the Penalty for Bottleneck (PFB) analysis and entrepreneurship policy (see the next chapter). Each of the fourteen pillars consists of an institutional and an individual variable. *Table 1* provides a more detailed picture of the

sub-indices, its pillars and variables. Variables are built up of 36 indicators. Some institutional indicators are complex creatures by themselves adding up to 76 sub-indicators altogether (For more details see Appendices A and B).

Table 1. The structure of the Regional Entrepreneurship and Development Index

	Sub-indexes	Pillars	Variables (ind./inst.)
REGIONAL ENTREPRENEURSHIP INDEX	ATTITUDES SUB-INDEX	OPPORTUNITY PERCEPTION	*OPPORTUNITY RECOGNITION*
			MARKET AGGLOMERATION
		STARTUP SKILLS	*SKILL PERCEPTION*
			QUALITY OF EDUCATION
		RISK ACCEPTANCE	*RISK PERCEPTION*
			BUSINESS RISK
		NETWORKING	*KNOW ENTREPRENEUR*
			SOCIAL CAPITAL
		CULTURAL SUPPORT	*CARRIER STATUS*
			OPEN SOCIETY
	ABILITIES SUB-INDEX	OPPORTUNITY STARTUP	*OPPORTUNITY MOTIVATION*
			BUSINESS ENVIRONMENT
		TECHNOLOGY ADOPTION	*TECHNOLOGY LEVEL*
			ABSORTIVE CAPACITY
		HUMAN CAPITAL	*EDUCATIONAL LEVEL*
			EDUCATION AND TRAINING
		COMPETITION	*COMPETITORS*
			BUSINESS STRATEGY
	ASPIRATION SUB-INDEX	PRODUCT INNOVATION	*NEW PRODUCT*
			TECHNOLOGY TRANSFER
		PROCESS INNOVATION	*NEW TECHNOLOGY*
			TECHNOLOGY DEVELOPMENT
		HIGH GROWTH	*GAZELLE*
			CLUSTERING
		GLOBALIZATION	*EXPORT*
			CONNECTIVITY
		FINANCING	*INFORMAL INVESTMENT*
			FINANCIAL INSTITUTIONS

Note: Individual variables are marked in white while institutional ones are marked in grey background.

3. Data sources and variable calculation

As mentioned previously, our entrepreneurship index incorporates both individual-level and institutional/environmental variables. Here we provide a full description of the data sources, the data collection method and the calculation of the variables from the indicators and sub-indicators. Finally, we deliver the general description of the variable and the sub-indices.

To give a full picture on the rationale behind the REDI data, here, we describe the super-index in a bottom-up fashion.

According to our knowledge, GEM APS (Global Entrepreneurship Monitor Adult Population Survey) is the only representative, cross-national survey on entrepreneurial activities, aptitudes and skills. Therefore, the individual data is fully based on the relevant GEM APS (Global Entrepreneurship Monitor Adult Population Survey) results. Moreover, we have taken into consideration all the relevant GEM data. Thus, mostly the available GEM data shaped the variable structure of the REDI index.

The GEM dataset lacks the necessary institutional/environmental data to create the described REDI index. The adaption of the country-level institutional GEDI variables for regional analyses proved to be not possible either, because not all the variables were available on a regional level.

A potential criticism of our method – as with any other index – might be the apparently arbitrary selection of institutional variables and the neglect of other important factors. In all cases, we aimed to collect and test alternative institutional factors before making our selection.

Our choices were constrained by the limited availability of institutional data in many regions. Several solutions exist to overcome this limitation. One possibility is to use closely correlated regional proxies to substitute missing variables.

As mentioned in the Introduction, the selection criteria for a particular institutional/environmental variable were:

1. The potential to link logically to the particular entrepreneurship variable;
2. The clear interpretation and explanatory power of the selected variable;
3. Avoiding the appearance of the same factor more than once in the different institutional variables[4];
4. The pillar created with the particular variable should positively correlate to the REDI.

Finally, the variables were organized into pillars based on our definition of entrepreneurship (see the Introduction).

[4] There is only one duplication in the data set we could not avoid: The corruption appears in the Corruption in the Social capital institutional variable and also in the EU QoG INDEX.

3.1. REDI individual data description

Table 3 contains the full list and the detailed description of the REDI individual-level variables and indicators. To get the total of the available informal startup capital of a region, the *Informal Investment* variable - by the multiplication of the mean amount of informal investment (Informal Investment Mean) and the prevalence of informal investment (Business Angel) - combines the two aspects of informal finance, namely the amount and its frequency. The Carrier Status variable is the average of the GEM Carrier and Status scores. All the other remaining REDI variables are based on a single GEM input score.

Table 2. GEM Adult Population Survey Details by Country

Individual variable	Description
Opportunity Recognition	The percentage of the 18-64 aged population recognizing good conditions to start business next 6 months in area he/she lives,
Skill Perception	The percentage of the 18-64 aged population claiming to possess the required knowledge/skills to start business
Risk Perception	The percentage of the 18-64 aged population stating that the fear of failure would not prevent starting a business
Know Entrepreneurs	The percentage of the 18-64 aged population knowing someone who started a business in the past 2 years
Career	The percentage of the 18-64 aged population saying that people consider starting business as good career choice
Status	The percentage of the 18-64 aged population thinking that people attach high status to successful entrepreneurs
Career Status	The status and respect of entrepreneurs calculated as the average of Career and Status
Opportunity Motivation	Percentage of the TEA (Total Early-Stage Entrepreneurial Activity) businesses initiated because of opportunity startup motive
Technology Level	Percentage of the TEA businesses that are active in technology sectors (high or medium)
Educational Level	Percentage of the TEA businesses owner/managers having participated over secondary education
Competitors	Percentage of the TEA businesses started in those markets where not many businesses offer the same product
New Product	Percentage of the TEA businesses offering products that are new to at least some of the customers
New Technology	Percentage of the TEA businesses using new technology that is less than 5 years old average (including 1 year)
Gazelle	Percentage of the TEA businesses having high job expectation average (over 10 more employees and 50% in 5 years)
Export	Percentage of the TEA businesses where at least some customers are outside country (over 1%)
Informal Investment Mean	Amount of informal investment
Business Angel	The percentage of the population aged 18-64 who provided funds for new business in past 3 years, excluding stocks and funds, average
Informal Investment	The amount of informal investment calculated as INFINVMEAN* BUSANG

Source: Own creation

The REDI 2017 individual variables are based on the pooled 2012-2014 GEM Adult Population Survey (APS) results. The GEM APS is a yearly, representative national sample of at least two thousand adults aged between 18 and 99. It includes all geographic regions of the countries involved; urban and rural areas as well.

It should be noted that most of the countries participated in the GEM survey all three years between 2012 and 2014. Austria and Denmark took the survey in 2012 and 2014 while Czech Republic joined the assessment network only for 2013. Table 4 shows the individual data sources and sample sizes as well.

Table 3. GEM Adult Population Survey Details by Country

Country		REDI 2013		REDI 2017		Basic Class.	No. of regions
		Sample size	Years	Sample size	Years		
AT	Austria	1996	2007	9102	2012; 2014	NUTS1	3
BE	Belgium	9811	2007-2009; 2011	6015	2012-2014	NUTS1	3
HR	Croatia	8516	2007-2011	6000	2012-2014	NUTS2	3
CZ	Czech Republic	2005	2011	4967	2013	NUTS1	1
DK	Denmark	9975	2007-2011	4225	2012; 2014	NUTS2	5
EE	Estonia	1721	2012*	6365	2012-2014	NUTS2	1
FI	Finland	10034	2007-2011	6043	2012-2014	NUTS2	5
FR	France	7994	2007-2011	8010	2012-2014	NUTS1	8
DE	Germany	10743	2008-2011	14607	2012-2014	NUTS1	16
EL	Greece	9962	2007-2011	6000	2012-2014	NUTS1	4
HU	Hungary	9417	2007-2011	6003	2012-2014	NUTS2	7
IE	Ireland	5823	2007-2008; 2011	5801	2012-2014	NUTS2	2
IT	Italy	10925	2007-2010	6052	2012-2014	NUTS1	5
LV	Latvia	10015	2007-2011	4000	2012-2013	NUTS2	1
LT	Lithuania	2003	2011	6003	2012-2014	NUTS2	1
NL	Netherlands	12484	2007-2011	8730	2012-2014	NUTS1	4
PL	Poland	2000	2011	6004	2012-2014	NUTS1	6
PT	Portugal	6036	2007; 2010-2011	6009	2012-2014	NUTS2	3
RO	Romania	8453	2007-2011	6007	2012-2014	NUTS1	4
SK	Slovak Republic	2000	2011	5987	2012-2014	NUTS2	4
SI	Slovenia	14090	2007-2011	6016	2012-2014	NUTS2	2
ES	Spain	127733	2007-2011	70300	2012-2014	NUTS2	17
SE	Sweden	6122	2007; 2010-2011	7477	2012-2014	NUTS2	8
UK	United Kingdom	72296	2007-2011	15024	2012-2014	NUTS1	12
Total		362154		230747			125

Note: In the case of Estonia data from 2012 have been used for calculation REDI 2013.

To calculate the individual indicators we used the GEM weights for both time periods analysed. GEM created weigh variables to correct the under- or overrepresentation of a particular age/gender group in each European NUTS1 and NUTS2 regions. The age groups considered were 18–24 years, 25–34 years, 35–44 years, 45–54 years and 55–64 years. Thus, individual cases have been aggregated bearing in mind discrepancies in regional age & gender patterns between the GEM Adult Population Survey samples and Eurostat data.

For 24 EU countries it was possible to create a regional representation of the GEM dataset. The exceptions are Bulgaria, Cyprus, Luxembourg, and Malta. In the case of 10 countries, GEM data were

regionalized at NUTS 1 (Annex C describes the NUTS system) level (Austria, Belgium, Greece, France, Germany, Italy, Netherlands, Poland, Romania, and United Kingdom). For four additional countries the country level classification was equal to the NUTS 1 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 "Continente" NUTS 1 region. For Spain, the two small African continent NUTS 2 regions, Ceuta and Melilla were also excluded. Thus, we have calculated the REDI for 24 countries which altogether contain a mix of 125 NUTS 1 and NUTS 2 regions[5]. For the REDI indicators this territorial classification was adopted consistently. Annex D lists the regions' names with their abbreviations by country.

By the sample sizes given this way, the 95% confidence level and 5% confidence interval were not reached only by four German and two Portugal regions. Nevertheless, these regions' confidence interval, at 95% confidence level, is close to the 5% threshold value: Bremen (8.8), Hamburg (5.3), Mecklenburg-Vorpommern (5.6), Saarland (7.2), Algavre (6.2) and Alentejo (5.4).

For more information on the GEM methodology and variables we refer to Reynolds et al (2005) and Bosma (2013). Bosma (2013) provides an update on the methodology and lists and discusses the academic articles that are (partly) based on GEM data.

3.2. REDI institutional data description

We have completed the institutional indicators and sub-indicators with relevant data from the followings sources:

- EUROSTAT Regional Database
- United Nations, Department of Economic and Social Affairs, Population Division
- EU Regional Competitiveness Index (Annoni–Kozovska, 2010; Annoni–Dijkstra, 2013)
- World Bank – World Development Index, Doing Business
- Legatum Prosperity Index,
- World Economic Forum,
- EU QoG Corruption Index (Charron et al. 2013, 2014a, 2014b, 2016),
- Heritage Foundation database,
- ESPON database,
- Cluster Observatory database,
- DG Regio Individual Dataset (not-published),
- Groh et al (2012) Global Venture Capital and Private Equity Country Attractiveness Index,
- OECD-PISA database,
- Observatory of Economic Complexity.

[5] In this respect it should also be noted that NUTS classifications are not always equally comparable in terms of region/population sizes; in fact for some countries a mix between NUTS 1/NUTS 2 or NUTS 2/NUTS 3 may be beneficial, dependent on the purpose of the analysis. For instance, the NUTS 1 region of Bremen is mostly limited to the core urban area and is much smaller in scope than for example the large NUTS 1 region of Bavaria, which includes Munich.

The full description of the institutional variables, indicators and sub-indicators as well as their level and source can be found in Appendix A and B. Compared to the earlier version of the REDI (see Szerb et al., 2014), some of the institutional variables, indicators or sub-indicators have been modified. Appendix E explains the changes in details.

For the REDI 2017, we applied the most recent institutional indicators available on August 31. 2016. Appendix B contains the year or the time period of each REDI 2013 and REDI 2017 indicator as well. Appendix B also reflects that, to eliminate potential duplications, instead of using existing complex institutional variables, we have created our own complex variables using simple indicators or sub-indicators.

- In eleven cases – Market Agglomeration, Quality of Education, Social Capital, Open Society, Business Environment, Absorptive Capacity, Education and Training, Business Environment, Clustering, Connectivity and Financial Institutions – the application of a complex measure (using both country level and regional level indicators) proved to be more fitting than using one single indicator. Most of these indicators are complex by themselves. For example the Business Environment variable consists of the Business Freedom country level and the EU QoG INDEX regional level indicators. The Business Freedom is the most composite indicator including ten sub-indicators. The EU QoG INDEX reflecting the quality of the government in a particular region contains four sub-indicators.

- For the calculation of Technology Transfer and Technology Development, regional level institutional indicators were available.

- For the evaluation of Business Risk we could identify one country level index which measures the extent to which investors are protected through disclosure of ownership and financial information.

- In three cases, instead of using whole existing complex index, we applied only sub-indices that were more relevant to entrepreneurship: for example Business Freedom is a component of the Index of Economic Freedom, Social Capital Sub-Index is a subset of the Legatum Prosperity Index, and the Depth of capital market is a sub-index of the Venture Capital and Private Equity Index.

As a general rule of regional level institutional variable calculation, if data were not available at NUTS 1 level, we calculated the population weighted mean of the available NUTS 2 regions. In cases, when both NUTS 1 and NUTS 2 regions were not available, NUTS 0 (country level) were used as substitutes (for details see Appendix C).

For handling the extreme distribution of the institutional indicators we follow Annoni and Kozovska (2010) method (see Appendix F for details).

3.3. Description of REDI Variables, Indices and Sub-Indices

We have tried to create variables that assess a specific aspect of the entrepreneurial ecosystem. Most of the times, single indicators were used as variables or several indicators were averaged to get a particular variable (See *Table* 2. and Appendix B for each case). At the same time the variables, as

the representatives of the same system, are naturally interrelated. This is reflected by the relatively frequent cross-references in their description below (*Table 4.).*

Finally, the variables were organized into pillars and sub-indices based on the definition of entrepreneurship that we have provided in the Introduction. To give a high-level, global picture of the REDI index, Appendix A shows its basic structure decomposed until indicator level.

In *Table 4.*, we explain the thinking and reasons behind the REDI pillar design and their composition (see also Acs et al., 2013; Acs et al., 2014; Szerb et al., 2014).

Table 4. Description of the REDI pillars and variables and their role in entrepreneurship.

Pillar	Description
The entrepreneurial attitudes (ATT) sub-index aims to identify the attitudes of a region's population as they relate to entrepreneurship. It is based on the following five variables:	
Opportunity Perception	It combines the individual-level variable of GEM Opportunity Recognition with the Market Agglomeration institutional-level variable. Numerous scholars define entrepreneurship in terms of opportunity recognition and exploration and new venture creation (e.g.: Ardichvilia et al, 2003; Shane & Ventakamaran, 2000; see Sautet (2017) for summary and recent debates on Austrian market theory). Market Agglomeration reflects to the size of the market in a particular region including the growth of the population, the level of urbanization, the accessibility of the region, business freedom and property rights. The regional demand for entrepreneurship is often linked to population growth and population density. Several studies (Keeble & Walker, 1994; Reynolds, 1994; Sternberg, 2004) point out that population growth and high population density positively affect the number of entrepreneurs. People living in urban areas are more likely to be aspiring entrepreneurs, nascent entrepreneurs and business founders compared to individuals living in rural areas (Bosma et al., 2008; Rotefoss & Kolvereid, 2005). Two important aspects of urban areas relate to this category of environmental resource; the demand for and supply of entrepreneurship (Delmar & Davidsson, 2000, Keeble & Walker, 1994, Reynolds 1994, Verheul et al., 2002). Large markets allow firms to develop and benefit from economies of scale and could give incentives to entrepreneurship and innovation (European Commission, 2010; Yasuhiro et al., 2012). Moreover, sspatial proximity of knowledge owners and potential users appears to be critical for the transmission of tacit knowledge as well. The spillover impact in knowledge production is positively related to the size and density of the region due to the richer network linkages and the wider selection of producer services in larger areas (Acs & Varga, 2005; Varga, 2000; see also the Process Innovation pillar). Given the preference for attractive urban regions, the positive effect of agglomeration may therefore partially be a sorting effect of entrepreneurial talent congregating in certain areas (Florida, 2002; Sternberg, 2012; see Start-up Skills pillar for details). Since Baumol (1990, 1993), a literature has emerged suggesting that disparities in entrepreneurial activity between countries or regions can be explained by the quality of their supporting institutions. Institutional theory has argued that company behaviour, including entrepreneurial choices, will be context specific (Meyer & Peng, 2005), and a literature has emerged to show that entrepreneurial activity is sensitive, among other things, to the quality of institutions (Batjargal, 2003; Henrekson, 2007; Sobel, 2008). A favourable business environment, where entrepreneurial activities are supported by institutions and a trustable governance system, will infer a positive effect on entrepreneurship (Baumol, 1993; Davidsson & Henrekson, 2002; North, 1990, 1994). Based on broad historical studies such as North (1981) and Rosenberg and Birdzell (1986) (see also Acemoglu & Johnson, 2005; Rodrik et al., 2004) it is now widely recognized that protection of property rights is of fundamental importance for economic growth. Aidis et al. (2010) find the property right system to play a pivotal role in determining entrepreneurial entry, in particular in low and middle income countries while Johnson et al. (2002) also provide evidence that weak property rights discourage entrepreneurs from reinvesting profits.

Start-up Skills	This pillar depends on the populations' self-esteem about its ability to start successfully a business (individual variable) and the Creative Class institutional variable. Self-perceived skills to start a successful business, even if they are overestimated, are important drivers of market entry decisions (Artinger & Power, 2015; Hayward et al., 2006; Koellinger et al., 2007; Robinson & Marino, 2015). According to the "economic geography of talent" hypothesis put forward by Florida (2002a, b) highly qualified people tend to live in close spatial concentration. Such regions are characterized by low barriers to entry for well-educated, young workers who are attracted in particular by cultural diversity and openness toward the new and the "different". Up until then a small number of empirical studies on the spatial mobility and entrepreneurial activities of the member of Florida's "creative class" (Boschma & Fritsch, 2009; Florida 2002b) show that they are highly mobile in a spatial sense, very discriminating when choosing locations and that they represent a high level of entrepreneurial potential. Given the fact that creative people are more inclined to economic independence, it seems plausible that they have a higher propensity to start a business comparing to non-creative people. Consequently, regions with a higher proportion of creative people (that is, mainly, urban areas) should also be characterized by higher start-up rates than rural areas (Sternberg, 2012). For the case of Italian regions, Piergiovanni et al. (2009) observed that the regional employment growth is influenced by the prevailing patterns of sectoral specialization and by the rate of growth of the share of firms in creative industries (artists' and writers' creation, fashion design, advertising, architectural and engineering activities and industrial design, software, etc.).
Risk Acceptance	The magnitude of risk acceptance of the population is the individual variable part of Risk Perception. On the institutional side the Business Disclosure rate of the country is used as a proxy of general business risk. Disclosure index measures the extent to which investors are protected through disclosure of ownership and financial information. 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 officers and directors for misconduct (ease of shareholder suits index). Starting a new venture or running a business means to operate in a large and equivocal problem space. Hall and Woodward (2010) calculated for example that rational people with average risk aversion should not choose the option of being an entrepreneur. In general, in the entrepreneurship literature, the fear of failure embodies an obstacle to entrepreneurship (Bosma et al., 2007; Hatala, 2005, Stuetzer et al., 2014) and influences entrepreneurial activities in a damaging way (Langowitz & Minniti, 2007; Li, 2011). A favourable business environment, where entrepreneurial activities are supported by institutions and a trustable governance system, will reduce the business risk and infer a positive effect on entrepreneurship (Baumol, 1993; Davidsson & Henrekson, 2002; North, 1990, 1994; see Opportunity Perception pillar for more details).
Networking	The individual variable, knowing an entrepreneur personally (Knowing Entrepreneur) is mixed together with the country level Social Capital and a regional level Technological Readiness variable. Knowing other entrepreneurs may decrease the uncertainty involved in entrepreneurship (Bosma et al., 2012; Kacperczyk, 2013; Nanda and Sørenson, 2010; see also Risk Acceptance pillar). Entrepreneurs may become role models and encourage other individuals to consider business ownership. Evidence suggests that areas with a high proportion of small firms may provide role models for potential entrepreneurs (Fritsch, 1992; Garofoli, 1994; Hart & Gudgin, 1994; Love, 1995; Malecki, 1997; Reynold, 1994; Spilling, 1996). Davidsson et al. (1994) claim that the availability of role models and people with relevant work experience is the single most important determinant of regional variation in new firm formation rates. Therefore, a region with high level of entrepreneurship may further encourage new entrepreneurial initiatives because it is easier to access information or resources from other entrepreneurs (Bosma et al., 2012). There are different conceptions of social capital relating to entrepreneurship (Westlund & Bolton, 2003). First, social capital can be seen as the network through which valuable resources for the start-up of a new firm can be attained. This view is in line with Bordieu's conception of social capital (Bourdieu & Waquant, 1992). This includes access to finance (Kerr & Nanda, 2009), access to ideas and the recognition of opportunities (Shane & Venkataraman, 2000) and access to labour in the form of friends and family helping out in the business (Dahl & Sorenson, 2009). Secondly, value can be derived from the social network itself through the shared values, information in the social group (Coleman 1990; see also High Growth pillar). The literature on role models can also be reframed in this conception of social capital. The role models, if relevant in a social group, can have an effect on the whole social network. "Empirical studies on Social Capital have shown that citizens' wellbeing improves through social trust, family and community ties, and civic group membership. Similarly, societies with lower levels of social capital have been shown to experience lower levels of economic growth"[6]. The Internet has become part of everyday life in the developed world. The technological readiness refers to the availability of the internet in a region. As long as someone has got an internet connection and a computer, tablet or smartphone, he can create and run an online business from anywhere and reach clients anywhere. According to Statistica.com, the worldwide B2C e-commerce sales reached 1,233 billion USD in 2015, and is still growing[7]. Networking and other social activities are also frequently placed into virtual spaces. Facebook and LinkedIn are hundreds of millions users from around the world.

6 http://www.prosperity.com/#!/?opts=2Ekxmx-Ulx3y1

7 http://www.statista.com/statistics/261245/b2c-e-commerce-sales-worldwide/

Cultural Support	The individual variable Carrier Status contains the view of the population about the carrier possibilities and the social status and respect of entrepreneurs. Open society is the institutional variable containing a country level (Personal freedom) and a regional level indicator (Corruption). Kibler et al. (2014) developed the concept of regional social legitimacy according to which regions develop specific cultural cognitive, normative, and regulative contexts that lead to different shared meanings and social perceptions of economic behavior. The regulative institutions are those controlling systems that are legally sanctioned, such as laws and regulations. Normative institutions, however, are not necessarily linked to any direct sanction system, but are maintained by (often unconscious) moral considerations and are thus indirect sanction systems (anyone who does not adhere to normative institutions loses his legitimacy and is marginalized in the long run). Examples of normative institutions are perceptions of what is accepted as good business practice in different contexts. Views on this may differ between industries, nations or regions. The cognitive institutions are shaped by culture and daily routines/practices and are thus more or less taken for granted by individuals. They are adhered to, therefore, without further reflection (Moodysson, 2007). The shared regional meanings and social perceptions of economic behavior have the potential to influence individual perception of entrepreneurship. Corruption has been seen as being negative for firm entry by raising the costs and therefore reducing the returns to entrepreneurial activity (Anokhin – Schulze, 2009). Desai and Acs (2007) argue that a corrupt environment may have negative supply side effects on entrepreneurs, and especially on those with higher aspirations, leading them to satisfy their ambitions through rent seeking rather than the formation of new firms. The effects of a corrupt institutional environment seem to have higher negative effect on higher growth aspiration entrepreneurship. Its negative effect impact more highly on potential new firms than incumbents, because incumbents have developed a higher resilience in operating longer in corrupt environment which is highly uncertain (Aidis et al., 2008, 2010). Estrin et al. (2012) find that the coefficient on freedom from corruption appears to be highly significant in explaining employment aspirations by entrepreneurs.
The entrepreneurial abilities (ABT) sub-index is principally concerned with measuring important characteristics of entrepreneurs and startups with high growth potential. It is based on five variables:	
Opportunity Startup	This pillar mixes together the Opportunity Motivation of the population (individual variable) with the favorability of the Business Environment (institutional variable). GEM defines opportunity entrepreneurs as those who pursue opportunities to take advantage of them and necessity entrepreneurs as those who became self-employed because of no better choices for work (Bosma et al, 2012). Necessity and opportunity entrepreneurships relate differently to economic development (see for summary Naude, 2008). The literature has also shown that the effect of entrepreneurship activity on regional development is driven by the institutional context in which entrepreneurial activity takes place. Since Baumol (1990, 1993), a literature has emerged suggesting that disparities in entrepreneurial activity between countries (or regions) can be explained by the quality of their supporting institutions. Institutional theory has argued that company behavior, including entrepreneurial choices, will be context specific (Meyer & Peng, 2005), and a literature has emerged to show that entrepreneurial activity is sensitive to the quality of institutions (Batjargal, 2003; Henrekson, 2007; Sobel, 2008) as well as to the level of economic and social development. The institutional context can be either conducive or detrimental to the entrepreneurship. It is reasonable to think that higher levels of corruption (see Cultural Support pillar) or weaker property rights (see Market Agglomeration pillar) will have a negative impact on entrepreneurship. A favorable business environment, where entrepreneurial activities are supported by institutions and a trustable governance system, will infer a positive effect in the creation and impact of entrepreneurship (North, 1990, 1994; Baumol, 1993; Davidsson & Henrekson, 2002). Henrekson's work (2007) points out that any social arrangement, including taxation, that channels savings and asset control to large institutional investors is likely to limit the supply of financial capital to potential entrepreneurs. The literature argues that taxation is an institutional barrier that affects entrepreneurial activities. As Elert et al. (2017) summarise "Many types of taxes affect entrepreneurial decisions. While tax rates should generally be low or moderate, policy makers should strive for simplicity rather than (targeted) concessions, and for a high degree of tax neutrality across owner categories, sources of finance and different types of economic activities.".
Technology Sector	It highlights the role of technology and creative sectors. We use the percentage of the young and nascent businesses that belong to a technology-intensive or creativity sectors (Technology level) as individual variable. The institutional variable (Absorption capacity) measures the technological readiness of the firms in a country and the regional level of employment in knowledge intensive and high technology firms. "In today's globalized world, technology is increasingly essential for firms to compete and prosper. Economies adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICT) in daily activities and production processes for increased efficiency and enabling innovation for competitiveness"[8] (see also Networking, Product and Process Innovation pillars for further details). Furthermore, Glaeser and Kerr (2009) find that abundant workers in relevant occupations strongly predict regional entry. Human resources in science and technology have a strong impact on the number of new start-ups and new jobs. They are typically the workers who come up with new ideas and put them into practice, which leads to more new and more innovative and productive firms and higher creation of jobs (Kern & Runge, 2009; see Process Innovation pillar as well).

[8] http://reports.weforum.org/global-competitiveness-report-2015-2016/

Human Capital	This pillar has two ingredients: the share of early phase entrepreneurs who have over secondary level of education (Educational Level) is merged together with the involvement of the region's population in training and life-long learning (Education and Training) and labor freedom. Education and learning has been related in the literature to knowledge, skills, problem-solving ability, discipline, motivation and self-confidence (Cooper et al., 1994). There seems to be agreement that attaining a high level of education positively influences the probability of becoming involved in business start-up processes (Bates, 1995; Cooper et al., 1994; Delmar & Davidsson, 2000). In addition, schooling has an important impact on successful entrepreneurship. Van der Sluis et al. (2008) review over 100 studies on the issue and they find a marginal return of 6.1% to an additional year of schooling. Entrepreneurs with high level of education are more likely to have a role model, and the likelihood that these entrepreneurs view their role models as crucially important is significantly higher (Bosma et al., 2012). The degree of regulation of labour markets and wage-setting can be expected to influence incentives for entrepreneurship, since it restricts the freedom of contracting and therefore curtails the possible combinations of factors of production. The literature has found important differences between countries in terms of labour market regulation. Henrekson (2007) states that there are reasons to believe that strict employment security provisions, and other regulations that restrict contracting flexibility, are more harmful for smaller and more entrepreneurial employers. Another labour market arrangement that may impact on the incentives for entrepreneurship is wage-setting institutions. Institutional pressures for wage compression are likely to disadvantage smaller and more entrepreneurial businesses. The cross-country comparative studies on the effect of labour market regulations on job counts can help to understand some entrepreneurship and firm evolutionary patterns. Birch and Medoff (1994) hypothesize that in the US the really good entrepreneurial firms become fast-growing gazelles and the self-employment is fairly low in US. Oppositely, in Italy, the high regulatory environment with high labour taxes make difficult and risky to grow businesses, such that they prefer to remain smaller (Lazerson & Lorenzoni, 1999).
Competition	The individual variable of Competitors is the number of competitors, benchmarking those ventures that have not too many competitors. Competition is generally believed to be good to customers because it reduces prices and induces firms to improve their product quality and innovation. However, a large number of customers could reflect to the fact that firms are just copying somebody else's product. Firms can avoid high competition by following a distinctive strategy, the "blue ocean" strategy. Blue oceans "..are defined by untapped market space, demand creation, and the opportunity for highly profitable growth." (Kim & Mauborgne, 2005). The institutional variable is Business Strategy measuring the country's nature of competitive advantage and the regional level sophistication of the businesses. "There is no doubt that sophisticated business practices are conducive to higher efficiency in the production of goods and services. Business sophistication concerns two elements that are intricately linked: the quality of a country's overall business networks and the quality of individual firms' operations and strategies. The quality of a country's business networks and supporting industries is important for a variety of reasons. When companies and suppliers from a particular sector are interconnected in geographically proximate groups, called clusters (see also High Growth pillar), 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, 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." [9]
The entrepreneurial aspiration (ASP) sub-index refers to the distinctive, qualitative, strategy-related nature of entrepreneurial activity. Entrepreneurial businesses are different from regularly managed businesses, thus it is particularly important to be able to identify the most relevant institutional and other quality-related interaction variables. Our idea about entrepreneurial aspirations is based on the Entrepreneurial orientation (Lumpkin & Dess, 1996), the internationalization (Acedo & Jones, 2007; Cavusgil & Knight, 20015) and the entrepreneurial finance (Chemmanur & Fulghieri, 2014) literatures. We have created five of them:	

[9] http://reports.weforum.org/global-competitiveness-report-2015-2016/

Product Innovation	Product Innovation reflects not only to the newness of the product (individual component), but also on the ability of the businesses in the region to create such products (institutional variable). The regional level institutional variable (Technology transfer) refers to the regions' potential to patent and to create scientific publications. Inventions and patents are the first steps toward product and process innovation. Then, the new knowledge has to be "materialized" by introducing new production methods and products into the market (Bhidé, 2008). The innovation process is shaped by the intensity of entrepreneurship (Acs et al., 2009; Baumol, 2010) and the institutional environment (Aldrich, 2011; Estrin et al., 2013). The literature highlights three main problems typical of regional innovations systems that need to be addressed: (1) fragmentation, (2) absence of key resources, and (3) negative lock-in (Tödtling & Trippl, 2005). The problem of fragmentation occurs when the authors are not aware of each other and/or when they do not act in harmony with each other. One reason may be that there is an institutional and/or functional mismatch. An example of institutional mismatch can be the absence of an overall collective action. Functional mismatch, where the functions that the innovation system supports do not result in mutually reinforcing synergies, is experienced in the case of a lack of coordination. The absence of key resources that are necessary for a proper functioning of an innovation system, such as the regional presence of human capital (see also Process Innovation), represents a grand challenge in many regions. Finally, negative lock-in represents the most difficult problem for regions today. Negative lock-in may occur when regional specialization has emerged in a sector that in the medium or long term does not have good growth potential, but which may still be an important part of the region's industrial identity. In this context, it is not necessarily just lock-in in obsolete technology that is in question, but also lock-in in skills and market terms. The prerequisites for avoiding this kind of negative lock-in are probably better in regions with a diversified economy within related industries, as this provides opportunities for new combinations of existing knowledge and thus renewal in terms both of technology and of market orientation. Additionally, Henning et al (2010) describe a final issue that is complementary to all the previous ones (4) inconsistencies between the regional economic structure and the priorities of the regional policy. A lack of correspondence between the policy measures implemented by the actors in the innovation system's support structure and, on the other hand, the regional economic structure, can result in an inefficient support structure and an unexploited regional innovation capacity.
Process Innovation	The Process Innovation pillar captures the use of new technologies by start-ups combined with the Gross Domestic Expenditure on Research and Development (GERD) and the relative number of R&D persons. GERD serves as measurement of the systematic research activity as opposed to easy to copy technological improvements. A high level of regional research and development (R&D) activity increases regional opportunities to start new knowledge-based businesses, and such a high level of R&D intensity is supposed to increase the creation of new technological knowledge and, through localized knowledge spillovers, the level of opportunities for start-ups in knowledge-based industries (Acs et al., 2009, Audretsch et al., 2006, Audretsch & Keilbach, 2007). Universities can be an important anchor tenants for regional clusters (Hausman, 2012; Chatterji et al, 2013; see High Growth pillar as well). See also Product Innovation.
High Growth	It includes the percentage of gazelles as businesses with high growth ambitions (Gazelle), the clustering and availability of venture capital institutional indicators. High Growth firms, called gazelles are believed to be one of the key element in job creation and growth (Acs and Mueller 2008; Henrekson and Johansson 2010; Stam et al 2009). Here we use expected growth in employment. Expected growth was found to be positively linked to the actual growth both on firm (Miner et al. 1994; Stam & Wennberg, 2009; Wiklund & Shepherd, 2003) and macroeconomic levels (Hessels et al., 2008; Stam et al., 2011). The potential role of growth aspirations in the actual growth is usually explained by the theory of planned behaviour (Ajzen, 1985, Delmar & Wiklund, 2008; Wiklund & Shepherd, 2003). The literature has explored the positive impact of clusters, defined as geographically proximate groups of interconnected firms and associated institutions in related industries, on new firm formation (Rocha & Sternberg, 2005). Industrial clusters can enhance new firm births as well as the productivity of existing firms. Linkages among firms and related institutions, which are the key characteristics of the cluster phenomenon, can serve as an important determinant of new firm formation. The network aspect of clusters helps nascent entrepreneurs to find resources and information easier and faster than in an isolated environment (Koo & Cho, 2011). Sternberg and Litzenberger (2004) also found that the existence of one or several industrial cluster(s) has a positive impact on the number of start-ups and attitudes. For the US, Koo and Cho (2011) found that clusters based on knowledge sharing (i.e., knowledge-labour cluster) significantly affect new firm formation, whereas clusters based on market transactions (i.e., value-chain cluster) do not seem to play a role. Delgado et al. (2010), also for the US, found that after controlling for convergence in start-up activity at the region-industry level, industries located in regions with strong clusters (i.e. a large presence of other related industries) experience higher growth in new business formation and start-up employment. Strong clusters are associated with the formation of new establishments of existing firms, thus influencing the location decision of multi-establishment firms and contributed greatly to start-up firm survival. For high growth start-uos and entrepreneurial firms traditional forms of financing, both debt and private equity is not a viable source. At the same time venture capital is particularly important. Venture cpaitalsts provide not only finance but also help the venture to manage growth successfully (Berger & Udell, 1998; Gompers et al., 2005; Kanniainen & Keuschnigg, 2004).

Globalization	The Globalization pillar combines together the export potential (Export) as measured by the percentage of the businesses that have foreign customers, and the connectivity and complexity of a region's economy. A frequently noticed characteristic of high growth potential businesses (see High Growth pillar) is their ambition to internationalize (Bosma et al., 2012). The connection between entrepreneurship and internationalization is well researched and documented in the international entrepreneurship literature (Oviatt and McDougall 2005; Kiss et al 2012). Recently, the "born global" phenomenon; i.e. businesses that export right from the startup has gained increasing attention (Kuemmerle 2005; Cavusgil and Knight 2015). Fernhaber, Gilbert and McDougall (2008) highlight the role of geographic location in the internationalization process. On a macro level, export data can be used to assess a county's economic complexity and predict future growth in wealth (Hausmann et al., 2014). "Well-developed infrastructure reduces the effect of distance between regions, integrating the national market and connecting it at low cost to markets in other countries and regions. In addition, the quality and extensiveness of infrastructure networks significantly impact economic growth and reduce income inequalities and poverty in a variety of ways…Effective modes of transport—including quality roads, railroads, ports, and air transport—enable entrepreneurs to get their goods and services to market in a secure and timely manner and facilitate the movement of workers to the most suitable jobs." [10]
Financing	The individual variable of the Financing pillar is a measure of informal financing possibilities provided by friends, relatives or business angels. The country level institutional variable the Depth of Capital Market is a complex variable by itself measuring the access to different capital and debt markets. Here we also have a regional institutional variable on the concentration of financial services. For many business ventures, the lack of financing represents the most important obstacle (e.g.: Parker 2009). While it is hard to deny the importance of banks in the provision of traditional type of debt especially in the European Union, over the last two decades some alternative forms of mainly equity financing has been emerging. Entrepreneurial finance refers to the alternative sources of capital (Denis, 2004; Winton & Yerramilli, 2008). Beside money, venture capitalist and business angels provide various assistance and help to the generally inexperienced young business owners (Gompers, 1995, Helman & Puri, 2002). Most start-ups have no other choice but to approach their relatives, friends or other acquaintances if the founders own savings are not enough for launching the business (Mason, 2007). GEM data based analyses highlight that the amount of informal investment exceeds that of the formal venture capital by 8-20 times. At the same time the average amount invested in one business by venture capitalists can be hundreds times higher than that of the informal venture source of family members, friends and alike (Bygrave & Hunt, 2004; Bygrave & Quill, 2007). Overall, the adequate supply of both formal and informal venture capital is vital for providing the necessary fuel for high growth potential businesses in their critical phases of the life cycle.

10 http://reports.weforum.org/global-competitiveness-report-2014 -2015/methodology/#view/fn-9

4. The computation of the Regional Entrepreneurship and Development Index

Index construction is a difficult task with many potential possibilities of calculation. Previously we have provided a description of the individual and institutional indicators, sub-indicators and variables. In this section we describe the way of calculation of the REDI scores from the variables. For the index creation, we followed the suggestions of the OECD's Handbook on constructing composite indicators (Giovannini et al., 2008).

For the purpose of this report we have calculated a REDI 2017 score for each of the 125 European regions. As the institutional pillars have been modified (see Appendix E), we have also recalculated the REDI 2013 (Szerb et al., 2014) scores. For the data transformation described in this chapter we used the REDI 2013 and 2017 scores in a united database, so the benchmark values are the same for the two REDI indices.

The construction of the pillars

We calculate all pillars from the variables using the interaction variable method; that is, by multiplying the individual variable with the proper institutional variable to demonstrate their combined effect (Acs –Varga, 2005). The notion behind this technique goes back to Baumol's (1996) idea that the value of entrepreneurship depends on both the individual effort and the institutional context.

$$z_{i,j} = IND_{i,j} * INS_{i,j} \qquad (1)$$

for all j = 1, ...,k the number of individual and institutional variables

$IND_{i,j}$ is the original score value for region i and individual variable j

$INS_{i,j}$ is the original score value for region i and institutional variable j

$z_{i,j}$ is the original pillar value for region i and pillar j

Treating the outliers: Capping

All index building is based on a benchmarking principle. The selection of the proper benchmarking considerably influences the index points and also the rank of the countries. However, the existence of outliers could lead to set up inappropriate benchmarks. Hence, we need to handle extreme value outliers. There are several outlier adjustment methods available. For example Tarabusi and Palazzi (2004) suggested the metric homogeneity improvement as taking the decimal logarithm of the data to decreases the differences between the extreme values and the other data points. Another method is categorization. While categorization solves the outlier problem it does not seem to be proper tool because decreases the relative differences amongst the countries significantly.

Capping is also frequently used to handle outliers. The question relates to the value of the cap. The Environmental Sustainability Index uses the 97.5 percentile adjustment. In addition they make an additional 2.5 percentile adjustment in the bottom (Giovannini et al., 2008). In our case we selected the 95 percentile score to adjust all of the fourteen pillars. It means that any observed pillar values

higher than the 95 percentile is lowered to the 95 percentile. It also means that at least six different regions have reached the maximum value in all of the 14 pillars. Hence, the best value is not a result of an extraordinarily effort of one or a few regions but a reachable benchmark for other regions too.

Table 4. The value of skewness of the original, the capped pillars, and the capped and average equalized pillars

Pillar	Skewness of the original pillars	Skewness of the capped pillars	Skewness of the capped and average equalized pillars
Opportunity Perception	1.194	1.103	.754
Startup Skills	.207	-.020	.292
Risk Perception	.320	.301	.477
Networking	.780	.707	.386
Cultural Support	.274	.151	-.148
Opportunity Startup	.053	-.117	.169
Technology Adoption	1.402	.855	.489
Human Capital	2.106	1.023	.735
Competition	.387	.255	.373
Product Innovation	.587	.000	.542
Process Innovation	1.051	.409	.465
High Growth	.468	.125	.167
Globalization	.167	.054	.357
Financing	3.167	.952	.428

Note: N=250; Red marked values show high skewness.

According to *Table 5*, the skewness of the original data pillars exceed the value 1 in four cases: Opportunity Perception, Human Capital, Process Innovation and Financing. After applying the capping, the skewness decreased in all cases but the distribution of one pillar, the Opportunity Perception stayed skewed. Finally, we made another adjustment before aggregating the pillars, the equalization of the average pillar values (this technique is described in the following part of the report). Table 5 shows that after the above series of transformation the skewness of all pillars is within the critical [-1,1] range.

Normalizing the pillars

Like other composite index components, our pillars are in different magnitudes. In order to be in exactly the same range, the normalization of the pillars is necessary. There are several available normalization methods. The most commonly used z-score, a mean of 0 and variance of 1 cannot be applied because our newly developed PFB method requires all pillars to be in the same range. A popular version is the Min-Max normalization technique, which arranges the data within an identical [0,1] range (Acs – Szerb, 2011). This approach has the disadvantage of increasing the differences, even if real deviations are minimal. This is the reason why we have turned to the distance normalization technique that preserves the distance (relative differences) amongst the regions.

$$x_{i,j} = \frac{z_{i,j}}{\max z_{i,j}} \quad (2)$$

for all j= 1,..m, m=14 is the number of pillars

where $x_{i,j}$ is the normalized score value for region i and pillar j

$z_{i,j}$ is the original pillar value for region i and pillar j

$\max_i z_{i,j}$ is the maximum value for pillar j

Applying the distance methodology the pillar values are all in the range [0,1], however the lowest pillar value is not necessary equal to 0. In this case all regions' efforts are evaluated in relation to the benchmarking region but the worst region is not set to zero per se.

Harmonization of the pillars: Equalize pillar averages

The different averages of the normalized values of the 14 pillars imply that reaching the same performance requires different effort. Higher average values – e.g. *Opportunity Startup* – could mean that it is easier to reach better REDI scores by improving those pillars as compared to pillars with lower average value – e.g. *Financing*. Since we want to apply REDI for public policy purposes, a one-to-one substitution of the pillars is necessary. It means that the marginal effect should be the same for all of the 14 pillars. Calculating all the marginal effects for all the regions would be a cumbersome task, so we suggest a simpler solution: to equalize the marginal effects of the components only on the average pillar values of all regions. This technique reduces but does not eliminate the distortion in calculating the marginal effects.

Practically, we have calculated the average values of the 14 pillars after the *capping* adjustment and the normalization and made the following average adjustment:

Let's xx_{ii} to be the normalized score for region i for a particular pillar j. The arithmetic average of pillar

j for number n regions is:

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{i,j}}{n} \quad \text{for all j} \qquad (3)$$

We want to transform $xx_{ii,jj}$ values such that the potential values to be in the [0,1] range.

$$yy_{ii,jj} = xx_{ii,jj}^{kk} \qquad (4)$$

where k is the "strength of adjustment", the k^{th} moment of xx_{jj} is exactly the needed average, $\bar{y}_j$. We have to find the root of the following equation for k:

$$\sum_{ii=1}^{nn} xx_{ii,jj}^{kk} - nn\bar{y}_{jj} = 0 \qquad (5)$$

It is easy to see based on previous conditions and derivatives that the function is decreasing and convex which means it can be quickly solved using the well-known Newton – Raphson method with an initial guess of 0. After obtaining k, the computations are straightforward. Note that if

$$\bar{x}_j < \bar{y}_j \quad kk < 1$$
$$\bar{x}_j = \bar{y}_j \quad kk = 1$$
$$\bar{x}_j > \bar{y}_j \quad kk > 1$$

that is k be thought of as the strength (and direction) of adjustment.

This technique have resulted the decrease of the over the average value pillars and the increase of the below the average pillars while keeping the maximum value at 1. *Table 6* provides information about the average pillar values before and after the adjustment.

Table 5. Average pillar values before and after the average equalization

Pillar	Pillar Averages	Equalized Pillar Averages
Opportunity Perception	0.370	0.488
Startup Skills	0.570	0.488
Risk Perception	0.544	0.488
Networking	0.414	0.488
Cultural Support	0.430	0.488
Opportunity Startup	0.566	0.488
Technology Adoption	0.397	0.488
Human Capital	0.398	0.488
Competition	0.538	0.488
Product Innovation	0.653	0.488
Process Innovation	0.505	0.488
High Growth	0.500	0.488
Globalization	0.584	0.488
Financing	0.362	0.488
Average	**0.488**	**0.488**

Note: N=250

While the average of the fourteen pillars is 0.488, they range from 0.362 (*Financing*) to 0.653 (*Product Innovation*). It implies that the increase of the REDI score by, for example, 5 points requires the growth of *Financing* by approximately 1.8 times more as compared to the *Product Innovation*. After applying the average equalization adjustment technique, the effect of the relative increase of any pillar is the same. This implies a one-to-one substitution of the pillars on the average. A further consequence of the adjustment that below average value pillars need *smaller increase* to reach the same growth in the REDI points. For example, after the average equalization, only 0.74 (0.362/0.488) times of the original value of *Financing* needs on the average to increase the REDI point by 5. At the same time, about 1.34 (0.653/0.488) times of the original value of *Product Innovations* required for the same 5 point increase.

The penalty for bottleneck methodology

We have defined entrepreneurship as the interaction of entrepreneurial attitudes, abilities, and aspiration across different levels of development. One issue this definition raises is how to bring system perspective dynamism into the model. After equalizing the averages of all pillars, 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.

$$h_{(i),j} = \min y_{(i),j} + (1 - e^{-\hat{y}_{(i)j} - \min y_{(i),j}\hat{}}) \qquad (6)$$

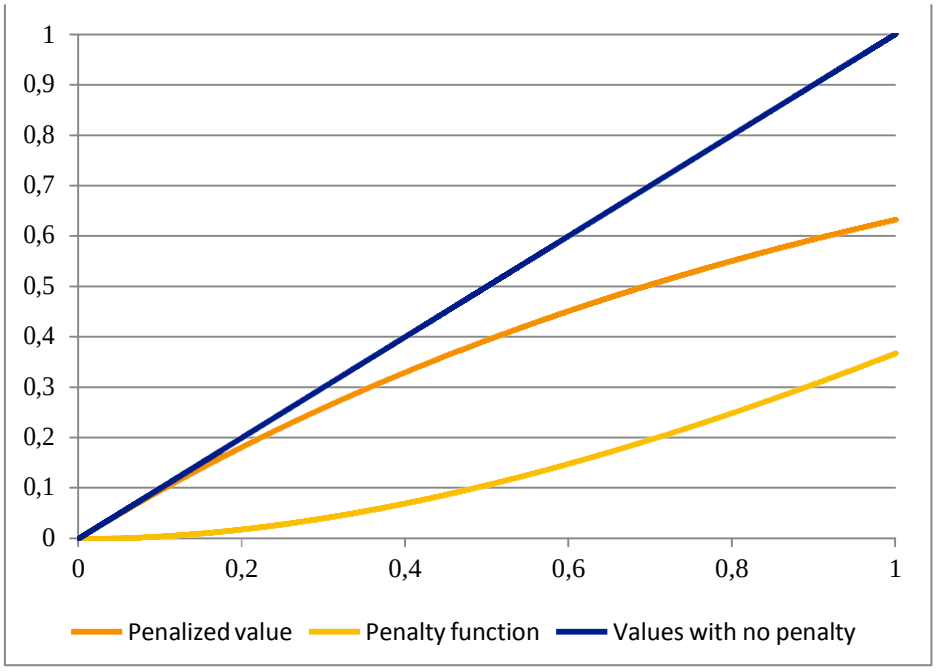
$h_{i,j}$ is the modified, post-penalty value of pillar j in region i
$y_{i,j}$ is the normalized value of index component j in region i
y_{min} is the lowest value of $y_{i,j}$ for region i.

i = 1, 2, …, n is the number of regions
j= 1, 2, …, m is the number of pillars

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. To the contrary, improving a relatively high pillar value will presumably 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 should be higher if differences are higher (Acs et al., 2011).

There are two potential drawbacks of the PFB method. One is the arbitrary selection of the magnitude of the penalty. A note that there is no objective criterion exists about the selection of the size or the calibration of the penalty. An intermediate solution seems to be useful for our purposes. It is shown in *Figure 2*.

Figure 2. The penalty function, the penalized values and the pillar values with no penalty



Note: $yy_{mmmmm} = 00$

In this case the maximum penalty is 0.368. This maximum penalty that is around a third loss of the original value looks reasonable. Larger penalty values rearrange the ranking of the regions considerably by closing the REDI values to the minimum value pillar of that region.

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 focus on improving the weakest link in the system (Acs et al 2014, Acs et al 2016, Bennett 2014). Altogether, we claim that the PFB methodology is theoretically better than the arithmetic average calculation. However, the PFB adjusted REDI is not necessary 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 improving the weakest link of the system which has a constraining effect on other pillars.

See also Appendix G for more details on PFB.

Subindex and REDI score calculation

The pillars are the basic building blocks of the sub-index: entrepreneurial attitudes, entrepreneurial abilities, and entrepreneurial aspirations. The value of a sub-index for any country is the arithmetic average of its PFB-adjusted pillars for that sub-index, multiplied by 100. The maximum value of the sub-indices is 100 and the potential minimum is 0, both of which reflect a regions' relative position in a particular sub-index.

$$ATT_i = 100 * \sum_{j=1}^{5} h_j \quad (7a)$$

$$ABT_i = 100 * \sum_{j=4}^{9} h_j \quad (7b)$$

$$ASP_i = 100 * \sum_{j=6}^{10} h_j \quad (7c)$$

where $h_{i,j}$ is the modified, post-penalty value of pillar j in country i

i = 1, 2, …, n = the number of countries

The super-index, the Regional Entrepreneurship and Development Index, is simply the arithmetic average of the three sub-indices:

$$REDI_i = \frac{1}{3}(ATT_i + ABT_i + ASP_i) \quad (8)$$

where $i = 1, 2, \ldots, n$ is the number of regions

For additional information on the calculation of REDI see Appendix H.

5. REDI score ranking and basic analysis

In this chapter, we report the rank and the REDI points of the investigated 125 European Union regions. We have applied various robustness methods to validate our results and investigate the underlying structure of the data. The main text contains the most important results while further information can be found in Appendix I. We also categorized the 125 regions into five clusters according to their REDI scores and show the outcome in a map. The robustness tests for the five cluster categorization are in Appendix I.

5.1. REDI scores and rankings

According to the REDI methodology described in the previous chapter, we have calculated the REDI 2013 (*Table 8*) and 2017 (*Table 9*) scores for each of the 24 countries' 125 regions. The tables display the ranked REDI scores from the most entrepreneurial to the least entrepreneurial. Hypothetically, the REDI scores could vary from around zero to a maximum of 100. As expected, the REDI variations in entrepreneurship over the 125 regions are substantial; for the REDI 2017 for example over four-fold between the 1st Stockholm and the 125th Del-Alfold. Stockholm, the most entrepreneurial region in the European Union, has reached 78.3 points out of the maximum reachable 100 points. At the same time, Del-Alfold has achieved only 17.7 points. Thus, in our case, the REDI 2017 scores range from 17.7 to 78.3 showing that even the best European region is about 20 points from the potential maximum level. The REDI 2013 varies on a somewhat wider scale, between 81.8 and 16.7.

Table 7 displays the changes in ranking during the examined time period for all the 125 regions. Comparing the REDI 2013 ranking with the REDI 2017 ranking, the average of the absolute changes is less than 10. The correlation between the two rankings is very strong, Spearman's rho = 0.937. Proving the stability of the index, the league table has hardly changed. The first five places are occupied by the same regions both in 2013 and 2017. As another example, thirty-five out of the forty regions with the highest performance in 2017 were also among the best forty in 2013.

However, changes are considerable for some outliner regions. The difference in the rankings fluctuates between -40 to 35. The most affected German Bremen has stepped ahead from the 62nd to the 27th place while Rheinland-Pfalz, a German region as well, has fallen from the 20th to the 60th place. *Table 7* shows the 10 regions with the greatest rise or suffering the most important loss during the examined time period.

Table 6. The most important changes in rankings between 2013 and 2017

Highest improvements					Most important drops				
REGION		REDI 2013	REDI 2017	Change	REGION		REDI 2013	REDI 2017	Change
DE5	Bremen	62	27	35	DEB	Rheinland-Pfalz	20	60	-40
DE6	Hamburg	39	8	31	ES12	Principado de Asturias	69	98	-29
PT18	Alentejo	107	76	31	FR6	Sud-Ouest (FR)	46	75	-29
DE8	Mecklenburg-Vorpommern	98	70	28	DK02	Sjælland	26	50	-24
DEC	Saarland	56	29	27	DK05	Nordjylland	6	30	-24
LV	Latvia	104	77	27	ES23	La Rioja	83	104	-21
DEF	Schleswig-Holstein	73	47	26	SE31	Norra Mellansverige	37	57	-20

AT3	Westösterreich	72	48	24	ES42	Castilla-la Mancha	95	113	-18
AT2	Südösterreich	75	52	23	SE32	Mellersta Norrland	53	71	-18
DE1	Baden-Württemberg	31	14	17	UKD	North West (UK)	25	43	-18

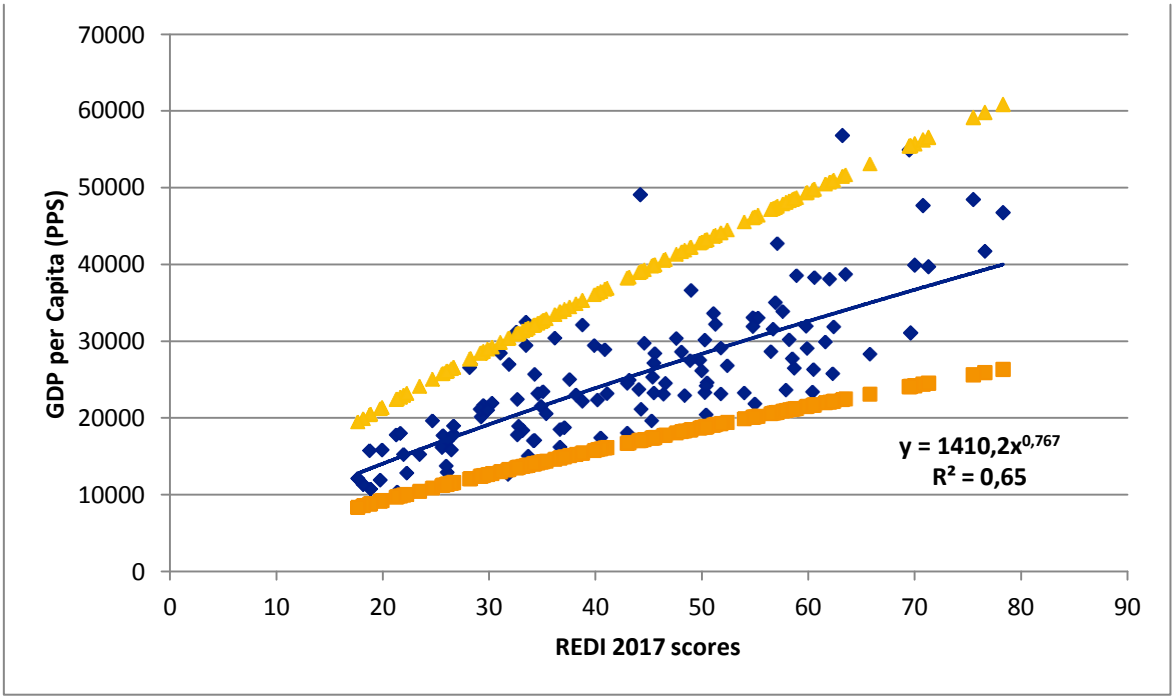
In general, considerable changes are caused by the Activity or Aspiration sub-indices. The Attitudes sub-index did not seem to cause large fluctuations. The highest improvements are typically concentrated on two-three pillars; most often on Human Capital and High Growth. On the contrary, apart from Nordjylland, the drops are caused by the plunge of one single or two pillars of the Aspiration sub-index (for further details see *Table 13*).

Among the most entrepreneurial twenty percent of REDI 2017 regions we find Ireland along with territories from Belgium, Denmark, Finland, France, Germany, the Netherlands, Sweden and UK. These regions are generally ahead of the less innovative Southern and Eastern European territories. However, in addition to other areas of the above countries, the capital region of Spain and Slovenia is in the 60^{th}–80^{th} percentile range of the REDI 2017 scores. On the other end of the scale, the areas with the lowest REDI 2017 score cover whole countries, namely, Croatia and Greece. When all regions of a country are at the bottom of the ranking that reflect not only well below average entrepreneurship but macroeconomic instability. Furthermore, Italian, Hungarian, Romanian, Slovakian and Spanish territories are below the 20^{th} percentile.

Within countries, most of the times capital cities, which are generally the largest and the most developed regions, rank ahead of less developed territories. There is one exception: Hamburg scored the most REDI 2017 points in Germany.

Since REDI claims to measure the role of entrepreneurship in economic development, it is worth examining the connection between the REDI scores and economic development, measured by the GDP per capita. Curve estimation showed that the power function describes best the impact of REDI on GDP. The regression of GDP on the REDI 2013 indicates that REDI explains about 57 percent of its variations. The REDI 2017 index explains 65 percent of GDP variations (Figure 3). The associated Pearson's correlation coefficient is 0.774, showing moderately strong connection between the REDI 2017 and per capita GDP. *Figure 3* shows the 2017 regression line with its 95% confidence intervals.

Figure 3. The connection between the REDI 2017 scores and the economic development



Notes: Power adjustment. Number=125

To see better the differences and similarities across European regions or regions of a given country, we have also conducted a K-means cluster analysis based on the REDI 2017 scores. For our purposes, the five group version proved to be the best. According to an ANOVA test, the differences between any two of the REDI groups are larger than within the groups, at p=0.000 level. *Figure 4* shows the cluster membership of all the 125 regions. Eight regions from 78.3 to 69.5 REDI points belong to the best cohort, the leaders in entrepreneurship and innovations. These are regions from the three involved Scandinavian countries, Germany, France, Ireland and UK. Twenty-seven regions, from the 9th to the 35th place, constitute the second group of regions. These regions are strong innovators. Their REDI scores range from 65.8 to 54.0. Besides the most of the remaining Scandinavian regions, British, Austrian, Belgian, Dutch, Irish, French and German areas can be found here. The following 33 regions of the third group mix the medium performers across Europe. It covers areas from Finland (Etelä-Suomi, 52.4 REDI points, 36th place) to Catalonia (40.9 REDI points, 68th place). This cluster contains the best performing Central- and South European territories – Estonia and the capital region of Poland, Spain, Slovenia and Portugal. The fourth group of thirty-four modest innovators ranges from 40.5 to 29.2 REDI points. It also groups together regions all across Europe. The last group of the twenty-three weakest innovators stretches from the 103rd place to the 125th place. Their REDI 2017 scores are much lower than other regions' points, running between 28.3 and 17.7. Spanish, Greek and Italian areas together with Eastern European –namely Croatian, Hungarian, Romanian and Slovak – territories make up this cluster.

A more detailed robustness analysis about the selection of the five clusters can be found in Appendix I.

Figure 4. The map of REDI 2017 scores in five cluster categories of the 125 European Union regions

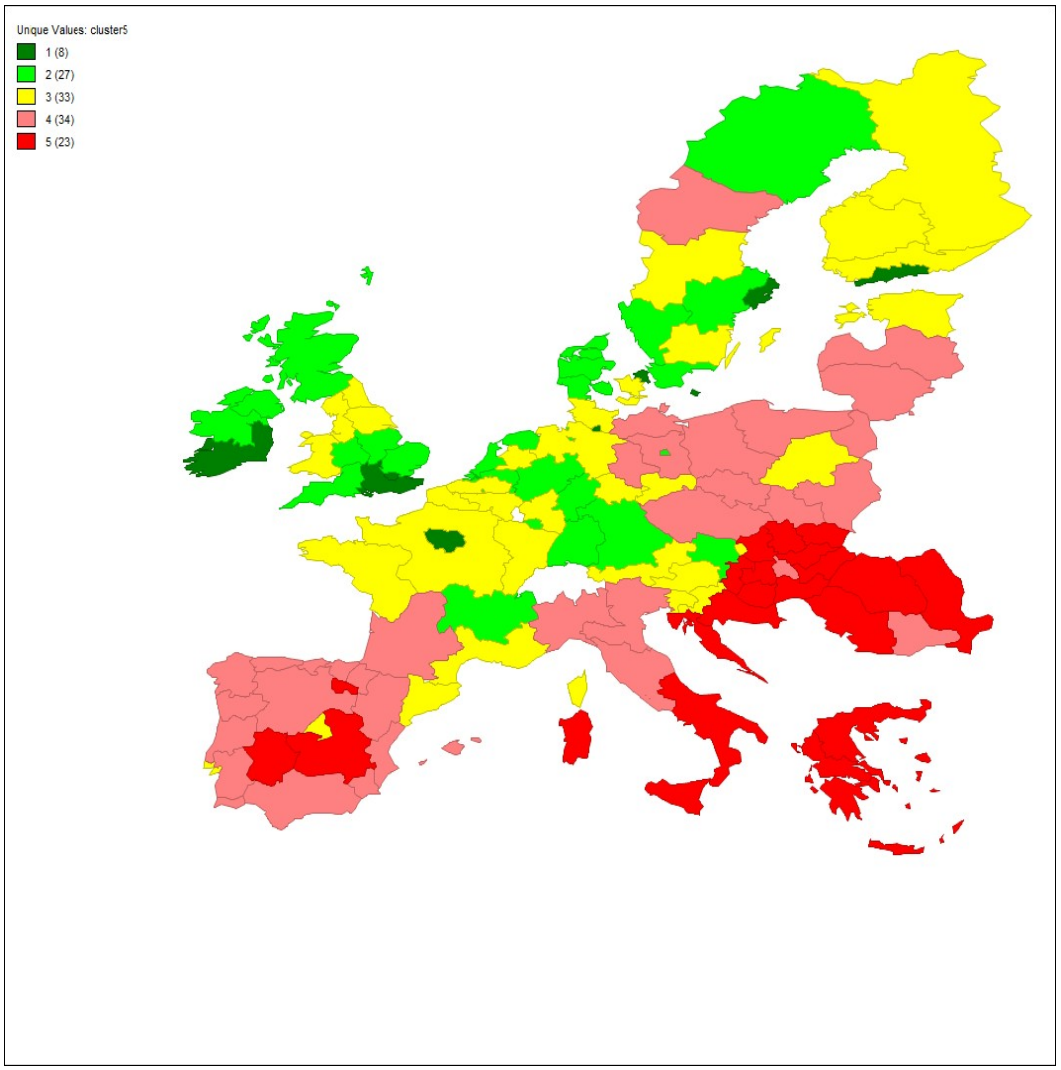


Table 7. The REDI 2013 ranking and scores, of the 125 European Union regions

Rank	REGION NAME	REDI	Rank	REGION NAME	REDI	Rank	REGION NAME	REDI
1	Hovedstaden	81.8	43	Småland med öarna	50.9	85	Galicia	33.6
2	London	75.8	44	Nordrhein-Westfalen	50.8	86	Region Pólnocno-Zachodni	33.4
3	Stockholm	74.0	45	Noord-Nederland	50.8	87	Canarias (ES)	33.2
4	Île de France	73.3	46	Sud-Ouest (FR)	50.5	88	Región de Murcia	32.9
5	Southern and Eastern	71.6	47	Méditerranée	49.9	89	Castilla y León	32.5
6	Nordjylland	68.9	48	Région wallonne	49.8	90	Aragón	32.1
7	Sydsverige	68.0	49	Pohjois- ja Itä-Suomi	49.7	91	Nord-Est	32.1
8	Östra Mellansverige	67.2	50	Comunidad de Madrid	49.5	92	Centro (IT)	31.5
9	Västsverige	66.8	51	North East (UK)	48.5	93	Norte	30.8
10	South East (UK)	64.2	52	Zahodna Slovenija	46.3	94	Cantabria	30.6
11	Midtjylland	63.3	53	Mellersta Norrland	45.6	95	Castilla-la Mancha	30.4
12	Berlin	62.5	54	Sachsen	45.3	96	Algarve	29.9
13	East of England	61.9	55	Ouest (FR)	44.2	97	Lithuania	29.3
14	Helsinki-Uusimaa	60.9	56	Saarland	44.0	98	Mecklenburg-Vorpommern	28.7
15	West-Nederland	60.7	57	Nord - Pas-de-Calais	43.5	99	Közép-Magyarország	28.4
16	South West (UK)	59.7	58	Lisboa	42.9	100	Jadranska Hrvatska	28.2
17	Syddanmark	59.6	59	Est (FR)	42.4	101	Region Wschodni	28.1
18	Övre Norrland	59.4	60	Bassin Parisien	42.1	102	Centro (PT)	27.3
19	Hessen	58.7	61	Vzhodna Slovenija	41.7	103	Kontinentalna Hrvatska	27.2
20	Rheinland-Pfalz	57.1	62	Bremen	41.4	104	Latvia	26.9
21	Border, Midland and Western	56.9	63	Bratislavský kraj	41.4	105	Attiki	26.7
22	West Midlands (UK)	56.4	64	Brandenburg	41.1	106	Extremadura	26.5
23	Bruxelles / Brussels	56.2	65	País Vasco	40.6	107	Alentejo	25.7
24	Scotland	56.2	66	Cataluña	39.4	108	Stredné Slovensko	25.3
25	North West (UK)	55.9	67	Region Poludniowo-Zachodni	39.2	109	Západné Slovensko	24.5
26	Sjælland	55.8	68	Estonia	38.9	110	Isole	24.2
27	Ostösterreich	55.4	69	Principado de Asturias	38.4	111	Sud	23.5
28	Northern Ireland (UK)	55.0	70	Region Centralny	38.3	112	Východné Slovensko	23.2
29	Zuid-Nederland	54.9	71	Sachsen-Anhalt	37.9	113	Macroregiunea trei	20.4

30	Vlaams Gewest	54.8	72	Westösterreich	37.3	114	Nisia Aigaiou, Kriti	20.1
31	Baden-Württemberg	54.8	73	Schleswig-Holstein	37.3	115	Nyugat-Dunántúl	20.0
32	Bayern	54.7	74	Czech Republic	37.2	116	Voreia Ellada	19.4
33	Etelä-Suomi	54.7	75	Südösterreich	36.9	117	Dél-Dunántúl	19.3
34	Oost-Nederland	54.6	76	Nord-Ovest	35.7	118	Közép-Dunántúl	18.6
35	Centre-Est (FR)	53.5	77	Comunidad Foral de Navarra	35,3	119	Észak-Magyarország	18.5
36	East Midlands (UK)	53.2	78	Comunidad Valenciana	35.1	120	Dél-Alföld	18.1
37	Norra Mellansverige	53.1	79	Region Pólnocny	34.7	121	Macroregiunea doi	18.1
38	Wales	53.1	80	Region Poludniowy	34.3	122	Macroregiunea unu	17.9
39	Hamburg	53.0	81	Andalucía	34.0	123	Észak-Alföld	17.8
40	Yorkshire and The Humber	52.9	82	Illes Balears	34.0	124	Macroregiunea patru	17.8
41	Niedersachsen	51.9	83	La Rioja	33.9	125	Kentriki Ellada	16.7
42	Länsi-Suomi	51.9	84	Thüringen	33.6			

Table 8. The REDI 2017 ranking and scores, of the 125 European Union 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
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			

Table 9. Changes in rankings between 2013 and 2017 (the order is based on the REDI 2017 ranking)

REGION	2017 rank	2013 rank	Change	REGION	2017 rank	2013 rank	Change	REGION	2017 rank	2013 rank	Change
SE11	1	3	2	UKD	43	25	-18	ES53	85	82	-3
DK01	2	1	-1	BE3	44	48	4	PL4	86	86	0
UKI	3	2	-1	DE9	45	41	-4	PL6	87	79	-8
IE02	4	5	1	SI02	46	52	6	ITI	88	92	4
FR1	5	4	-1	DEF	47	73	26	ITC	89	76	-13
FI1B	6	14	8	AT3	48	72	24	ES61	90	81	-9
UKJ	7	10	3	FI19	49	42	-7	LT	91	97	6
DE6	8	39	31	DK02	50	26	-24	ES13	92	94	2
SE22	9	7	-2	PT17	51	58	7	PT16	93	102	9
NL3	10	15	5	AT2	52	75	23	ITH	94	91	-3
BE1	11	23	12	FR5	53	55	2	ES24	95	90	-5
DE3	12	12	0	FR3	54	57	3	PL3	96	101	5
UKK	13	16	3	SE21	55	43	-12	HU10	97	99	2
DE1	14	31	17	FR4	56	59	3	ES12	98	69	-29
DK03	15	17	2	SE31	57	37	-20	RO3	99	113	14
DE2	16	32	16	FR8	58	47	-11	ES11	100	85	-15
UKM	17	24	7	EE	59	68	9	ES62	101	88	-13
IE01	18	21	3	DEB	60	20	-40	ES70	102	87	-15
SE12	19	8	-11	UKC	61	51	-10	EL3	103	105	2
SE23	20	9	-11	SK01	62	63	1	ES23	104	83	-21
DE7	21	19	-2	FR2	63	60	-3	SK02	105	109	4
UKH	22	13	-9	FI1D	64	49	-15	ITG	106	110	4
FR7	23	35	12	SI01	65	61	-4	SK03	107	108	1
DK04	24	11	-13	PL1	66	70	4	ES43	108	106	-2
UKF	25	36	11	DEG	67	84	17	RO1	109	122	13
NL4	26	29	3	ES51	68	66	-2	SK04	110	112	2
DE5	27	62	35	PL2	69	80	11	ITF	111	111	0
AT1	28	27	-1	DE8	70	98	28	HR04	112	103	-9
DEC	29	56	27	SE32	71	53	-18	ES42	113	95	-18
DK05	30	6	-24	ES21	72	65	-7	HR03	114	100	-14
NL1	31	45	14	CZ	73	74	1	RO4	115	124	9

UKN	32	28	-4	DEE	74	71	-3	EL1	116	116	0
DEA	33	44	11	FR6	75	46	-29	HU22	117	115	-2
SE33	34	18	-16	PT18	76	107	31	RO2	118	121	3
UKG	35	22	-13	LV	77	104	27	EL4	119	114	-5
FI1C	36	33	-3	PL5	78	67	-11	EL2	120	125	5
NL2	37	34	-3	ES22	79	77	-2	HU23	121	117	-4
UKE	38	40	2	PT15	80	96	16	HU31	122	119	-3
BE2	39	30	-9	DE4	81	64	-17	HU21	123	118	-5
ES30	40	50	10	ES52	82	78	-4	HU32	124	123	-1
DED	41	54	13	ES41	83	89	6	HU33	125	120	-5
UKL	42	38	-4	PT11	84	93	9				

5.2. The analysis of the three sub-indices and the fourteen pillars

While the REDI points are suitable to compare the overall entrepreneurial performances of the regions they are not proper for policy application. The REDI needs to be decomposed to be able to get a more accurate picture about the entrepreneurial profile of the regions and the potential direction of entrepreneurship policy action. *Table 11 and 12* provides the REDI 2013 and 2017 scores respectively and the ranking of the 125 regions in all three sub-indices.

The examination of the three REDI 2017 sub-indices demonstrates the varieties of the regions entrepreneurial characteristics. A few well balanced regions exist, e.g. Stockholm is one of these with 75.4 ATT, 86.3 ABT and 73.2 ASP scores. Brussels is in 11th place in the REDI 2017 ranking but a closer look at its sub-indices reveals a relatively low ATT score (55.5, 37th place), a somewhat higher ABT value (62.8, 24th place) but its ASP score is relatively very high (71.5, 4th place). Picking up a Spanish region, Principado de Asturias, has an acceptable ATT score (32.9), a relatively high ABT score (37.5) but a very low ASP score (20.3).

An analysis on the 14 pillars' level provides an even more detailed and precise picture about the entrepreneurial profile of a region. *Table 13* shows the 2017 non-penalized average equated pillar values for all the 125 regions. The colors help to identify the position of a region's particular pillar. For example, Noord-Nederland has a high value in Startup Skills (green color) but reached a more modest score in Globalization (amber color) and a relatively low point in Risk Perception (reddish color). Greener colors mean higher and better scores while reddish color imply poor performance that may call for policy intervention.

Table 10. The Entrepreneurial attitudes (ATT), Entrepreneurial Abilities (ABT) and Entrepreneurial Aspirations (ASP) values and ranks of the 125 regions in the case of REDI 2013

Regional Code	ATT	ATT Rank	ABT	ABT Rank	ASP	ASP Rank	Regional Code	ATT	ATT Rank	ABT	ABT Rank	ASP	ASP Rank
AT1	53.7	40	56.0	30	56.5	23	HR03	19.7	107	27.9	91	37.1	79
AT2	40.6	67	37.3	68	32.8	88	HR04	18.9	108	26.6	94	36.2	82
AT3	41.4	63	26.4	95	44.3	55	HU10	26.9	101	29.9	87	28.4	106
BE1	56.3	34	52.7	39	59.6	17	HU21	15.6	119	22.0	107	18.3	123
BE2	47.8	49	58.8	25	58.0	20	HU22	18.5	109	25.1	100	16.3	125
BE3	41.6	61	46.7	49	61.0	15	HU23	15.8	118	20.8	110	21.3	119
CZ	29.2	99	24.2	101	58.2	18	HU31	13.9	121	21.0	109	20.8	121
DE1	52.1	42	55.9	31	56.4	24	HU32	13.8	122	22.2	104	17.5	124
DE2	52.0	43	54.1	33	58.2	19	HU33	14.4	120	18.9	113	21.2	120
DE3	58.4	33	63.8	15	65.3	7	IE01	64.1	21	59.1	22	47.4	49
DE4	33.2	89	50.2	44	40.0	68	IE02	70.7	8	79.4	3	64.9	8
DE5	42.4	59	35.3	73	46.7	50	ITC	31.5	93	32.0	82	43.7	57
DE6	55.6	36	59.6	21	43.7	59	ITF	23.4	105	19.9	111	27.1	113
DE7	53.2	41	52.0	41	71.0	3	ITG	22.3	106	22.1	106	28.1	109
DE8	33.5	87	25.1	99	27.3	111	ITH	30.0	97	30.4	86	36.0	83
DE9	46.0	51	48.6	47	61.2	14	ITI	29.8	98	26.1	97	38.6	74
DEA	51.8	44	46.7	48	54.0	28	LT	23.6	104	28.5	89	35.7	84
DEB	49.5	46	52.8	38	69.0	5	LV	24.7	103	26.4	96	29.6	99
DEC	43.0	57	37.8	64	51.2	35	NL1	55.3	37	53.0	37	43.9	56
DED	44.1	54	42.7	57	49.1	43	NL2	60.5	27	54.6	32	48.8	45
DEE	33.7	86	42.2	58	37.9	76	NL3	65.1	18	60.2	20	56.6	22
DEF	39.2	68	44.5	54	28.2	107	NL4	61.1	24	53.8	35	49.9	37
DEG	33.4	88	38.3	61	29.2	103	PL1	42.2	60	27.3	93	45.3	53
DK01	79.3	2	88.2	1	77.7	2	PL2	36.9	73	21.3	108	44.8	54
DK02	60.3	28	57.9	28	49.1	44	PL3	31.3	95	15.5	120	37.3	78

DK03	65.7	16	63.3	18	49.7	40	PL4	35.7	80	22.2	105	42.2	64
DK04	68.6	10	69.2	8	52.1	29	PL5	36.3	76	29.8	88	51.5	33
DK05	68.4	11	72.9	6	65.4	6	PL6	35.7	81	18.7	115	49.8	39
EE	39.1	69	38.0	63	39.6	69	PT11	31.0	96	23.6	102	37.9	75
EL1	12.3	124	16.4	118	29.5	102	PT15	32.6	91	25.8	98	31.4	95
EL2	11.0	125	15.7	119	23.6	116	PT16	26.8	102	22.6	103	32.6	89
EL3	17.9	111	31.1	83	31.1	97	PT17	43.8	55	35.0	74	49.9	38
EL4	12.4	123	18.9	114	29.0	104	PT18	28.6	100	19.0	112	29.6	98
ES11	35.1	82	36.0	71	29.5	100	RO1	16.9	115	13.9	123	23.0	118
ES12	37.7	72	40.0	60	37.6	77	RO2	16.6	116	10.4	125	27.2	112
ES13	34.1	84	34.1	76	23.7	115	RO3	17.8	112	14.5	121	28.8	105
ES21	41.5	62	43.6	56	36.8	81	RO4	16.2	117	13.9	122	23.2	117
ES22	35.8	78	37.8	65	32.2	91	SE11	80.8	1	79.4	4	61.7	12
ES23	36.8	74	33.9	77	31.1	96	SE12	72.3	7	66.7	12	62.7	10
ES24	35.7	79	36.0	70	24.7	114	SE21	66.0	15	51.4	43	35.2	86
ES30	47.8	48	49.0	46	51.7	32	SE22	76.1	3	65.7	14	62.3	11
ES41	33.2	90	32.0	81	32.2	90	SE23	72.5	6	67.4	9	60.5	16
ES42	32.2	92	30.9	84	28.0	110	SE31	63.7	22	52.6	40	42.9	63
ES43	31.4	94	27.8	92	20.2	122	SE32	54.2	38	53.1	36	29.5	101
ES51	44.1	53	37.2	69	36.8	80	SE33	67.4	13	53.8	34	57.0	21
ES52	38.4	70	35.6	72	31.5	93	SI01	43.4	56	34.2	75	47.6	47
ES53	36.8	75	33.7	78	31.4	94	SI02	45.8	52	38.0	62	55.0	26
ES61	36.0	77	30.5	85	35.6	85	SK01	34.8	83	28.1	90	61.3	13
ES62	33.9	85	32.6	80	32.1	92	SK02	17.8	113	16.6	117	39.1	70
ES70	38.3	71	33.1	79	28.1	108	SK03	18.2	110	17.1	116	40.7	67
FI19	67.5	12	44.5	55	43.6	60	SK04	17.3	114	13.7	124	38.7	73
FI1B	72.6	5	58.9	24	51.3	34	UKC	54.2	39	57.5	29	33.8	87
FI1C	69.0	9	45.6	52	49.4	41	UKD	60.9	25	63.4	16	43.5	61
FI1D	64.5	19	45.8	51	38.7	72	UKE	59.4	29	58.4	26	40.9	66

FR1	63.3	23	70.4	7	86.4	1	UKF	59.1	30	61.7	19	38.8	71
FR2	40.6	66	37.5	66	48.1	46	UKG	60.5	26	63.4	17	45.4	52
FR3	41.1	64	41.8	59	47.5	48	UKH	64.4	20	66.0	13	55.2	25
FR4	40.9	65	37.3	67	49.1	42	UKI	75.2	4	82.7	2	69.6	4
FR5	42.8	58	46.0	50	43.7	58	UKJ	66.4	14	74.4	5	51.7	31
FR6	47.8	47	51.8	42	51.9	30	UKK	65.5	17	67.2	10	46.5	51
FR7	47.4	50	49.5	45	63.5	9	UKL	59.0	31	58.1	27	42.2	65
FR8	49.7	45	45.1	53	54.9	27	UKM	58.6	32	67.0	11	43.0	62
							UKN	55.7	35	59.0	23	50.3	36

Table 11. The Entrepreneurial Attitudes (ATT), Entrepreneurial Abilities (ABT) and Entrepreneurial Aspirations (ASP) values and ranks of the 125 regions in the case of REDI 2017

Regional Code	ATT	ATT Rank	ABT	ABT Rank	ASP	ASP Rank	Regional Code	ATT	ATT Rank	ABT	ABT Rank	ASP	ASP Rank
AT1	54.9	40	63.4	23	52.6	30	HR03	18.9	112	21.0	112	30.8	98
AT2	46.6	53	52.2	48	44.2	52	HR04	17.1	114	24.3	104	35.5	87
AT3	49.2	47	52.7	45	45.1	48	HU10	21.0	109	34.2	81	38.1	79
BE1	55.5	37	62.8	24	71.5	4	HU21	12.1	121	23.2	106	20.9	120
BE2	43.9	60	53.3	43	56.8	19	HU22	15.1	119	24.6	103	25.3	113
BE3	39.2	71	51.2	51	60.5	15	HU23	11.4	122	22.7	107	25.4	111
CZ	30.5	98	32.0	88	53.7	28	HU31	10.9	124	22.0	109	23.7	116
DE1	56.3	35	61.4	28	68.3	5	HU32	10.9	125	18.5	120	25.3	112
DE2	53.8	42	59.9	33	67.9	6	HU33	11.3	123	20.9	114	21.0	119
DE3	61.6	18	67.1	17	58.6	16	IE01	67.2	8	65.8	20	48.2	42
DE4	36.3	79	32.6	86	36.2	84	IE02	70.1	6	77.2	5	66.6	8
DE5	57.1	32	53.2	44	60.9	14	ITC	28.3	100	30.1	92	42.0	62
DE6	66.6	10	69.4	12	72.5	3	ITF	23.7	106	18.2	121	35.2	89
DE7	56.6	33	62.2	25	57.9	18	ITG	21.6	108	19.8	119	38.8	76
DE8	39.3	70	51.4	50	30.0	102	ITH	27.4	102	28.1	95	42.3	60
DE9	48.9	48	48.2	58	53.8	27	ITI	28.1	101	29.9	93	42.6	58
DEA	54.0	41	54.5	40	56.0	21	LT	27.1	103	32.6	85	38.8	75
DEB	44.9	55	49.8	55	39.1	74	LV	35.1	88	33.3	83	41.7	65
DEC	48.2	49	55.2	39	66.7	7	NL1	57.4	30	60.1	32	48.3	40
DED	46.9	52	57.6	37	47.1	46	NL2	58.2	28	55.8	38	41.3	66
DEE	33.8	91	46.6	62	34.1	91	NL3	65.4	11	71.1	11	53.9	26
DEF	47.0	51	58.4	35	44.1	53	NL4	61.3	21	61.8	27	49.5	36
DEG	40.1	68	42.2	68	41.2	67	PL1	44.1	59	30.9	91	53.9	25
DK01	77.5	2	86.6	1	65.6	9	PL2	42.1	62	28.0	96	51.3	33
DK02	50.5	44	64.2	22	30.6	99	PL3	35.5	87	20.0	118	40.0	72

DK03	60.4	22	71.6	10	52.7	29	PL4	40.8	66	20.0	117	41.9	64
DK04	57.2	31	66.8	18	50.6	34	PL5	40.7	67	24.7	102	44.6	51
DK05	57.9	29	69.3	13	42.3	61	PL6	41.6	63	21.1	110	38.4	78
EE	49.7	45	44.3	65	41.9	63	PT11	35.8	83	26.4	100	40.7	70
EL1	15.1	118	24.0	105	27.1	108	PT15	36.6	78	37.4	75	32.0	94
EL2	13.6	120	22.4	108	24.1	114	PT16	29.9	99	27.8	98	40.3	71
EL3	20.1	111	32.9	84	32.1	93	PT17	45.7	54	44.3	64	54.3	24
EL4	15.2	117	20.8	115	27.8	105	PT18	36.3	80	32.1	87	43.0	57
ES11	33.5	92	29.2	94	25.7	110	RO1	24.2	105	17.3	123	36.9	82
ES12	32.9	94	37.5	74	20.3	121	RO2	20.5	110	11.8	125	31.9	95
ES13	34.9	89	35.8	79	27.3	107	RO3	24.8	104	20.9	113	43.9	54
ES21	38.2	75	45.8	63	32.4	92	RO4	23.4	107	12.1	124	31.3	96
ES22	35.7	84	37.6	73	35.3	88	SE11	75.4	3	86.3	2	73.2	2
ES23	35.5	86	27.9	97	21.1	118	SE12	60.0	23	68.1	16	51.7	32
ES24	36.1	81	35.7	80	23.8	115	SE21	59.1	25	50.5	54	27.0	109
ES30	47.1	50	57.8	36	48.3	41	SE22	67.1	9	74.0	6	56.4	20
ES41	34.8	90	38.6	71	30.3	100	SE23	63.5	15	68.4	15	47.5	44
ES42	30.8	97	25.5	101	17.9	125	SE31	55.5	39	52.1	49	28.9	103
ES43	31.8	96	27.4	99	19.3	123	SE32	50.8	43	50.7	52	18.1	124
ES51	44.2	58	41.4	69	37.2	81	SE33	58.9	26	60.5	30	44.9	49
ES52	37.8	77	38.5	72	28.3	104	SI01	41.2	65	43.0	67	44.8	50
ES53	39.1	72	35.9	78	27.8	106	SI02	44.5	56	49.7	56	55.8	22
ES61	35.6	85	33.8	82	30.2	101	SK01	32.9	95	37.4	76	62.2	13
ES62	33.4	93	31.0	90	23.5	117	SK02	17.0	115	20.8	116	42.4	59
ES70	36.1	82	32.0	89	19.5	122	SK03	17.7	113	21.0	111	40.7	69
FI19	61.6	17	49.4	57	35.6	86	SK04	16.9	116	17.7	122	43.4	56
FI1B	71.8	5	73.5	8	64.6	11	UKC	49.6	46	52.4	46	30.8	97
FI1C	63.8	14	52.2	47	41.1	68	UKD	61.5	19	53.7	42	36.0	85
FI1D	56.0	36	39.5	70	34.2	90	UKE	58.3	27	60.2	31	36.7	83

FR1	56.6	34	74.0	7	81.8	1	UKF	64.4	12	60.7	29	48.5	39
FR2	38.6	73	47.9	60	45.7	47	UKG	62.3	16	59.7	34	39.8	73
FR3	39.5	69	47.1	61	52.5	31	UKH	61.4	20	65.6	21	49.2	37
FR4	38.2	76	43.2	66	55.2	23	UKI	80.6	1	82.7	3	63.3	12
FR5	41.4	64	48.2	59	50.2	35	UKJ	73.4	4	77.4	4	58.0	17
FR6	38.4	74	36.0	77	38.5	77	UKK	67.6	7	71.6	9	47.7	43
FR7	44.3	57	66.4	19	64.8	10	UKL	59.2	24	54.4	41	37.5	80
FR8	42.2	61	50.6	53	43.5	55	UKM	63.8	13	68.5	14	49.1	38
							UKN	55.5	38	62.0	26	47.4	45

Note: number of observations = 125

Table 12. The REDI 2017 average equalized pillar scores of the 125 European Union regions

Regional Code	Opportunity Perception	Strat-up skills	Risk Perception	Networking	Cultural Support	Opportunity Startup	Technology Absorption	Human Capital	Competition	Product Innovation	Process Innovation	High Growth	Globalization	Financing
AT1	0.68	0.81	0.36	0.62	0.54	0.65	0.74	0.56	0.94	0.74	0.58	0.29	0.78	0.49
AT2	0.36	0.60	0.38	0.58	0.63	0.62	0.62	0.43	0.67	0.58	0.81	0.29	0.59	0.21
AT3	0.51	0.65	0.39	0.58	0.58	0.69	0.56	0.42	0.72	0.59	0.50	0.21	0.69	0.51
BE1	0.79	0.64	0.59	0.42	0.44	0.43	0.41	0.92	1.00	1.00	1.00	0.90	0.68	0.42
BE2	0.57	0.31	0.59	0.32	0.49	0.40	0.63	0.69	0.56	0.52	0.72	0.34	0.91	0.64
BE3	0.45	0.24	0.59	0.39	0.40	0.38	0.46	0.62	0.83	0.68	0.80	0.47	0.90	0.68
CZ	0.49	0.71	0.12	0.24	0.17	0.25	0.47	0.40	0.27	0.66	0.64	0.66	0.90	0.47
DE1	0.67	0.74	0.34	0.58	0.67	0.68	0.83	0.45	0.72	0.57	0.77	0.74	0.97	0.78
DE2	0.55	0.70	0.35	0.56	0.65	0.67	0.74	0.38	0.80	0.60	0.81	0.85	0.81	0.68
DE3	0.90	0.86	0.37	0.65	0.58	0.52	1.00	0.58	0.89	0.44	0.64	0.71	0.77	0.55
DE4	0.35	0.45	0.31	0.50	0.65	0.33	0.01	0.44	1.00	0.17	0.24	0.41	0.77	0.79
DE5	0.74	0.71	0.39	0.60	0.68	0.61	0.66	0.39	0.61	1.00	0.57	1.00	0.30	0.65
DE6	1.00	1.00	0.39	0.67	0.64	0.68	0.89	0.51	1.00	0.69	0.58	1.00	0.94	0.84
DE7	0.70	0.72	0.36	0.62	0.63	0.56	0.77	0.51	0.89	0.34	0.51	0.57	0.78	1.00
DE8	0.28	0.39	0.34	0.47	0.66	0.48	0.55	0.44	0.97	0.32	0.29	0.26	0.54	0.18
DE9	0.44	0.55	0.36	0.58	0.65	0.67	0.29	0.36	0.77	0.46	0.47	0.62	0.61	0.75
DEA	0.70	0.66	0.35	0.57	0.63	0.55	0.57	0.42	0.84	0.60	0.29	0.75	0.74	0.71
DEB	0.50	0.61	0.33	0.53	0.68	0.68	0.91	0.34	0.55	0.11	0.20	0.80	0.79	0.49
DEC	0.48	0.52	0.32	0.58	0.62	0.70	0.89	0.40	0.43	0.69	0.34	0.89	1.00	0.97
DED	0.49	0.57	0.34	0.49	0.64	0.48	0.85	0.45	0.90	0.24	0.44	0.57	0.52	0.84
DEE	0.22	0.33	0.31	0.47	0.62	0.60	0.52	0.41	0.81	0.07	0.46	0.21	0.56	0.76
DEF	0.41	0.56	0.37	0.56	0.67	0.64	0.75	0.41	1.00	0.21	0.39	0.38	0.57	0.95
DEG	0.28	0.43	0.29	0.50	0.64	0.49	0.63	0.23	0.47	0.36	0.23	0.60	0.69	0.36
DK01	1.00	0.75	0.58	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.71	0.43	0.44	1.00
DK02	0.78	0.24	0.56	0.82	0.96	1.00	0.75	1.00	0.93	0.83	0.07	0.40	0.10	0.46
DK03	0.88	0.31	0.61	0.81	1.00	1.00	0.65	1.00	0.93	0.98	0.57	0.45	0.24	0.83
DK04	0.91	0.43	0.58	0.81	1.00	1.00	0.82	1.00	0.86	0.89	0.69	0.60	0.12	1.00
DK05	0.84	0.34	0.58	0.76	1.00	1.00	1.00	1.00	0.60	0.60	0.35	0.31	0.19	1.00
EE	0.70	0.98	0.61	0.49	0.19	0.44	0.53	0.52	0.45	0.60	0.63	0.62	0.29	0.20
EL1	0.22	0.24	0.25	0.12	0.01	0.15	0.33	0.37	0.25	0.34	0.65	0.10	0.20	0.36
EL2	0.16	0.22	0.25	0.11	0.00	0.13	0.34	0.31	0.25	0.39	0.45	0.06	0.23	0.28
EL3	0.36	0.40	0.26	0.14	0.00	0.14	0.50	0.50	0.50	0.52	0.63	0.17	0.37	0.30
EL4	0.20	0.29	0.23	0.13	0.01	0.19	0.19	0.34	0.22	0.40	0.71	0.00	0.26	0.39
ES11	0.23	0.51	0.31	0.41	0.40	0.24	0.41	0.37	0.25	0.29	0.39	0.16	0.10	0.46
ES12	0.28	0.49	0.30	0.41	0.41	0.43	0.63	0.44	0.30	0.18	0.56	0.06	0.05	0.31
ES13	0.26	0.49	0.33	0.43	0.44	0.41	0.46	0.37	0.36	0.28	0.42	0.16	0.10	0.55
ES21	0.39	0.60	0.33	0.41	0.44	0.44	0.86	0.59	0.34	0.29	0.86	0.19	0.10	0.48
ES22	0.26	0.53	0.34	0.43	0.44	0.42	0.48	0.53	0.27	0.52	0.98	0.13	0.11	0.43
ES23	0.28	0.50	0.34	0.42	0.47	0.42	0.27	0.35	0.18	0.20	0.41	0.10	0.12	0.30
ES24	0.31	0.55	0.33	0.41	0.43	0.35	0.51	0.42	0.31	0.28	0.36	0.15	0.10	0.40
ES30	0.48	0.88	0.35	0.43	0.41	0.46	1.00	0.73	0.47	0.49	0.81	0.44	0.27	0.62
ES41	0.22	0.48	0.33	0.40	0.42	0.43	0.48	0.45	0.31	0.31	0.38	0.17	0.19	0.57
ES42	0.15	0.45	0.30	0.40	0.41	0.23	0.36	0.28	0.22	0.18	0.16	0.13	0.09	0.38

ES43	0.16	0.47	0.31	0.44	0.45	0.38	0.27	0.32	0.24	0.29	0.31	0.09	0.06	0.30
ES51	0.39	0.82	0.36	0.46	0.43	0.33	0.58	0.45	0.43	0.55	0.58	0.24	0.20	0.45
ES52	0.32	0.57	0.34	0.40	0.41	0.30	0.55	0.44	0.38	0.39	0.39	0.19	0.16	0.36
ES53	0.30	0.61	0.36	0.46	0.44	0.39	0.49	0.28	0.40	0.31	0.27	0.15	0.21	0.53
ES61	0.26	0.51	0.33	0.43	0.39	0.31	0.37	0.38	0.36	0.34	0.39	0.34	0.16	0.35
ES62	0.24	0.46	0.30	0.40	0.46	0.34	0.42	0.33	0.25	0.20	0.35	0.15	0.10	0.48
ES70	0.32	0.56	0.35	0.39	0.38	0.28	0.42	0.32	0.37	0.30	0.20	0.11	0.13	0.27
FI19	0.80	0.62	0.46	1.00	0.80	0.84	0.44	0.45	0.46	0.36	0.58	0.39	0.23	0.30
FI1B	1.00	0.82	0.50	1.00	0.77	1.00	1.00	0.75	0.62	0.93	0.98	0.89	0.48	0.36
FI1C	0.73	0.85	0.52	0.95	0.77	0.88	0.67	0.32	0.52	0.61	0.62	0.37	0.38	0.23
FI1D	0.70	0.73	0.50	0.94	0.78	0.85	0.37	0.31	0.36	0.59	0.64	0.49	0.10	0.20
FR1	0.69	0.55	0.73	0.44	0.49	0.53	1.00	0.73	1.00	0.83	1.00	1.00	0.92	0.84
FR2	0.32	0.20	0.70	0.38	0.52	0.54	0.54	0.40	0.66	0.65	0.44	0.47	0.37	0.60
FR3	0.54	0.18	0.69	0.31	0.47	0.49	0.36	0.50	0.81	0.61	0.78	0.46	0.72	0.49
FR4	0.34	0.18	0.71	0.36	0.51	0.47	0.43	0.42	0.56	0.60	0.80	0.61	0.70	0.54
FR5	0.32	0.23	0.71	0.40	0.57	0.51	0.28	0.53	0.83	0.50	0.75	0.54	0.49	0.49
FR6	0.37	0.25	0.79	0.41	0.54	0.46	0.41	0.50	0.33	0.45	0.87	0.45	0.05	0.65
FR7	0.44	0.26	0.74	0.42	0.52	0.56	0.92	0.76	0.90	1.00	0.95	0.76	0.73	0.43
FR8	0.46	0.31	0.82	0.40	0.47	0.41	0.58	0.55	0.93	0.66	0.67	0.13	0.53	0.59
HR03	0.37	0.49	0.19	0.06	0.01	0.08	0.28	0.21	0.39	0.23	0.33	0.47	0.34	0.47
HR04	0.30	0.43	0.19	0.05	0.01	0.11	0.33	0.22	0.50	0.27	0.50	0.57	0.40	0.45
HU10	0.42	0.51	0.12	0.17	0.02	0.17	0.57	0.57	0.37	0.44	0.39	0.61	0.63	0.30
HU21	0.19	0.16	0.11	0.16	0.03	0.22	0.33	0.29	0.19	0.16	0.13	0.33	0.43	0.12
HU22	0.29	0.21	0.12	0.16	0.03	0.26	0.27	0.33	0.23	0.19	0.13	0.34	0.78	0.11
HU23	0.17	0.14	0.10	0.15	0.03	0.16	0.27	0.28	0.31	0.36	0.20	0.57	0.30	0.07
HU31	0.17	0.13	0.11	0.14	0.02	0.19	0.34	0.30	0.15	0.08	0.19	0.57	0.39	0.17
HU32	0.14	0.15	0.11	0.15	0.02	0.14	0.21	0.29	0.17	0.31	0.23	0.44	0.32	0.14
HU33	0.16	0.16	0.10	0.14	0.02	0.18	0.29	0.26	0.19	0.21	0.20	0.23	0.42	0.12
IE01	0.50	0.78	0.84	0.58	0.99	0.73	0.61	0.85	0.64	0.51	0.43	0.64	0.48	0.39
IE02	0.48	0.78	0.83	0.64	0.98	0.69	0.72	0.94	0.97	0.70	0.72	0.81	0.50	0.72
ITC	0.38	0.27	0.43	0.23	0.21	0.21	0.65	0.18	0.31	1.00	0.63	0.11	0.38	0.50
ITF	0.30	0.24	0.40	0.21	0.16	0.04	0.29	0.11	0.37	1.00	0.46	0.18	0.27	0.35
ITG	0.21	0.21	0.35	0.21	0.17	0.05	0.18	0.15	0.51	0.98	0.40	0.10	0.38	0.65
ITH	0.32	0.21	0.42	0.25	0.26	0.38	0.38	0.11	0.35	0.96	0.72	0.36	0.42	0.16
ITI	0.34	0.31	0.39	0.25	0.20	0.15	0.45	0.23	0.48	1.00	0.70	0.12	0.40	0.43
LT	0.51	0.25	0.50	0.28	0.04	0.25	0.39	0.70	0.23	0.39	0.48	0.80	0.35	0.38
LV	0.55	0.76	0.40	0.23	0.11	0.25	0.35	0.48	0.38	0.41	0.27	1.00	0.42	0.42
NL1	0.37	0.89	0.32	0.80	0.85	0.97	0.63	0.45	0.63	0.64	0.41	0.35	0.46	0.67
NL2	0.54	0.97	0.31	0.86	0.89	0.94	0.50	0.49	0.72	0.48	0.46	0.20	0.55	0.56
NL3	0.77	1.00	0.30	0.89	0.89	0.92	0.85	0.68	0.89	0.63	0.60	0.49	0.54	0.61
NL4	0.62	0.89	0.31	0.81	0.89	0.95	0.52	0.59	0.74	0.62	0.44	0.30	0.62	0.67
PL1	0.48	1.00	0.34	0.49	0.32	0.14	0.42	0.54	0.24	1.00	0.35	0.73	0.74	0.55
PL2	0.43	0.78	0.35	0.48	0.30	0.18	0.37	0.44	0.18	0.98	0.29	0.58	0.66	0.55
PL3	0.37	0.50	0.34	0.44	0.33	0.15	0.23	0.35	0.10	0.97	0.20	0.59	0.41	0.28
PL4	0.43	0.75	0.39	0.49	0.35	0.18	0.23	0.35	0.09	0.73	0.22	0.49	0.48	0.59
PL5	0.45	0.64	0.38	0.47	0.34	0.20	0.32	0.38	0.14	0.99	0.29	0.49	0.59	0.32
PL6	0.48	0.69	0.38	0.46	0.36	0.17	0.19	0.37	0.13	0.68	0.21	0.54	0.46	0.29
PT11	0.37	0.42	0.40	0.25	0.42	0.31	0.25	0.21	0.30	0.38	0.78	0.30	0.54	0.23
PT15	0.25	0.49	0.40	0.27	0.52	0.51	0.46	0.22	0.39	0.23	0.30	0.37	0.47	0.29
PT16	0.13	0.40	0.40	0.25	0.43	0.36	0.29	0.25	0.26	0.51	0.60	0.43	0.46	0.28
PT17	0.51	0.72	0.45	0.30	0.42	0.34	0.57	0.38	0.54	0.44	1.00	0.42	0.52	0.61
PT18	0.31	0.37	0.37	0.25	0.64	0.60	0.20	0.22	0.34	0.49	0.49	0.55	0.51	0.28
RO1	0.37	0.08	0.70	0.10	0.16	0.08	0.22	0.24	0.17	0.45	0.17	1.00	0.33	0.33
RO2	0.34	0.02	0.67	0.09	0.12	0.02	0.10	0.21	0.16	0.21	0.14	0.91	0.29	0.48

RO3	0.45	0.16	0.72	0.12	0.09	0.02	0.34	0.40	0.19	0.42	0.48	1.00	0.54	0.47
RO4	0.38	0.05	0.78	0.10	0.14	0.04	0.11	0.24	0.12	0.33	0.18	0.95	0.30	0.21
SE11	1.00	0.53	0.70	0.95	0.89	0.96	1.00	0.87	1.00	0.95	1.00	0.78	0.69	0.49
SE12	1.00	0.24	0.67	0.83	0.86	1.00	0.79	0.68	0.83	0.43	0.96	0.51	0.56	0.44
SE21	1.00	0.22	0.73	0.84	0.85	0.93	0.58	0.37	0.44	0.28	0.32	0.33	0.21	0.22
SE22	1.00	0.34	0.76	0.89	0.87	0.84	1.00	0.73	0.85	0.70	0.75	0.44	0.74	0.39
SE23	1.00	0.32	0.74	0.91	0.87	1.00	0.85	0.64	0.82	0.44	1.00	0.54	0.45	0.25
SE31	0.93	0.23	0.72	0.81	0.90	0.80	0.78	0.53	0.44	0.46	0.44	0.13	0.36	0.17
SE32	1.00	0.26	0.73	0.80	0.93	1.00	0.81	0.47	0.61	0.22	0.25	0.00	0.23	0.32
SE33	1.00	0.22	0.71	0.89	0.82	0.77	0.73	0.62	0.75	0.56	1.00	0.62	0.21	0.24
SI01	0.26	0.68	0.39	0.43	0.42	0.41	0.48	0.42	0.47	0.49	0.42	0.51	0.61	0.33
SI02	0.35	0.71	0.40	0.47	0.40	0.30	0.74	0.50	0.59	0.99	0.75	0.42	0.64	0.32
SK01	0.65	0.62	0.20	0.47	0.06	0.18	0.96	0.57	0.22	0.96	1.00	0.76	1.00	0.75
SK02	0.17	0.08	0.19	0.40	0.07	0.21	0.32	0.24	0.10	0.44	0.25	0.67	0.77	0.48
SK03	0.15	0.10	0.19	0.42	0.08	0.16	0.36	0.24	0.13	0.38	0.33	0.71	0.52	0.47
SK04	0.18	0.07	0.18	0.43	0.06	0.12	0.27	0.19	0.16	0.75	0.36	0.76	0.46	0.37
UKC	0.50	0.45	0.92	0.54	0.81	0.78	0.41	0.82	0.75	0.48	0.42	0.35	0.45	0.07
UKD	0.62	0.62	0.91	0.58	0.83	0.74	0.48	0.74	0.43	0.34	0.48	0.51	0.25	0.28
UKE	0.64	0.56	0.89	0.65	0.81	0.83	0.46	0.86	0.85	0.35	0.44	0.65	0.40	0.17
UKF	0.56	0.63	1.00	0.67	0.76	0.63	0.51	0.73	0.80	0.79	0.66	0.33	0.49	0.32
UKG	0.64	0.61	1.00	0.59	0.77	0.78	0.41	0.73	0.82	0.40	0.39	0.54	0.49	0.26
UKH	0.59	0.71	1.00	0.75	0.79	0.79	0.74	0.83	1.00	0.62	0.94	0.73	0.51	0.17
UKI	0.85	1.00	0.98	0.76	0.81	0.83	0.82	1.00	1.00	0.48	0.52	1.00	0.76	0.56
UKJ	0.70	0.91	0.93	0.67	0.83	0.79	0.77	0.94	0.98	0.40	0.80	0.64	0.50	0.69
UKK	0.54	0.75	1.00	0.69	0.75	0.73	0.79	0.75	0.92	0.46	0.37	0.57	0.52	0.51
UKL	0.43	0.51	0.89	0.61	0.79	0.56	0.33	0.72	0.73	0.33	0.35	0.35	0.39	0.46
UKM	0.46	0.58	0.96	0.63	0.78	0.67	0.47	0.93	0.93	0.41	0.60	0.59	0.42	0.46
UKN	0.38	0.42	0.78	0.59	0.80	0.83	0.49	0.61	0.76	0.56	0.55	0.57	0.36	0.39

Note: The colors reflect to the value of the score from the best (green) toward the medium (amber) to the worst (red).

Showing the varieties of the potential investigations we present three types of spider diagrams: One that compares the leading regions (*Figure 5*) the other that relates the leading and the medium ranking and lagging regions (*Figure 6*) and one the pictures the same country regions (*Figure 7*).

According to *Figure 5*, apart from a few cases, the three leading regions are above the average pillar values. Only Hovedstaden's High Growth and Globalization and London's Product Innovation values are below the 125 regions' averages. All three regions have some common features: all seems to be strong in Opportunity Perception, Cultural Support, Opportunity Startup, Technology Absorption, Human Capital and Competition. However, the differences between them are more notable. Hovedstaden reached the maximum value for most of the pillars and it is stronger than the other two regions in Networking, Cultural Support, Opportunity Startup, Product Innovation and Financing. London's relative advantages are the Startup Skills, Risk Acceptance, High Growth and Globalization pillars. At the same time, London is relatively weak in Cultural Support, Opportunity Startup, Technology Absorption, Product and Process Innovations. Among the three leading regions, Stockholm is the strongest in Process Innovation, and relatively weak in Startup Skills and Financing.

Figure 5. The comparison of the 2017 entrepreneurial profile of the three leading regions

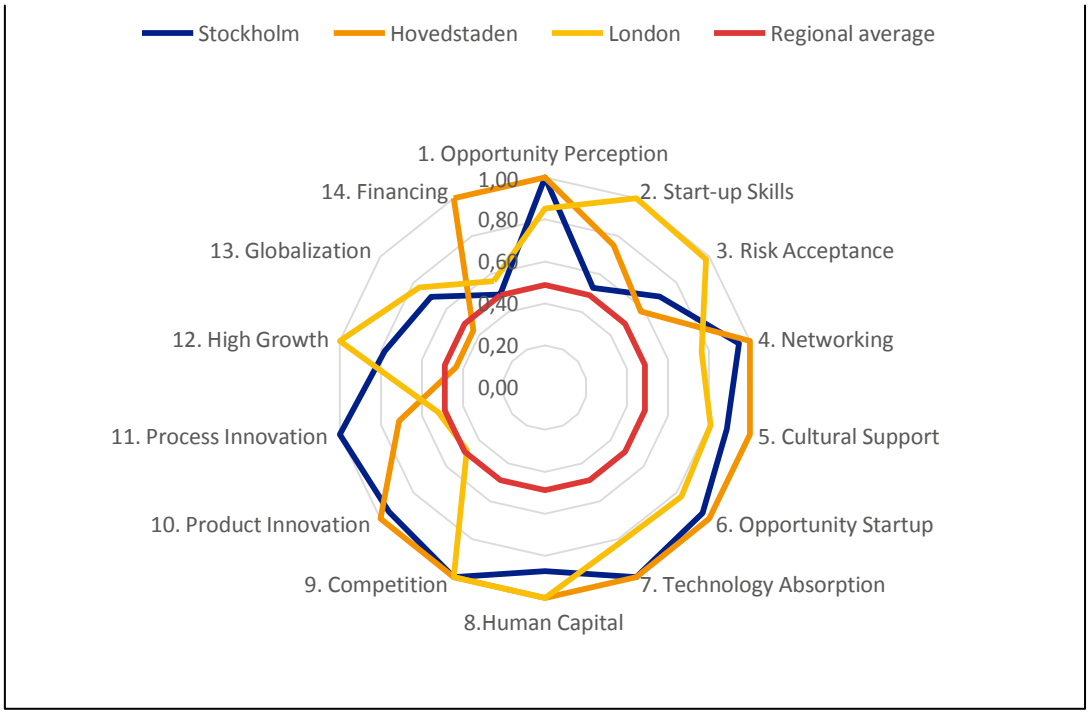


Figure 6. The comparison of the REDI 2017 entrepreneurial profile of the leading (Stockholm) a medium ranking (Vzhodna Slovenija) and a lagging (Macroregiunea trei) region

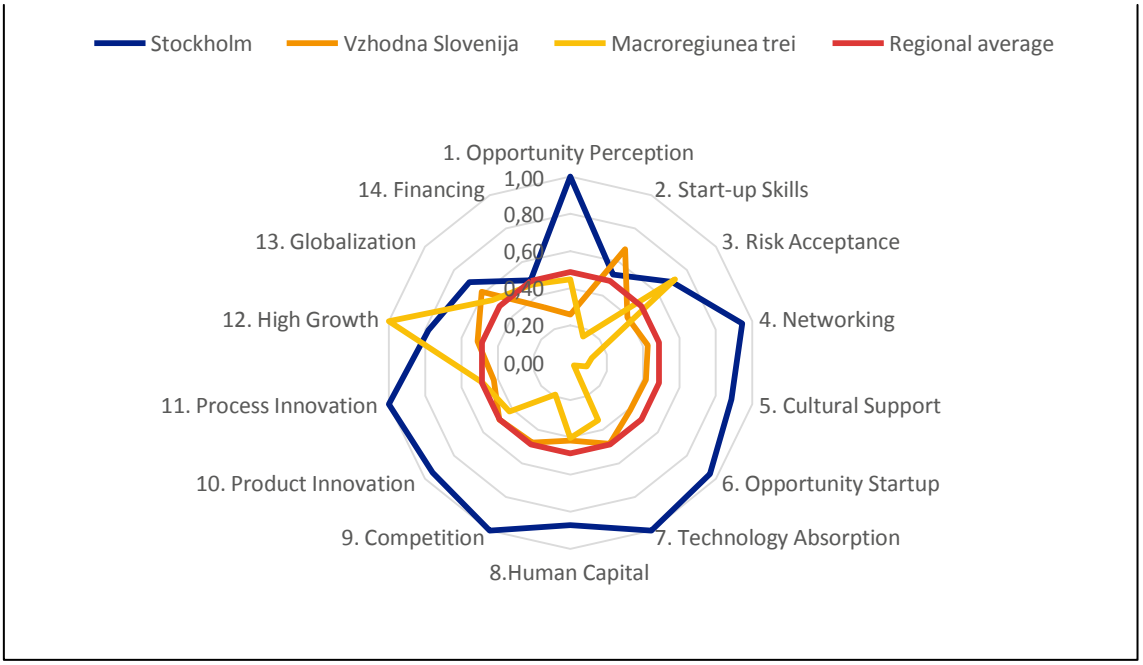
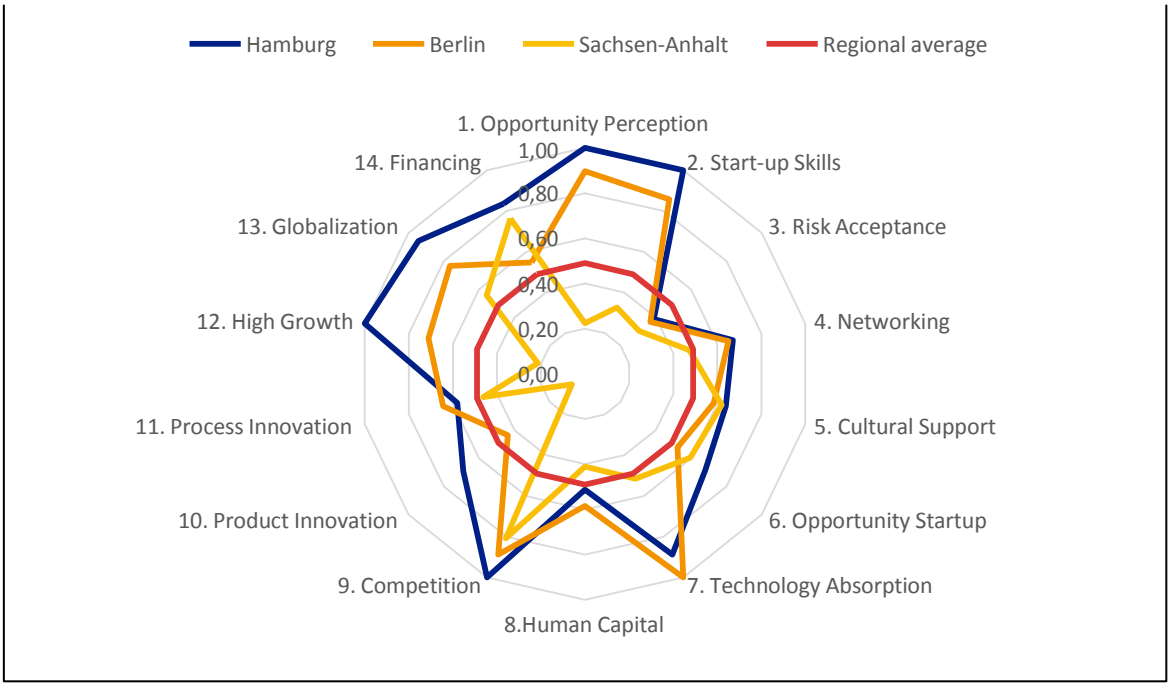


Figure 6 displays outstanding differences between the three analyzed regions. It also shows that even if the rankings determined by the diverse pillars generally overlap the order settled by the REDI 2017 index, all regions have some relative strengths and weaknesses. Apart from Risk Acceptance and High Growth, Stockholm is the leader of the group. The Romanian Macroregiuna trei

demonstrates a varied picture. Its scores usually stay below the two other regions and the average of the 125 regions but it is the leader of the group in Risk Acceptance and High Growth. On the other hand, it is critically weak in Cultural Support and Opportunity Perception. Vzhodna Slovenija typically moves between the other two territories. However, its Startup Skills are the highest among the three examined territories and it is the most modest in Opportunity Perception, High Growth and Financing.

Figure 7. The comparison of the entrepreneurial profile of three German regions by REDI 2017



The comparison of the three German regions (*Figure 7*) prevail some notable similarities and differences amongst Berlin, Hamburg and Sachsen-Anhalt. Hamburg and Berlin are the most innovative and entrepreneurial German regions, they occupy the 8th and 12th places respectively in the REDI 2017 ranking. In general, Hamburg is somewhat ahead of Berlin but the two regions follow about the same trend. Berlin is considerably weaker only in Financing, High Growth and Product Innovation. While Berlin, partially a former East German region, has caught up to the leading regions of Europe, Sachen-Anhalt's, the other former East German region, entrepreneurial performance is about the same as some relatively strong former socialist regions or countries, such as Region Centralny (Poland), Czech Republic and Bratislavský kraj. Sachen-Anhalt, number 74 in the REDI 2017 ranking, is the second least innovative German region. Still it is about the same level as the two other territories in Risk Acceptance, Cultural Support and Opportunity Startup. It even considerably outperforms Berlin in Financing. It is because its individual variable of the Financing pillar -the amount of informal financing possibilities provided by friends, relatives or business angels- is higher than Berlin's. Its main disadvantages are in Opportunity Perception, Startup Skills, Product Innovation and High Growth.

5.3. he examination of the underlying pillar structure of the REDI

As a part of the robustness check, we provide a basic analysis of the interrelationship between the different variables. Although the PFB methodology provides a practical solution for how to take this interrelationship into account, it does not save us from examining the underlying structure of the pillar. It is particularly important to have a well-defined nested structure of the whole index.

The arbitrary selection of the pillars would cause confusion, false interpretation, and, finally, a misleading policy interpretation. The OECD handbook of composite indicators suggests analyzing the dataset in two dimensions, pillars and observation units, in the case of each region (Giovannini et al., 2008). We have already provided detailed analyses at the regional level; here we are presenting a pillar-level analysis by calculating the common (Pearson) correlation coefficients. We report correlations between the average adjusted pillars, shown in *Table 14*, and the correlations between the pillars after applying the PFB methodology, shown in *Table 15*.

In general, there is a positive correlation between the average adjusted pillars. The effect size of the correlations ranges from weak to very strong. Globalization and High Growth are the most independent pillars. Globalization does not correlate with four and High Growth is independent from three pillars. Most importantly, there is no negative relationship between the pillars. The positive connection between the entrepreneurship pillars is vital for proper policy interpretation and suggestions. If the connection between the pillars were negative, the improvement of a pillar value would not necessary improve the REDI value. As it was expected, the PFB, implying a closer relationship between the entrepreneurial features, improved the correlation between the pillars. As expected, after the PFB, all pillars were correlated at the 0.01 level.

There are other ways to check out the consistency of the dataset and the potentially strong connection between the pillars. The Kaiser-Meyer-Olkin test is a measure of how well the data is suited for factor analysis. The Bartlett's test of sphericity checks if the observed correlation matrix diverges from the identity matrix; i.e.: if the dimensions of variables can be diminished. The Kaiser – Meyer – Olkin measures for the average adjusted pillar values are 0.85 and 0.9 for the PFB adjusted pillars, well above the critical value of 0.50. The Bartlett test is significant at the 0.000 level, excluding the possibility that the pillars are not interrelated. Both tests reinforce the fact that the 14 pillars of REDI are closely correlated, and it is worth looking for a single complex measure. Thus, these tests support the internal consistency of the structure as described with the 14 selected pillars.

Table 13. The correlation matrix between the average adjusted pillar values

	Average adjusted pillars	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	*REDI scores*	*1*	*.768***	*.602***	*.581***	*.795***	*.789***	*.791***	*.750***	*.765***	*.805***	*.449***	*.536***	*.379***	*.398***	*.515***
2	Opportunity Perception		1	.475**	.441**	.794**	.616**	.691**	.624**	.633**	.541**	.353**	.389**	.333**	.233**	.375**
3	Startup Skills			1	.102	.535**	.415**	.427**	.486**	.386**	.396**	.276**	.268**	.158*	.225**	.256**
4	Risk Perception				1	.387**	.492**	.468**	.333**	.577**	.511**	.101	.298**	.284**	.093	.103
5	Networking					1	.832**	.848**	.567**	.600**	.573**	.341**	.294**	.138*	.179**	.428**
6	Cultural Support						1	.904**	.518**	.647**	.666**	.228**	.268**	.030	.063	.345**
7	Opportunity Startup							1	.570**	.650**	.682**	.178**	.298**	.058	.115	.304**
8	Technology Adoption								1	.605**	.624**	.298**	.408**	.230**	.242**	.415**
9	Human Capital									1	.641**	.295**	.364**	.225**	.104	.315**
10	Competition										1	.283**	.408**	.184**	.371**	.387**
11	Product Innovation											1	.388**	.180**	.248**	.288**
12	Process Innovation												1	.098	.175**	.221**
13	High Growth													1	.431**	.156*
14	Globalization														1	.393**
15	Financing															1

****Correlation is significant at the 0.01 level (2-tailed).** ***Correlation is significant at the 0.05 level (2-tailed).**

N=250

Table 14. The correlation matrix between the pillar values after applying the PFB method

	Penalized pillars	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	*REDI scores*	1	.855**	.692**	.681**	.870**	.841**	.850**	.825**	.840**	.870**	.602**	.646**	.537**	.535**	.636**
2	Opportunity Perception		1	.591**	.556**	.812**	.674**	.724**	.701**	.716**	.659**	.504**	.521**	.495**	.396**	.494**
3	Startup Skills			1	.271**	.639**	.555**	.559**	.602**	.540**	.534**	.405**	.401**	.312**	.343**	.393**
4	Risk Perception				1	.519**	.607**	.572**	.474**	.677**	.623**	.278**	.440**	.405**	.253**	.268**
5	Networking					1	.864**	.865**	.671**	.697**	.681**	.495**	.439**	.335**	.335**	.539**
6	Cultural Support						1	.912**	.621**	.717**	.739**	.404**	.432**	.243**	.239**	.478**
7	Opportunity Startup							1	.660**	.721**	.762**	.345**	.453**	.266**	.277**	.432**
8	Technology Adoption								1	.701**	.720**	.454**	.536**	.401**	.384**	.528**
9	Human Capital									1	.731**	.446**	.507**	.396**	.276**	.455**
10	Competition										1	.446**	.556**	.378**	.492**	.510**
11	Product Innovation											1	.517**	.326**	.351**	.420**
12	Process Innovation												1	.267**	.308**	.370**
13	High Growth													1	.544**	.305**
14	Globalization														1	.472**
15	Financing															1

****. Correlation is significant at the 0.01 level (2-tailed). N=250**

5.4. Calculating the REDI with the different combination of individual and institutional variables

Here, as a part of the robustness check, we have tested different combinations of the individual and the institutional variables. We have conducted three other types of calculation. We calculated the REDI scores of the 125 regions by using only the individual variables (Individual REDI); only the institutional variables (Institutional REDI); and independently the fourteen individual and the fourteen institutional variables (REDI 28). The Individual REDI is the version where we use the GEM Adult Population Survey individual data.

The Pearson correlation coefficients of the REDI points and the rank correlation coefficients (Spearman's rho) for the four versions are reported in *Table 16*.

Table 15. The Pearson's correlation coefficients and Spearman's rho values with different REDI versions

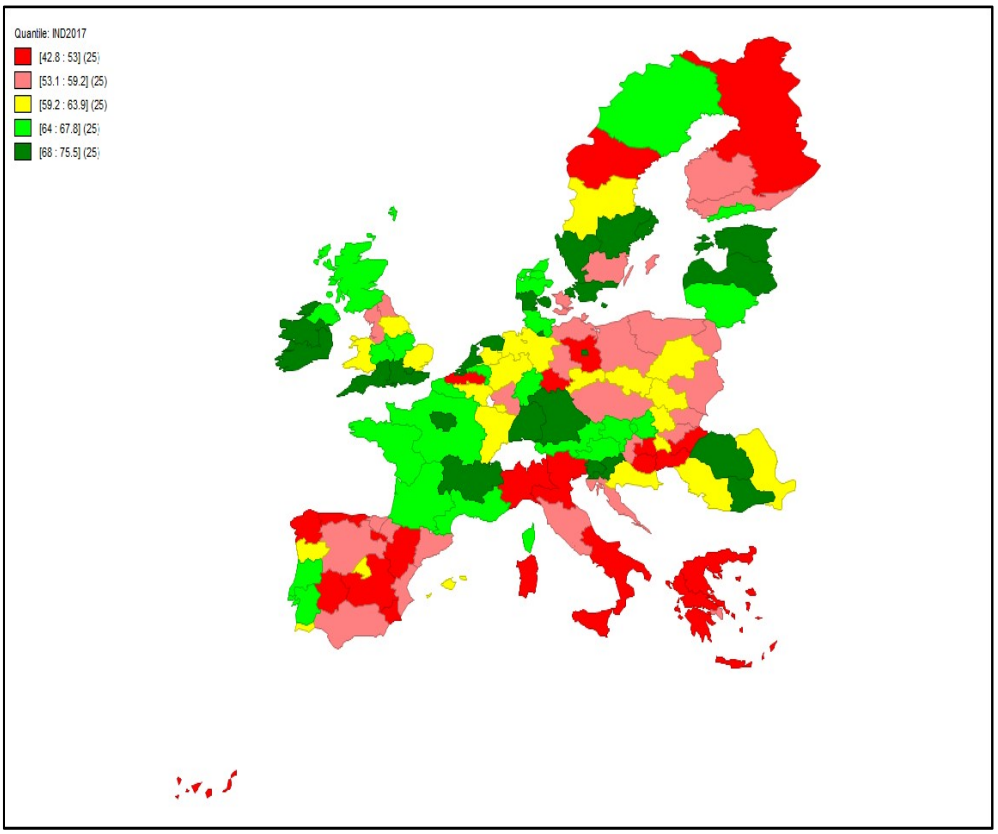
			1	2	3	4
1	REDI	Pearson's correlation	1.00	.709**	.954**	.985**
		Spearman's rho	1.00	.727**	.953**	.987**
2	Individual REDI	Pearson's correlation		1.00	.467**	.695**
		Spearman's rho		1.00	.503**	.708**
3	Institutional REDI	Pearson's correlation			1.00	.941**
		Spearman's rho			1.00	.945**
4	REDI 28	Pearson's correlation				1.00
		Spearman's rho				1.00

Number of observations=250
Note: All correlation coefficients are significant at p= 0.01 level

According to *Table 16*, the four versions are highly correlated to one another. The Individual REDI shows the lowest correlation with the other three versions. Any version using the institutional variables correlates highly with all the other versions.

The map of the 125 regions with the Individual REDI 2017 scores in five clusters is presented in *Figure 8*.

Figure 8. The map of the GEM Individual REDI 2017 scores in five categories of the 125 European Union regions



If we compare the original and individual REDI scores we can see that the individual scores have significantly smaller range and interquartile range than in the original case (*Table 17*). The interquartile range is only 10.21 points and it means that mid 50% of the points are within this range.

Table 16. The descriptive statistics of the original REDI and the Individual REDI scores

	REDI scores	Individual REDI scores
Average	43.54	60.98
Median	44.07	62.14
Minimum	17.72	42.84
Maximum	78.29	75.51
Range	60.57	32.67
Interquartile range	22.90	11.67

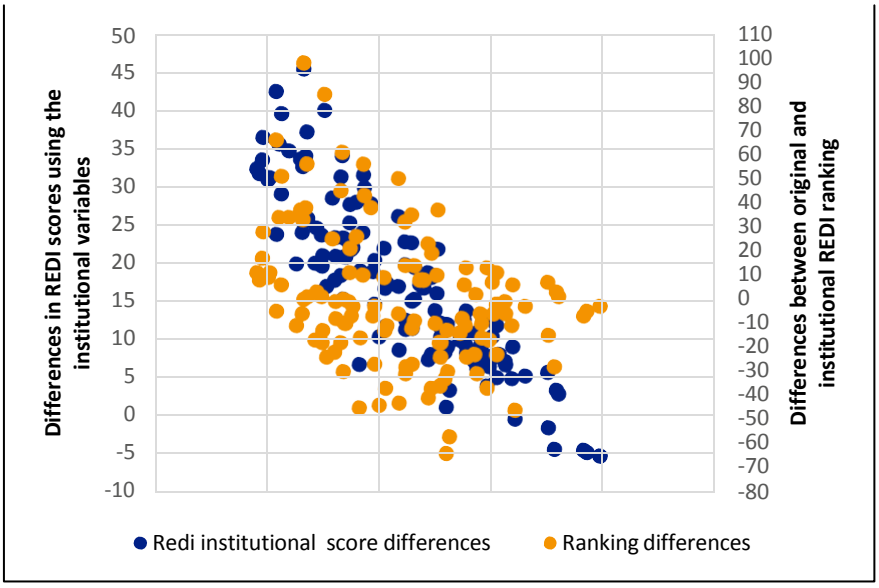
Note: N=250

We can see that the Individual REDI average value (60.86) is much higher than that of the original REDI scores. Taking into account the lower interquartile range it means that the individual variables prevail lower differences. Comparing the REDI 2017 ranking with the Individual REDI 2017 ranking the changes are substantial, range from -64 to 98. This means that calculating only with the individual variables, Romanian Macroregiunea unu has stepped ahead from the 109th place to the 11th while the Belgian Vlaams Gewest has fallen from the 39th to the 103rd place. The goodness of fit between the individual REDI 2017 scores and the GDP per capita is moderate (Pearson's coefficient=0.46). Thus the individual REDI explanatory value is inferior to the REDI superindex. It

means that ignoring institutions at the regional level produces only a partial picture. The drivers of regional differences are not entrepreneurial attitudes, abilities and aspirations alone.

Figure 9 shows the comparison of the original REDI 2017 and the Individual REDI 2017 scores and ranking. The point differences are shown by the blue points and the differences in points are on the primary (left) Y axis ("Differences in REDI scores with individual variables"). The orange points and the secondary (right) Y axis show us the differences between the original and individual REDI rankings. The differences are shown in the function of the REDI 2017 scores. It is straightforward from *Figure 9* that score changes are in much smaller in magnitude than the rank changes. Score changes also diminish as the REDI 2017 value increases.

Figure 9. The differences in the REDI 2017 scores and ranking using the individual variables



The same type of analysis for the Institutional REDI and the REDI 28 has also been done. In both cases the differences between the original REDI and these two cases are much lower than the case of the Individual REDI. For the detailed comparison and the new rankings and scores for all the four versions see Appendix J.

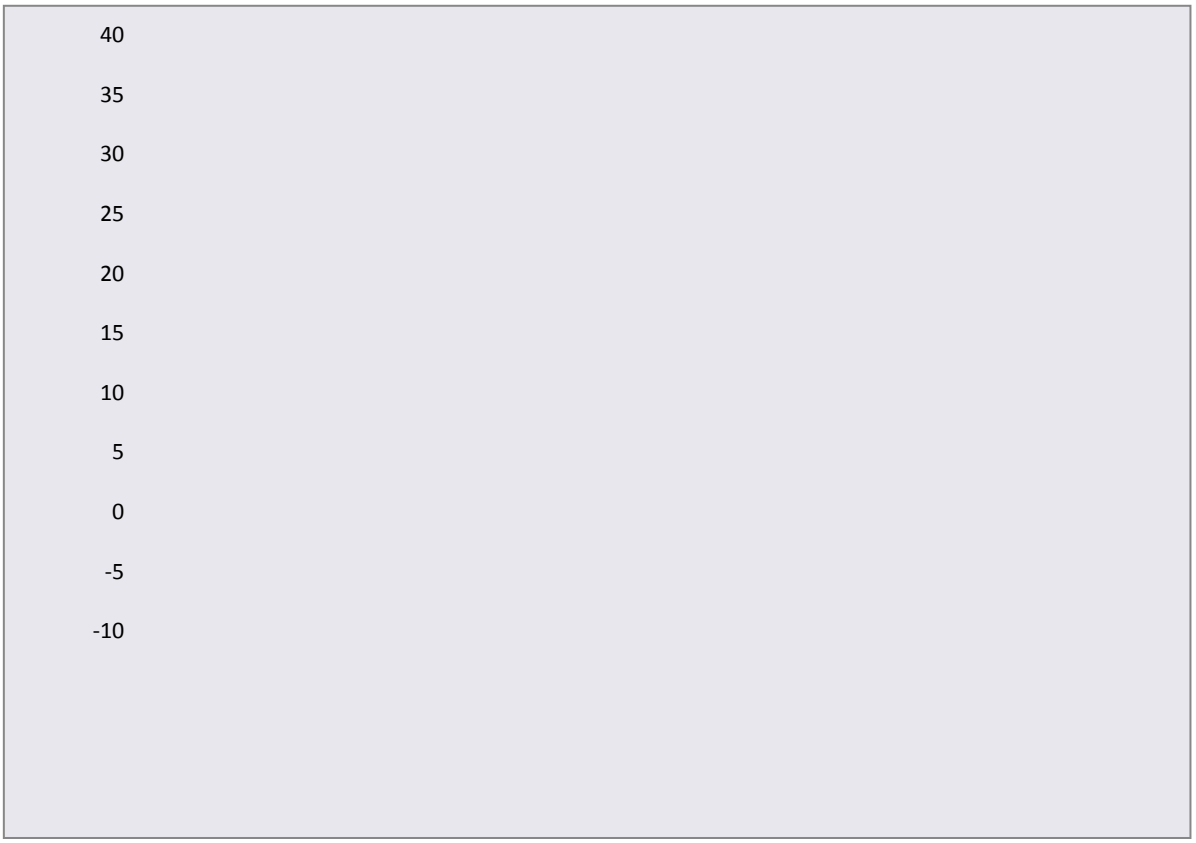
5.5. Robustness analysis: The effect of discarding a pillar

The aim of the robustness analysis is to examine the extent to which the final ranking depends on the set of choices made during the selection and transformation of the variables included in the sub-indices. A typical robustness test is to drop out one pillar at a time and view the changes in the rank of the regions. It is an appropriate method to evaluate the balance among the pillars in the REDI. This is usually called an uncertainty analysis. We have recalculated the REDI 2017 scores with the help of the penalty adjusted method, but we discarded one pillar at a time. So basically the model just slightly changed. We run fourteen simulations to see the effect of excluding each pillar one at the time.

The box-plot chart (*Figure 10*) displays the minimum, maximum values together with the lower and upper quartile (Q_1, Q_3) values (range and interquartile range) of the distribution of the difference

between the modified rank, obtained discarding one pillar, and the reference rank, computed on the basis of the original REDI scores.

Figure 10. Distribution of the REDI 2017 rank differences (uncertainty analysis discarding one pillar at a time)



The REDI index was built up and computed in a way to create an index which is not sensitive to respecification. As it was expected, the results reinforce the balanced role of the pillars. All the interquartile ranges are between the band -3 and +2, meaning that, for all the simulations, for more than 50% of the cases the maximum shift of the region rank is up to only 3 position wide. Taking a closer look at the above diagram, it can be seen that apart of *Financing*, the typical rank shift is a maximum 2 positions. The total ranges (maximum-minimum) are above 30 only for the *Financing* pillar. This high fluctuation is due to the relatively weak performance of North-East UK, as compared to its other pillar values. Excluding this extreme pillar value, North-Est UK stepped ahead 27 places in the REDI 2017 ranking. Beyond this case the minimum and maximum differences in *Financing* are within +18 and -3. In general, the higher fluctuations in ranking are generally caused by one or a couple of territories for all pillars. If we take into account that altogether 125 regions are in the analysis, this clearly shows the balanced construction of the pillars and the overall REDI.

Looking at the Spearman rank correlation coefficients in *Table 18* we feel that the earlier statement is even more confirmed. In each case of the simulations the new ranks are in a very strong stochastic relationship (values are above 0.99) with the original ranking.

Table 17. Spearman rank correlation coefficient by the excluded pillars

Excluded pillar	Spearman rank correlation coefficient
Opportunity Perception	0.998
Strat-up skills	0.993
Risk Acceptance	0.995
Networking	0.999
Cultural Support	0.996
Opportunity Startup	0.997
Technology Adoption	0.998
Human Capital	0.996
Competition	0.997
Product Innovation	0.995
Process Innovation	0.997
High Growth	0.993
Globalization	0.990
Financing	0.991

In connection with the analysis of the effect of excluding one pillar at a time the next question is the amount of compensability effects. Compensability is the "existence of trade-off, i.e. the possibility of offsetting a disadvantage on some criteria by a sufficiently large advantage on another criterion" (Munda, 2008, 71. p.). We applied Ordered Weighted Averaging (OWA) approach to present one aspect of compensability in case of the REDI 2017 (Yager, 1996). This technique looks for different scenarios of weights to put together more variables into a single index. The variables are to be in descending order. From our point of view there are three special cases defined for the OWA operators (set of weights, where the sum of the weights is 1).

- Purely optimistic operator (O): the highest pillar value gets all of the weight (1). So basically the overall index takes into account just the highest value. This concept expresses an "or" multiple criteria condition, where the satisfaction of at least one criterion is enough to have a good position.

- Purely pessimistic operator (P): the lowest pillar gets the weight 1. So the overall index will include only the value of the lowest pillar. It can be understood as an "and" condition. No compensation is allowed, all criteria must be satisfied at the same time.

- From our point of view an operator, which calculates a simple arithmetic mean of the pillars (A) is interesting as well, to see, how far the penalty weighted results from the average situation are.

These three different scenarios are calculated at the level of the sub-indices based on the average equalized pillar values, and then the REDI 2017 score comes as a simple arithmetic mean of the sub-indices (the same way as in the original methodology). The results are displayed in *Figure 11* together with the original (penalty adjusted) REDI 2017 scores.

As an obvious result, the average and the original REDI scores move between the pessimistic and the optimistic lines. It is also clear, that the aim of the penalty adjusted was reached, as the original REDI 2017 scores are always below the average line. It means that compensability is restricted within the REDI indicator, and a balanced performance is rewarded. It is also important to look at the result at the level of the regions. What is the variability of the different scenarios within the regions? Regions with very low pessimistic REDI scores are also those with very high optimistic results.

Figure 11. REDI 2017 scores calculated with different scenarios of the OWA operators

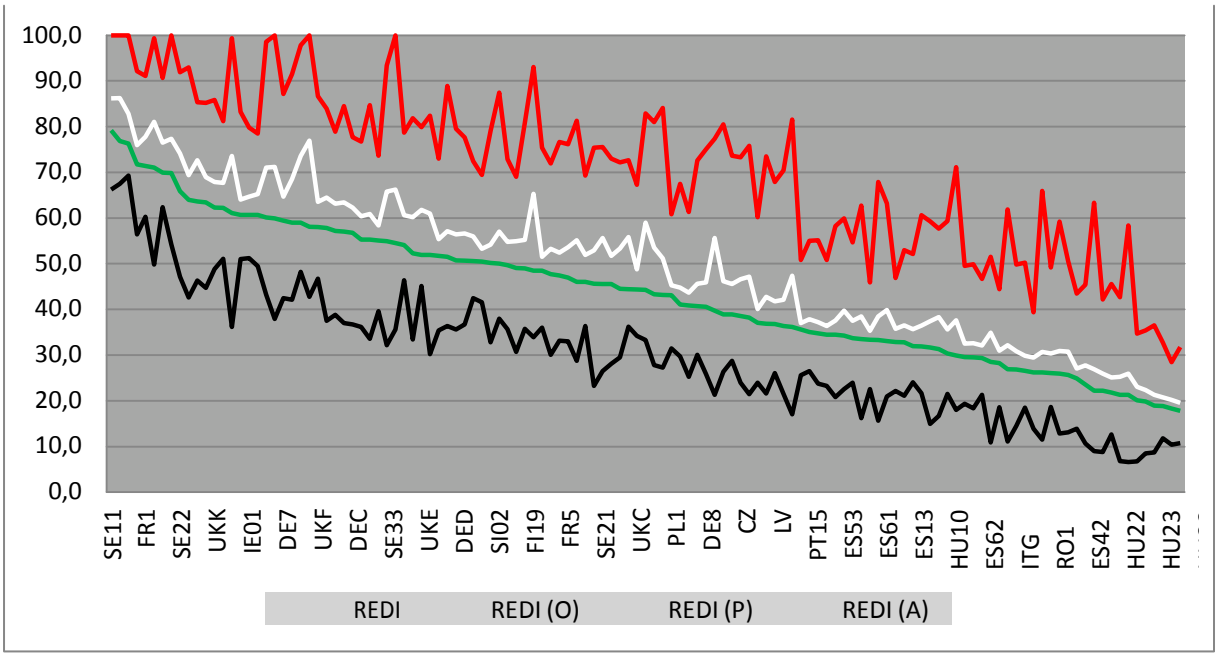


Table 18. The 17 most effected regions by the changes of the weight

GEO code	DE4	DK05	DK03	SE23	SE33	DK02	DK04	PL1	SE32	SE12	RO1	RO4	FR6	ES21	FI1D	RO3	ES30
GEO title	**Brandenburg**	**Nordjylland**	**Syddanmark**	**Vastsverige**	**Övre Norrland**	**Sjalland**	**Midtjylland**	**Region Centralny**	**Mellersta Norrland**	**Östra Mellansverige**	**Macroregiunea unu**	**Macroregiunea patru**	**Sud-Ouest (FR)**	**País Vasco**	**Pohjois- ja Ita-Suomi**	**Macroregiunea trei**	**Comunidad de Madrid**
Opportunity perception	0.36	0.84	0.89	1.00	1.00	0.78	0.91	0.48	1.00	1.00	0.38	0.38	0.37	0.39	0.70	0.45	0.48
Strat-up skills	0.45	0.35	0.31	0.33	0.22	0.24	0.44	1.00	0.26	0.25	0.08	0.05	0.26	0.60	0.73	0.16	0.88
Risk Acceptance	0.32	0.59	0.61	0.75	0.72	0.57	0.58	0.35	0.73	0.68	0.70	0.78	0.79	0.34	0.51	0.72	0.36
Networking	0.50	0.76	0.82	0.91	0.89	0.82	0.82	0.49	0.80	0.83	0.10	0.11	0.41	0.42	0.94	0.12	0.44
Cultural support	0.65	1.00	1.00	0.87	0.82	0.96	1.00	0.32	0.93	0.86	0.16	0.14	0.55	0.45	0.78	0.09	0.42
Opportunity startup	0.34	1.00	1.00	1.00	0.77	1.00	1.00	0.15	1.00	1.00	0.09	0.04	0.47	0.45	0.85	0.02	0.46
Technology adoption	0.59	0.52	0.53	0.56	0.53	0.70	0.73	0.41	0.37	0.61	0.16	0.17	0.61	0.48	0.23	0.31	0.76
Human capital	0.02	1.00	1.00	0.92	0.80	1.00	1.00	0.52	0.87	0.85	0.28	0.15	0.36	0.96	0.43	0.41	0.97
Competition	1.00	0.61	0.93	0.83	0.75	0.93	0.87	0.25	0.62	0.83	0.17	0.12	0.33	0.35	0.36	0.19	0.47
Product innovation	0.18	0.60	0.98	0.44	0.57	0.83	0.89	1.00	0.23	0.44	0.45	0.33	0.45	0.30	0.60	0.42	0.49
Process innovation	0.24	0.36	0.58	1.00	1.00	0.08	0.69	0.35	0.26	0.96	0.18	0.18	0.87	0.86	0.64	0.49	0.82
High growth	0.41	0.31	0.45	0.54	0.62	0.41	0.60	0.73	0.00	0.51	1.00	0.95	0.46	0.20	0.49	1.00	0.45
Globalization	0.77	0.20	0.24	0.46	0.21	0.11	0.12	0.74	0.23	0.56	0.34	0.31	0.05	0.11	0.10	0.54	0.27
Financing	0.80	1.00	0.83	0.25	0.24	0.46	1.00	0.55	0.32	0.45	0.34	0.21	0.65	0.49	0.20	0.47	0.63
REDI	36.1	54.5	61.1	59.9	54.9	48.5	58.1	43.1	39.7	60.1	26.2	22.3	38.2	38.9	43.3	29.9	51.5
REDI rank	80	34	15	20	33	50	24	65	71	19	109	115	75	72	64	99	40
REDI (O)	81.6	100.0	99.4	100.0	93.4	93.1	100.0	84.0	77.4	98.6	66.0	63.4	75.8	80.5	81.0	71.1	88.9
REDI (P)	17.1	35.6	36.2	37.9	32.1	33.9	42.7	27.3	21.3	43.3	11.5	9.0	21.4	26.4	27.8	18.0	36.3
REDI (A)	47.3	66.2	73.5	71.2	65.8	65.3	76.9	51.2	55.6	71.0	30.7	26.9	47.2	46.2	53.5	37.6	57.1
REDI(O)-REDI(P)	64.5	64.4	63.2	62.1	61.3	59.1	57.3	56.8	56.1	55.3	54.5	54.4	54.4	54.2	53.2	53.1	52.6

Detailed data of the 17 most effected regions can be found in *Table 19*. Beside the average equalized data of the pillars the table includes the original REDI 2017 score and ranks, the scores based on the three scenarios (REDI(O) – optimistic, REDI(P) – pessimistic, REDI(A) – average), and the difference between the optimistic and pessimistic scores.) They are those regions that are influenced by the compensability effect the most. In addition, they are the most sensitive ones with respect to the change of the weighting scheme. It means those regions where the average distance (range) of the lowest and highest pillars within the sub-indices is the highest. In *Table 19* the green cells indicate the highest and the red ones the lowest values within the pillar. Being red or green does not necessarily mean that the specific value is very high or very low on an absolute scale but the value is relatively "extreme" within a given pillar. The 17 most affected regions are coming randomly from every part of the original REDI ranking (the ranks can be seen in the grey row of *Table 19*), which means, that the sensitivity to compensability is independent from the overall position of the regions.

Uncertainty analysis together with the compensability effect analysis supports the robustness of the REDI indicator. The results justify, that the index provides a synthetic picture of the regional entrepreneurship within the European Union at the level of regions, while representing a balanced diversity of the different aspects (pillars).

5.6. he comparison of REDI 2017 to other regional indices

In this part of the report we compare the REDI scores and rankings to other available regional level indexes:

- Regional Competitiveness Index (RCI)
- Regional Innovation Scoreboard (RIS)
- Quality of Government Index (QoG)
- Regional Corruption Index

Note that three out of the four indices were used partially or fully in the REDI as measuring various institutional dimensions of regional level entrepreneurship. Therefore, we regress the REDI 2017 on the above indicators, i.e. REDI will be the dependent variable of the statistical analyses. For the same reason, it can be expected that these indices should show a significant correlation and close relationship with REDI.

The EU Regional Competitiveness Index (Annoni–Dijkstra, 2013) intended to measure and to examine the various levels of competitiveness at the regional level. "RCI 2013 reveals a strong regional dimension of competitiveness, which national level indicators cannot capture. The RCI shows the strengths and weaknesses of each of the EU NUTS2 regions. It can provide a guide to what each region should focus on, taking into account its specific situation and its overall level of development."[11]

The RCI uses only institutional variables to measure regional competitiveness. The RCI contains 3 sub-indexes built up of 11 pillars: (I) Basic Sub-index: (1) Institutions (2) Macroeconomic Stability (3) Infrastructure (4) Health (5) Basic Education (II) Efficiency Sub-index: (1) Higher Education and

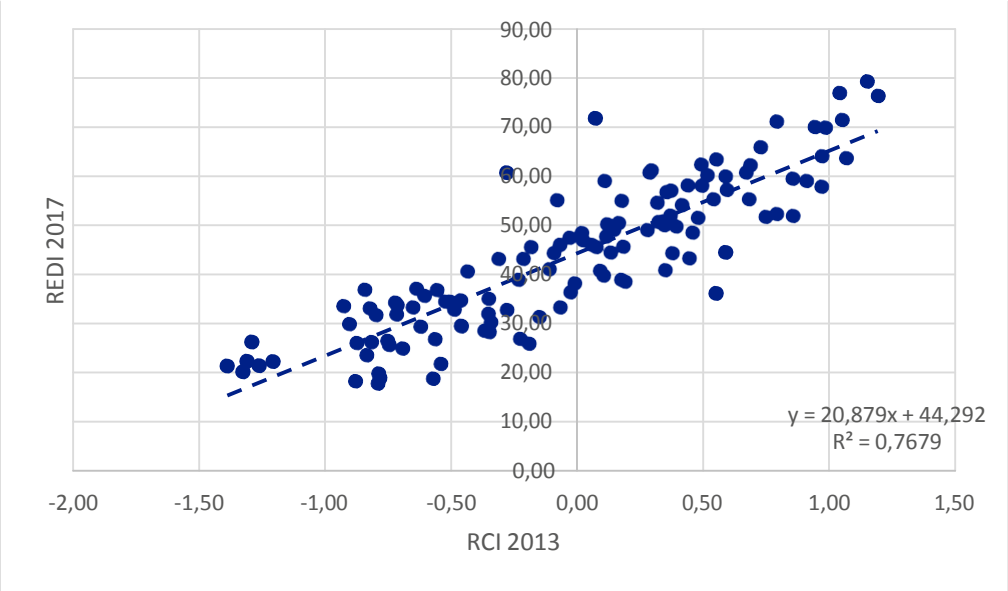
[11] Source: http://ec.europa.eu/eurostat/statistics-explained/index.php/Regional_competitiveness_statistics (downloaded on 20.02.2017.)

Lifelong Learning (3) Labor Market Efficiency (4) Market Size (III) Innovation Sub-index: (1) Technological Readiness (2) Business Sophistication (3) Innovation. The index scores have been calculated for 274 regions of the European Union.

For comparing the RCI with REDI 2017, the missing NUTS1 level data were calculated as the population (2013 Eurostat data) weighted average of NUTS2 level RCI data (Austria, Belgium, Germany, France, Greece, Italy, The Netherlands, Poland, Romania and United Kingdom). In the REDI we applied several parts of the RCI: (1) GVA in K-N sectors (Business strategy institutional variable); (2) Scientific publications (Technology Transfer institutional variable); (3) three RCI variables were used to determine the Infrastructure sub-index (Connectivity institutional variable) (see Appendix B for further details).

The connection between the REDI 2017 index and the EU Regional Competitiveness Index (RCI 2013) is positive and significant, as expected. A regression analysis showed that RCI 2013 explains 77% of the REDI 2017 variations (*Figure 12*).

Figure 12. The connection between the Regional Entrepreneurship and Development Index (REDI 2017) and the EU Regional Competitiveness Index (RCI 2013)



Note: Linear adjustment. Number of observations=125

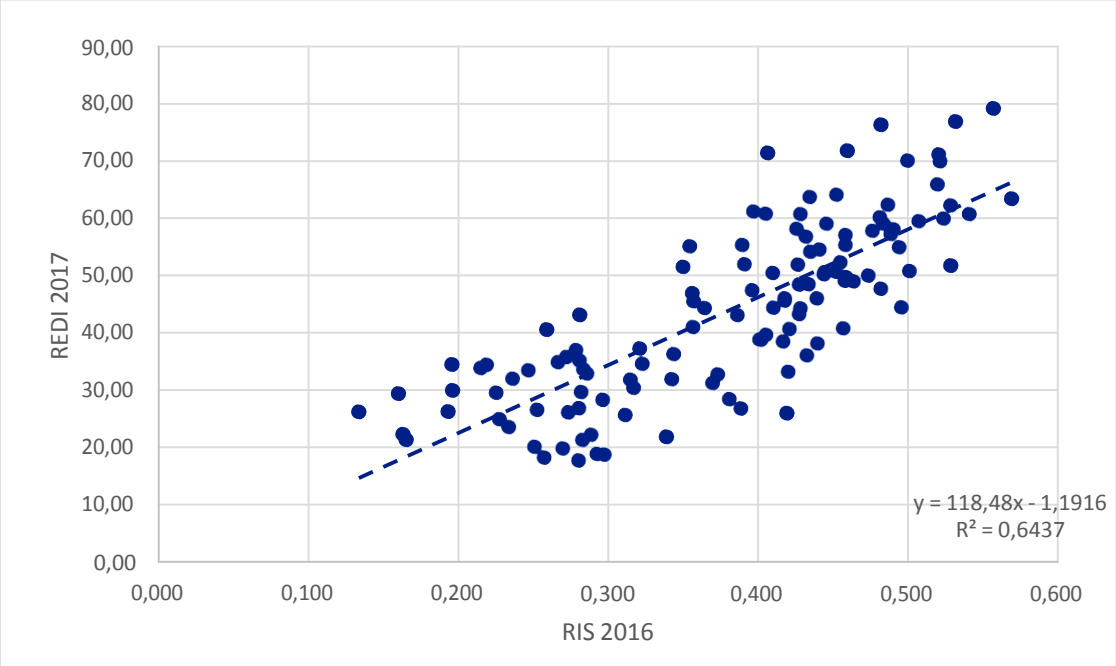
For examining the connection between regional level entrepreneurship measured by REDI and innovation we used the Regional Innovation Index 2016 (Hollanders et al., 2016). "The Regional Innovation Scoreboard (RIS) is a regional extension of the European Innovation Scoreboard (EIS). The EIS provides a comparative assessment of the innovation performance at the country level of the EU Member States and other countries (…). The RIS addresses this gap and provides statistical facts on regions' innovation performance. Regional innovation performance is measured using a composite

indicator – the Regional Innovation Index (RII) – which summarizes the performance on 12 indicators." (Hollanders et al., 2016)[12]

Thus, the RII incorporates several aspects of the regional innovativeness such as creative workers, life-long learning, hi-tech sectors, R&D and patenting. Following the Methodology Report (Hollanders et al., 2016), the Regional Innovation Index was calculated as the unweighted average of the normalized scores of the 12 indicators used in the RIS 2016. For the RIS 2016, most recent data refers to 2014 in the case of two indicators, 2013 for three indicators, 2012 for six indicators and 2011 for one indicator. The RIS covers 29 NUTS 1 level regions and 185 NUTS 2 level regions. For the comparison of RIS with REDI, we have calculated the missing NUTS 1 level results similarly to the RCI. There were no available data for Estonia, Latvia and Lithuania. These countries were left out from the analysis.

The regression of REDI 2017 on RII 2016 showed that RII explains 64 % of its variance (*Figure 13*).

Figure 13. The connection between the Regional Entrepreneurship and Development Index (REDI 2017) and the Regional Innovation Index (RII 2016)



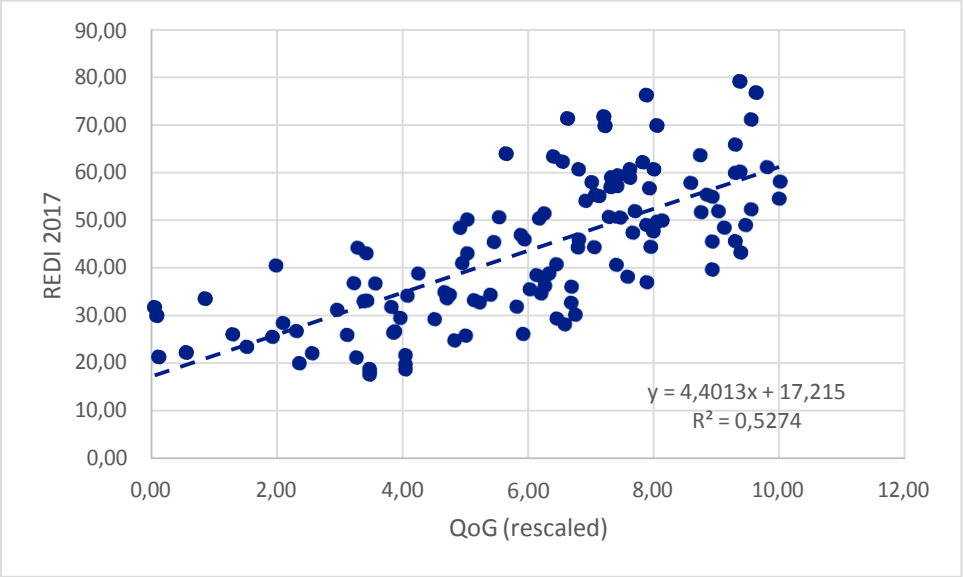
Note: Linear adjustment. Number of observations=122

The European Quality of Government Index (EQI) and the Regional Corruption Index are coming from the same survey. In fact, the Regional Corruption Index is a part of the EQI. "The QoG EU Regional Data is the result of a survey of corruption on a regional level within the EU conducted during 2013. It covers all 28 member states and two accession countries (Serbia and Turkey). The sub-national regions are at the NUTS 1 or NUTS 2 level, depending on the country. The questionnaire was answered by 85,000 citizen respondents, which is the largest sub-nationally-focused survey on QoG

[12] Source: https://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en (downloaded on 23.02.2017.)

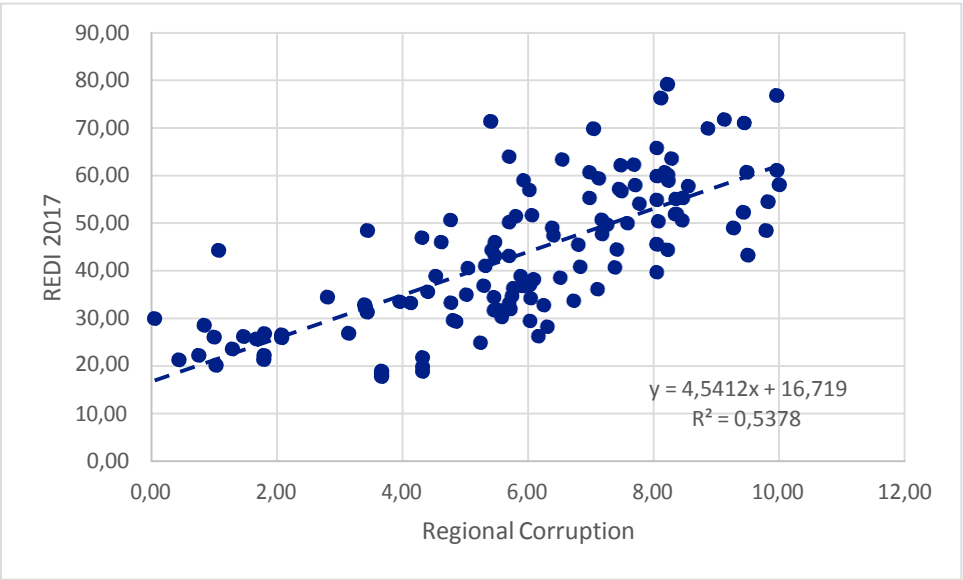
to date. The national level estimates are taken from the World Bank Governance Indicators. The regional estimates are comprised of 16 separate indicators."[13]

Figure 14. The connection between the Regional Entrepreneurship and Development Index 2017 (REDI) and the European Quality of Governance Index 2013 (EQI)



Note: Linear trend-line. N=125

Figure 15. The connection between the Regional Entrepreneurship and Development Index 2017 (REDI) and the Regional Corruption Index 2013



Note: Linear trend-line. N=125

[13] Source: http://qog.pol.gu.se/data/datadownloads/qogeuregionaldata (downloaded on 20.02.2017.)

The EQI was re-scaled (converted to a scale of 0 to 10). In the case of REDI, the EQI was employed to partially characterize the REDI Business Environment institutional variable (*Business Environment institutional pillar*), and the Regional Corruption Index was used in order to determine the Corruption institutional variable (*Open society institutional pillar*). The Regional Corruption Index is the only institutional variable that appears two times in the REDI, first as a part of the EQI and second as an independent regional institutional variable in the Open Society. The EQI 2013 (*Figure 14*) and the Regional Corruption Index (*Figure 15*) explain about the same amount of REDI's variance, 53% and 54%, respectively.

Furthermore, as we can see from the correlation table (*Table 20*) that all the four indices correlate significantly with the Regional Entrepreneurship and Development Index. Moreover, all five regional indices have a strong connection with the per capita GDP. This finding is not a surprise since all of them aim to explain different dimensions of regional development.

Table 19. Correlations coefficients between REDI GDP per capita and four regional indices

		1	2	3	4	5	6
1	REDI	1.00	.774**	.800**	.877**	.726**	.733**
2	GDP per capita		1.00	.686**	.785**	.514**	.455**
3	Regional Innovation Scoreboard			1.00	.870**	.711**	.620**
4	Regional Competitiveness Index				1.00	.787**	.722**
5	Quality of Government					1.00	.866**
6	Regional Corruption Index						1.00

Note: All correlations are significant at the 0.01 level. N=125

At the same time, REDI incorporates a much larger aspect of the complex ES than the other indices. In all probability, this is why it is in a closer connection with the GDP than the other indices. These results furnish further support to that REDI is superior to the other indices in describing the entrepreneurial and innovation related differences across regions.

6. Policy Application of the REDI: Regional entrepreneurship policy scenarios in the European Union to optimize resources

6.1. The REDI in the current entrepreneurship policy context.

In recent years, we have seen the implementation of policies following a place-based rationale. Strategic decisions have been set to prioritize activities to improve regional conditions such as increasing well-being, economic performance or prosperity. As Audretsch (2015) argues in this context, policy intervention is economically justified because of the existence of market and system failures. Among them, network and knowledge externalities and externalities associated with entrepreneurial failure or success. Network externalities refer to the benefits of geographical proximity and colocation of individuals engaging in complementary activities. Knowledge externalities appear when knowledge tends to spill over in face-to-face interactions, and the use of favorable incentives can facilitate the creation of knowledge. Externalities can also appear when entrepreneurship has failed as knowledge generated with failing entrepreneurs can be picked up by other and regenerated into new productive activities. Finally, the "demonstration effect" born by a successful entrepreneur can be transmitted to encourage new potential entrepreneurs to start new businesses. All of these market failures have been supported in many places with different policy interventions depending on the place starting conditions and endowments. Yet, the need for entrepreneurial evidence to support place-based holistic entrepreneurship policy has never been greater in Europe, given the current awareness regarding the role played by entrepreneurship in fostering economic growth and resilience amongst European regions, and the centrality of these issues in the current European policy context.

6.2. Optimizing the entrepreneurial ecosystem

Using the logic above, we performed a simulation exploring the effect of regional entrepreneurship policy designed to alleviate systemic bottlenecks and improve the REDI score in all regions by 5 points. Unfortunately, we do not know the monetary values of the improvement; therefore we only use the term "unit per capita" without specifying the monetary value of a "unit". The reliance on the per capita data resolves the problem of the different size regions. As a first approximation, we assume that the total cost of developing a pillar is proportional to the number of inhabitants, so the full cost of improving any pillar in a region can be calculated as the multiplication of the size of the population with the per capita unit. Moreover, our exercise is based on the assumptions that the marginal costs of improving any regions' any pillar are the same. While this seems to be an unrealistic assumption, the average equalization of the pillar values methodology equalizes the marginal cost of improvement over the average of the fourteen pillars. Hence, a part of the distortion is handled. The different cost structures of the regions can be handled by assuming the use of the purchasing power parity (PPP) units. Further, we assume that the allocation of the inputs is free of any distribution losses or corruption. It is important to note that the results of the simulation cannot be used directly as policy suggestions. This scenario only aims to demonstrate the practical, policy applicability of the REDI methodology. Further scenarios with different assumptions can also be developed as we do in Szerb et al. (2017).

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 the most binding constraints, our simulation therefore provides an idea of how policy efforts should be allocated to achieve an 'optimal' outcome, defined as the largest possible increase in the REDI index score.

Table 20 shows the result of our optimization exercise for all the 125 regions. For illustration purposes we provide a short analysis of the selected country regions of Denmark, Estonia, France, and Hungary. In this case the additional inputs 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 21*, the total effort represents all the amount of the inputs that the region is spending for entrepreneurship in PPP units per capita. It is the sum of the average normalized values of the fourteen pillars. The percentage numbers under the pillar names are the percentage of the additional input in units necessary to add to the particular pillar value in order to reach the required alleviation of the pillar constraint. A zero value indicates that no additional input is needed, as the pillar is currently not a binding constraint. The additional effort column provides the overall sum of the required additional inputs. 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 the 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. However, 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 regional system to more fully utilize its existing regional 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. In the table only a few regions (DE6, DK04, FR6, FR7, FR8 and LT) have such a single pressing bottleneck, but many more have only two or three bottlenecks.

Table 20. Simulation of the benchmarking policy allocation to increase the REDI score by 5

Region	REDI	Opportunity Perception	Startup Skills	Risk Perception	Networking	Cultural Support	Opportunity Startup	Technology Absorption	Human Capital	Competition	Product Innovation	Process Innovation	High Growth	Globalization	Financing	Additional input
Ostösterreich	57.01	0.0%	0.0%	34.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	65.7%	0.0%	0.0%	0.23
Südösterreich	47.71	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	27.4%	0.0%	53.8%	0.28
Westösterreich	49.08	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	28.6%	0.0%	0.0%	0.0%	0.0%	71.4%	0.0%	0.0%	0.22
Région de Bruxelles-Capitale	64.00	0.0%	0.0%	0.0%	24.6%	18.1%	21.2%	0.0%	11.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.1%	0.42
Vlaams Gewest	51.71	0.0%	32.8%	0.0%	30.8%	0.0%	11.8%	0.0%	0.0%	0.0%	0.0%	0.0%	24.6%	0.0%	0.0%	0.42
Région wallonne	50.66	0.0%	75.4%	0.0%	8.0%	4.0%	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.22
Czech Republic	38.88	0.0%	0.0%	49.7%	7.6%	33.0%	5.9%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.29
Baden-Württemberg	62.19	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.18
Bayern	60.67	0.0%	0.0%	83.1%	0.0%	0.0%	0.0%	13.9%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.23
Berlin	63.39	0.0%	0.0%	62.5%	0.0%	0.0%	2.0%	0.0%	0.0%	0.0%	35.5%	0.0%	0.0%	0.0%	0.0%	0.26
Brandenburg	36.13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.13
Bremen	57.18	0.0%	0.0%	31.5%	0.0%	0.0%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	67.2%	0.0%	0.24
Hamburg	69.84	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.16
Hessen	59.42	0.0%	0.0%	47.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	52.9%	0.0%	0.0%	0.0%	0.0%	0.29
Mecklenburg-Vorpommern	40.71	16.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	13.5%	20.4%	0.0%	45.1%	0.35
Niedersachsen	49.71	0.0%	0.0%	19.5%	0.0%	0.0%	0.0%	0.0%	80.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.21
Nordrhein-Westfalen	55.30	0.0%	0.0%	35.8%	0.0%	0.0%	0.0%	0.0%	7.3%	0.0%	0.0%	56.9%	0.0%	0.0%	0.0%	0.27
Rheinland-Pfalz	44.46	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	73.1%	26.9%	0.0%	0.0%	0.0%	0.18
Saarland	56.73	0.0%	0.0%	48.4%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%	39.9%	0.0%	0.0%	0.0%	0.31
Sachsen	50.75	0.0%	0.0%	28.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	71.1%	0.0%	0.0%	0.0%	0.0%	0.24
Sachsen-Anhalt	38.54	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	93.3%	0.0%	6.7%	0.0%	0.0%	0.16
Schleswig-Holstein	50.02	0.0%	0.0%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	92.9%	0.0%	0.0%	0.0%	0.0%	0.18
Thüringen	40.84	19.2%	0.0%	16.7%	0.0%	0.0%	0.0%	28.7%	0.0%	0.0%	1.8%	31.9%	0.0%	0.0%	1.6%	0.44

Hovedstaden	76.86	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.4%	49.6%	0.0%	0.23
Sjalland	48.47	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	59.1%	0.0%	40.9%	0.0%	0.17
Syddanmark	61.12	0.0%	28.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	71.5%	0.0%	0.17
Midtjylland	58.08	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.10
Nordjylland	54.52	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.9%	89.1%	0.0%	0.15
Estonia	45.52	0.0%	0.0%	0.0%	0.0%	46.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.9%	40.3%	0.30
Voreia Ellada	22.21	0.0%	0.0%	0.0%	17.7%	51.0%	7.5%	0.0%	0.0%	0.0%	0.0%	0.0%	23.8%	0.0%	0.0%	0.35
Kentriki Ellada	20.14	3.0%	0.0%	0.0%	16.0%	42.6%	11.3%	0.0%	0.0%	0.0%	0.0%	0.0%	27.1%	0.0%	0.0%	0.40
Attiki	28.53	0.0%	0.0%	0.0%	10.8%	78.9%	10.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.20
Nisia Aigaiou, Kriti	21.34	0.0%	0.0%	0.0%	9.9%	44.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	45.8%	0.0%	0.0%	0.37
Galicia	29.59	9.1%	0.0%	0.0%	0.0%	0.0%	8.6%	6.0%	0.0%	4.5%	0.0%	0.0%	28.5%	43.3%	0.0%	0.40
Principado de Asturias	30.32	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.6%	0.0%	45.2%	49.2%	0.0%	0.30
Cantabria	32.79	4.6%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%	0.0%	0.0%	0.0%	0.0%	34.9%	53.8%	0.0%	0.33
País Vasco	38.89	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	29.7%	70.3%	0.0%	0.22
Comunidad Foral de Navarra	36.34	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	45.1%	53.8%	0.0%	0.29
La Rioja	28.25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.5%	0.0%	16.8%	11.0%	0.0%	36.0%	29.7%	0.0%	0.43
Aragón	31.98	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	41.7%	57.4%	0.0%	0.33
Comunidad de Madrid	51.48	0.0%	0.0%	29.4%	1.4%	8.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	60.6%	0.0%	0.28
Castilla y León	34.73	23.1%	0.0%	0.0%	0.0%	0.0%	0.0%	3.9%	0.0%	4.5%	3.9%	0.0%	34.3%	30.2%	0.0%	0.46
Castilla-la Mancha	24.92	15.1%	0.0%	0.0%	0.0%	0.0%	0.0%	12.7%	0.0%	2.5%	8.8%	14.1%	19.4%	27.3%	0.0%	0.51
Extremadura	26.23	14.4%	0.0%	0.0%	0.0%	0.0%	0.0%	8.1%	0.0%	0.0%	0.0%	0.0%	33.9%	43.6%	0.0%	0.38
Cataluna	41.08	0.0%	0.0%	3.4%	0.0%	0.0%	12.0%	0.0%	0.0%	0.0%	0.0%	0.0%	36.6%	48.0%	0.0%	0.36
Comunidad Valenciana	35.02	3.4%	0.0%	0.0%	0.0%	0.0%	8.6%	8.6%	0.0%	0.0%	0.0%	0.0%	35.8%	43.6%	0.0%	0.41
Illes Balears	34.45	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	32.5%	0.0%	0.0%	0.0%	6.8%	37.8%	22.0%	0.0%	0.40
Andalucía	33.32	20.7%	0.0%	3.6%	0.0%	0.0%	7.5%	22.3%	0.0%	0.0%	1.4%	0.0%	1.6%	43.0%	0.0%	0.44
Región de Murcia	29.48	4.2%	0.0%	0.0%	0.0%	0.0%	0.0%	13.4%	0.0%	0.7%	15.2%	0.0%	25.6%	40.8%	0.0%	0.40
Canarias (ES)	29.36	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.8%	0.0%	0.0%	0.0%	15.1%	37.1%	32.0%	0.0%	0.43
Länsi-Suomi	49.01	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	10.5%	0.0%	0.0%	53.3%	29.6%	0.29
Helsinki-Uusimaa	71.02	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.3%	88.7%	0.15
Etelä-Suomi	52.28	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	47.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	52.5%	0.24
Pohjois- ja Ita-Suomi	43.27	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	79.2%	18.5%	0.17
Île de France	71.38	0.0%	9.5%	0.0%	47.4%	28.1%	15.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.29
Bassin Parisien	44.33	24.2%	69.7%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.3%	0.0%	0.26

Nord - Pas-de-Calais	46.95	0.0%	85.3%	0.0%	13.2%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.19
Est (FR)	46.02	6.9%	93.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.19
Ouest (FR)	47.43	16.8%	47.7%	0.0%	0.0%	0.0%	0.0%	0.0%	35.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.30
Sud-Ouest (FR)	38.21	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.14
Centre-Est (FR)	59.01	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.14
Méditerranée	46.03	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.14
Jadranska Hrvatska (Adriatic Croatia)	23.57	0.0%	0.0%	0.0%	29.5%	45.8%	24.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.33
Kontinentalna Hrvatska (Continental Croatia)	25.65	0.0%	0.0%	0.0%	33.8%	49.8%	16.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.30
Közép-Magyarország	31.33	0.0%	0.0%	25.2%	1.4%	71.9%	1.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.21
Közép-Dunántúl	18.83	1.6%	6.9%	17.3%	7.3%	33.3%	0.0%	0.0%	0.0%	0.0%	7.8%	12.0%	0.0%	0.0%	13.9%	0.51
Nyugat-Dunántúl	21.80	0.0%	0.0%	17.0%	7.5%	39.6%	0.0%	0.0%	0.0%	0.0%	1.9%	14.0%	0.0%	0.0%	20.0%	0.43
Dél-Dunántúl	19.87	2.1%	8.7%	17.5%	6.6%	34.0%	5.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.4%	0.47
Észak-Magyarország	18.94	2.4%	11.1%	14.4%	9.1%	32.6%	0.0%	0.0%	0.0%	5.9%	21.7%	0.0%	0.0%	0.0%	2.8%	0.49
Észak-Alföld	18.32	9.2%	8.6%	16.6%	8.4%	33.1%	10.4%	0.0%	0.0%	4.2%	0.0%	0.0%	0.0%	0.0%	9.6%	0.50
Dél-Alföld	17.81	6.2%	6.2%	17.8%	11.6%	33.4%	3.7%	4.4%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	15.1%	0.52
Border, Midland and Western	60.69	11.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.9%	27.6%	0.0%	13.7%	39.7%	0.38
Southern and Eastern	71.77	52.0%	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	45.8%	0.0%	0.32
Nord-Ovest	33.27	0.0%	0.0%	0.0%	4.9%	11.6%	11.3%	31.2%	0.0%	0.0%	0.0%	0.0%	41.0%	0.0%	0.0%	0.35
Sud	25.95	0.0%	0.0%	0.0%	0.0%	8.4%	47.7%	42.2%	0.0%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.31
Isole	26.89	0.0%	0.0%	0.0%	0.0%	3.7%	39.2%	30.3%	0.0%	0.0%	0.0%	0.0%	26.8%	0.0%	0.0%	0.35
Nord-Est	31.70	0.0%	7.6%	0.0%	0.0%	0.0%	0.0%	64.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.9%	0.25
Centro (IT)	33.53	0.0%	0.0%	0.0%	1.4%	13.1%	27.2%	21.8%	0.0%	0.0%	0.0%	0.0%	36.5%	0.0%	0.0%	0.37
Lithuania	33.10	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.17
Latvia	36.88	0.0%	0.0%	0.0%	18.7%	65.8%	12.5%	0.0%	0.0%	0.0%	0.0%	3.1%	0.0%	0.0%	0.0%	0.26
Noord-Nederland	55.29	15.4%	0.0%	29.9%	0.0%	0.0%	0.0%	27.3%	0.0%	0.0%	0.0%	6.8%	20.6%	0.0%	0.0%	0.38
Oost-Nederland	51.89	0.0%	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	83.0%	0.0%	0.0%	0.17
West-Nederland	63.60	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.14
Zuid-Nederland	57.79	0.0%	0.0%	46.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	53.0%	0.0%	0.0%	0.26
Region Centralny	43.13	0.0%	0.0%	0.0%	0.0%	0.0%	77.5%	0.0%	0.0%	22.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.19
Region Poludniowy	40.57	0.0%	0.0%	0.0%	0.0%	2.9%	41.3%	4.2%	0.0%	43.3%	0.0%	8.3%	0.0%	0.0%	0.0%	0.31
Region Wschodni	31.89	0.0%	0.0%	0.0%	0.0%	0.0%	28.1%	16.2%	0.0%	42.5%	0.0%	13.2%	0.0%	0.0%	0.0%	0.33

Region Pólnocno-Zachodni	34.28	0.0%	0.0%	0.0%	0.0%	0.0%	24.6%	9.6%	0.0%	56.9%	0.0%	8.8%	0.0%	0.0%	0.0%	0.26
Region Poludniowo-Zachodni	36.79	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	11.2%	0.0%	53.7%	0.0%	1.8%	0.0%	0.0%	0.0%	0.29
Region Pólnocny	33.73	0.0%	0.0%	0.0%	0.0%	0.0%	28.4%	10.4%	3.1%	40.2%	0.0%	18.0%	0.0%	0.0%	0.0%	0.36
Norte	34.46	0.0%	0.0%	0.0%	16.4%	0.0%	4.0%	24.8%	21.8%	7.3%	0.0%	0.0%	5.5%	0.0%	20.2%	0.51
Algarve	35.63	19.4%	0.0%	0.0%	16.0%	0.0%	0.0%	3.4%	13.9%	0.0%	23.6%	10.9%	0.0%	0.0%	12.7%	0.57
Centro (PT)	32.85	44.7%	0.0%	0.0%	14.5%	0.0%	0.0%	16.4%	9.4%	9.9%	0.0%	0.0%	0.0%	0.0%	5.2%	0.39
Lisboa	48.46	0.0%	0.0%	3.3%	37.5%	9.4%	27.4%	0.0%	8.0%	0.0%	4.9%	0.0%	9.6%	0.0%	0.0%	0.43
Alentejo	37.08	4.3%	0.0%	0.0%	19.3%	0.0%	0.0%	26.7%	37.2%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%	0.39
Macroregiunea unu	26.19	0.0%	26.4%	0.0%	21.1%	7.8%	25.3%	8.6%	0.0%	6.0%	0.0%	4.9%	0.0%	0.0%	0.0%	0.45
Macroregiunea doi	21.30	0.0%	31.4%	0.0%	15.2%	8.1%	31.7%	10.7%	0.2%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%	0.42
Macroregiunea trei	29.93	0.0%	0.8%	0.0%	16.3%	27.3%	55.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.25
Macroregiunea patru	22.26	0.0%	28.9%	0.0%	14.8%	7.2%	29.8%	1.6%	6.0%	11.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.43
Stockholm	79.18	0.0%	42.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	57.4%	0.24
Östra Mellansverige	60.13	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.13
Smaland med öarna	45.61	0.0%	24.0%	0.0%	0.0%	0.0%	0.0%	16.6%	0.0%	0.0%	9.9%	0.0%	0.0%	26.0%	23.5%	0.40
Sydsverige	65.82	0.0%	55.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.3%	0.0%	33.8%	0.23
Vastsverige	59.90	0.0%	26.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	73.1%	0.17
Norra Mellansverige	45.54	0.0%	10.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	51.9%	0.0%	37.4%	0.24
Mellersta Norrland	39.72	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.12
Övre Norrland	54.92	0.0%	34.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.2%	26.8%	0.27
Vzhodna Slovenija	43.13	37.9%	0.0%	8.8%	1.3%	3.3%	4.8%	19.9%	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	21.9%	0.46
Zahodna Slovenija	50.19	20.4%	0.0%	8.4%	0.0%	8.8%	32.9%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	0.0%	27.0%	0.41
Bratislavsky kraj	44.31	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.12
Západné Slovensko	26.82	8.9%	31.0%	4.2%	0.0%	31.2%	0.0%	0.0%	0.0%	24.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.43
Stredné Slovensko	26.54	13.0%	23.6%	4.4%	0.0%	28.2%	10.1%	3.7%	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.45
Vychodné Slovensko	26.06	3.8%	28.5%	2.8%	0.0%	30.1%	16.5%	10.6%	0.0%	7.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.43
North East (UK)	44.42	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.12
North West (UK)	50.57	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	18.1%	0.0%	0.0%	44.4%	37.5%	0.32
Yorkshire and The Humber	51.94	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.14
East Midlands (UK)	58.02	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	47.0%	0.0%	53.0%	0.28
West Midlands (UK)	54.12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.9%	14.6%	0.0%	0.0%	75.6%	0.21

East of England	58.97	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.11
London	76.30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	49.6%	32.6%	0.0%	0.0%	17.8%	0.27
South East (UK)	69.93	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	73.7%	0.0%	0.0%	26.3%	0.0%	0.21
South West (UK)	62.31	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	27.3%	59.4%	0.0%	4.3%	9.0%	0.28
Wales	50.43	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	26.9%	23.5%	23.7%	15.0%	2.8%	0.51
Scotland	60.71	20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.2%	0.0%	0.0%	29.5%	19.7%	0.46
Northern Ireland (UK)	55.08	23.7%	15.8%	0.0%	0.0%	0.0%	0.0%	11.2%	0.0%	0.0%	0.0%	0.0%	0.0%	28.5%	20.8%	0.46

Source: own calculation.

According to *Table 20*, there are huge differences in the allocation of the inputs between the regions. 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 (0.10 units per capita). All the other Danish regions have such an 'uneven' profile and require additional inputs only for two pillars out of Startup Skills, Process Innovation, Globalization, Finance or High Growth. In contrast, Estonia (EE) 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. French regions show larger differences in ES as compared to Danish ones: Ile 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 in the bottom of 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 (0.21–0.52). In addition, multiple pillars need to develop in the Hungarian regions, mostly Cultural Support, Risk Perception, and Financing.

Entrepreneurship policy implementation

For entrepreneurship policy implementation the percentage of the inputs are applied. We categorize the pillars and classify the policy actions for each region according to their percentage increase of the required inputs and the percentage of the affected regions of a particular country into four categories as top priority, medium priority, low priority and watching list (*Table 21*).

Table 21. The categorization of the pillars according to the percentage increase of the required inputs and the percentage of the affected regions in a particular country

% of the required inputs/ Affected regions	All regions	More than 50% of the regions	25- 50 percent of the regions	1-25 percent of the regions
15 percent and up	Top national priority	Top regional priority	Medium regional priority	Low regional priority
10–14 percent	Top national priority	Medium regional priority	Medium regional priority	Low regional priority
5–9 percent	Medium national priority	Low regional priority	Low regional priority	Watching list
3–5 percent	Low national priority	Watching list	Watching list	Watching list

While perfect categorization is not possible because of the large number of variations, it still provides a useful guideline about the magnitude of the bottleneck caused by a particular pillar. In the following we use this categorization for each of the 24 countries. It is important to remember that bottlenecks are identified and evaluated not on an absolute but on a relative basis as compared to the other pillar values of the same region. So, it could happen that a region with high REDI scores have a bottleneck around 0.45 - for example Ile de France's lowest pillar score is the Networking with 0.44 – that could be the best score for a lower developed region – the best pillar of Greek Kentriki

Ellada is Process Innovation with 0.45 pillar score. *Table 22* provides a summary of the additional input allocation over the countries.

Table 22. Input allocation in country level

	Additional input		Increase of REDI
Country	Unit	%	Score
Austria	0.73	1.9%	5.01
Belgium	1.06	2.8%	5.01
Croatia	0.63	1.7%	5.01
Czech Republic	0.29	0.8%	5.00
Denmark	0.82	2.2%	5.01
Estonia	0.30	0.8%	5.01
Finland	0.85	2.3%	5.01
France	1.66	4.4%	5.01
Germany	3.83	10.2%	5.01
Greece	1.31	3.5%	5.00
Hungary	3.14	8.4%	5.00
Ireland	0.70	1.9%	5.00
Italy	1.62	4.3%	5.01
Latvia	0.17	0.4%	5.01
Lithuania	0.26	0.7%	5.00
Netherlands	0.96	2.6%	5.01
Poland	1.73	4.6%	5.01
Portugal	2.28	6.1%	5.01
Romania	1.55	4.1%	5.00
Slovak Republic	1.43	3.8%	5.01
Slovenia	0.86	2.3%	5.00
Spain	6.36	17.0%	5.01
Sweden	1.79	4.8%	5.01
United Kingdom	3.36	9.0%	5.00
Sum/average	***37.66***	***100.0%***	***5.01***

Austria

Austria's three NUTS 1 regions are listed in the first part of the ranking with relatively high REDI scores between 56.9 (Ostösterreich) and 47.6 (Südösterreich). As for the REDI scores and ranking, the three regions are rather homogeneous with respect to the bottleneck pillars as well. High Growth is the weakest pillar that constitutes a top, country wide priority. Risk Perception is acceptable in the case of Ostösterreich (0.28), and Westösterreich (0.39) but relatively low in Südösterreich 0.36). Therefore, regional policy should improve these two pillars in the affected regions (top priorities). Financing is Südösterreich weakest pillar. Austrian regions need about the same amount of inputs to reach a five point REDI development.

Belgium

Belgium also has three NUTS 1 regions. The leading Région de Bruxelles-Capitale is ranked at 11th place with a REDI score of 63.2. The other two regions perform rather similarly; Vlaams Gewest occupies 39th place while the most vulnerable Region Wallonne is in 44th place. Country wide

problems can be found in two pillars, Opportunity Startup and Networking. They require country wide policy actions. The Startup Skills pillar is the weakest pillar both in Region Wallonne and Vlaams Gewest. Therefore it should be a top regional policy priority to improve this pillar in the two affected regions. High Growth is Vlaams Gewest's other binding constraint requiring medium priority local policy attention. Financing is particularly low in the capital region, but is not a problem for the other two territories. Cultural Support and Human Capital are also problematic for Région de Bruxelles-Capitale. Cultural Support pulls back Region Wallonne as well. All these pillars represent medium level policy priorities. Region Wallonne needs about half of the inputs (0.22) that the other two regions (0.42) need to improve its REDI scores by 5.

Czech Republic

The Czech Republic consists of only one NUTS 1 region, so we are not able to carry out a regional level analysis. The overall entrepreneurial performance of the country is good; with 38.8 REDI scores it occupies the 73rd place in the ranking. Risk Perception and Cultural Support are the two most binding constraints, requiring altogether 82 percent of all the additional inputs (top priorities). Networking and Opportunity Startup (medium priorities) are the other relatively weak pillars. Czech Republic is particularly strong in the Aspiration sub-index.

Croatia

Croatia has only two NUTS 2 regions which have very similar entrepreneurial levels and profiles with REDI scores of 23.5 (Jadranska Hrvatska) and 25.6 (Kontinentalna Hrvatska). From the results it seems that, at least on the NUTS 2 level, it is not worth discussing regional policy in Croatia; national level policy steps are necessary. It is also obvious that Croatia's pillar structure is relatively imbalanced; all its entrepreneurship and innovation related obstacles derive from three pillars of the Ability and Attitude sub-indices. The country's weakest point is Cultural Support. However, Networking and Opportunity Startup pillars require top level priority policy intervention as well.

Denmark

Danish NUTS 2 regions are amongst the most entrepreneurial EU regions. In fact Hovedstaden occupies the second place and the worst Danish region, Sjaelland is ranked at the 50th place with a still impressive 48.4 REDI score. All five Danish regions perform on a very high level in Opportunity Perception, Networking, Cultural Support, Opportunity Startup, Technology Absorption, Human Capital, Competition and Product Innovation. Top priority country wide actions are necessary to improve Globalization which is the most binding constraint for three and the second most important for the remaining two Danish regions. In the cases of Hovedstaden and Nordjylland the score of High Growth pillar is relatively low (medium regional priority). Sjaelland's Process Innovation is critically low. This region should use 59% of its new inputs to improve this pillar. Startup Skills are problematic for Syddanmark (low regional priorities). Hovedstaden needs more (0.23) while Midtjylland demands considerably less (0.1) inputs than the other three Danish regions (0.13–0.17) to reach five point REDI improvement.

Estonia

Estonia represents a NUTS 2 region as a country. After Zahodna Slovenija, its 45.3 REDI score is the second largest amongst the former socialist regions. Estonia's most problematic pillars are Financing and Cultural Support (top national priorities). There is a relatively smaller problem in the case of Globalization (medium level policy priority).

Finland

Finnish regions can be found in the first half of the REDI ranking. Helsinki-Uusimaa is the best with 70.0 and Pohjois- ja Ita-Suomi is the weakest with 43.2 REDI scores. They show a rather homogenous picture regarding their weak pillars. Most of the problems concentrate on the Aspiration sub-index. The low level of Financing restricts the entrepreneurial development of all Finish regions requiring national level top priorities. Globalization needs to be developed in three out of the four regions (top level regional policy priority). Länsi-Suomi's Product Innovation and Etelä-Suomi's Human Capital are relatively weak too (low level regional priority). The requirement of additional inputs varies largely across the regions (0.16–0.28).

France

France is large country with diversely entrepreneurial regions. Ile de France, as the most agglomerated region in France, is ranked fifth out of the 125 EU regions with a 70.8 REDI score. At the same time, mainly due to its extremely low Globalization pillar value, Sud-Ouest, the weakest France NUTS 1 region has only a 37.6 REDI score. Indeed, Sud-Ouest should spend all of its extra inputs on that pillar. Centre-Est and Méditerranée are the two other regions with only one bottleneck. The development policy in Centre-Est should fully concentrate on Startup Skills while in Méditerranée on High Growth. High Growth does not require national, country wide policy interventions in France. The most binding pillar, pulling back all but one region, is Startup Skills. Apart from the last two regions mentioned and Ile de France, this pillar represents the main restriction to development. Therefore, the Startup Skills pillar is a top regional policy priority. The capital region's weakest pillar is Networking. Nord-Pas-de-Calais and Bassin Parisien face Networking problems as well but on a less serious level. Next to Networking, Opportunity Perception is a pillar affecting three regions. One region is suffering from the lack of Cultural Support and Technology Absorption (low priority). The extra inputs needed fluctuate between 0.14 and 0.31 across regions.

Germany

Germany is probably the most diverse EU country in terms of the level and the profile of entrepreneurship. German regions rank from the 8th to the 81th places on the overall ranking. While Hamburg, the best German region, has 69.5 REDI score, Brandenburg, a former socialist region, reached only a REDI score of 35.1. Apart from Berlin and Sachsen, the former East German regions – Brandenburg, Mecklenburg-Vorpommern, Sachsen-Anhalt, and Thüringen – are at the second half of the ranking. Examining Germany's pillar level entrepreneurial profile, Startup Skills, Networking, Cultural Support and Opportunity Startup – does not constrain any German region. It seems that three pillars, Risk Perception, Product Innovation, and Human Capital constitute national bottlenecks. Risk Perception is a binding constraint for twelve out of the sixteen regions. Out of these twelve regions, five – Baden-Württemberg, Bayern, Berlin, Hamburg and Saarland – should devote the

highest percentage of their additional inputs to that pillar. Surprisingly, Product Innovation is a bottleneck for eight and the most serious constraint for five – Hessen, Rhineland-Pfalz, Sachsen, Sachsen-Anhalt and Schleswig-Holstein regions (top regional policy priorities). Human Capital is also a constraint for eight regions, most importantly for Bayern, Thüringen and Niedersachsen. Process Innovation restricts five regions. For two- Nordrhein-Westfalen and Thüringen, this pillar represents the most critical impasse to development. These latest two pillars require medium level regional policy focus. All the other pillars are problematic for one to three regions. Technology Absorption is found to pull back Brandenburg and Niedersachsen severely. Globalization is Bremen and Financing is Mecklenburg-Vorpommern major problem. Opportunity Perception, Technology Absorption, Competition and High Growth need a relatively lesser extent improvement in the affected regions. Local policy intervention is still necessary. Reflecting the diversity of the entrepreneurial profile of the German regions, the necessary amount to reach five REDI development varies largely, between 0.13 and 0.43 across regions.

Greece

The REDI ranking of the Greek regions reflect their desperate economic situation: Attiki, the best Greek region is 103rd and the other three regions are between the 116th and the 120th places. Greek regions are very similar with respect to their problematic points. The most problematic pillar is Cultural Support. Networking is also at a low level and affects all four regions. Opportunity Startup and High Growth hit three out of the four regions moderately or severely. Opportunity Perception should be on Kentriki Ellada region's watchlist as well. Attiki would need considerably less extra inputs to develop five points than the other Greek regions.

Hungary

Just viewing the level of entrepreneurship, there is a divide between the capital region and the other part of Hungary: Közép-Magyarország has 31.1 REDI score while all the other six NUTS 2 regions reached 17.7–21.7 REDI score. All Hungarian regions are amongst the last places of the overall ranking between 97th (Közép-Magyarország) and 125th (Dél-Alföld). Indeed, Hungarian regions occupy the last five places of the ranking. Viewing the problematic fields, the Attitude related two pillars – Risk Perception and Cultural Support – can be assigned as top national priorities. Indeed, Cultural Support is at an acutely low level. Networking is a less problematic pillar, still needing country level attention (medium level national priority). Financing, being insufficient in six regions, is on the top regional policy priority list. Product Innovation is seriously problematic in three and Process Innovation in two regions. These pillars are assigned to the medium level regional policy priority category. Opportunity Perception, Opportunity Startup, Competition and Startup Skills are set into the low level regional policy priority class. Hungarian regions are in the bottom of 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 (0.21–0.52).

Ireland

Despite the hard years since 2008, the two Irish NUST 2 regions are amongst the best according to their REDI scores: Southern and Eastern (71.3) is ranked as 4th and Border, Midland and Western (60.4) is ranked as 18th. The entrepreneurial profiles of the two regions have got some similarities. Opportunity Perception and Globalization are the pillars constraining both regions (top national priority). However, Financing and Process Innovations are the two most grave bottleneck pillars of Border, Midland and Western (top regional priority). Besides these four pillars, Product Innovation requires attention in Border, Midland and Western Ireland (medium level regional priority).

Italy

It is difficult to describe the entrepreneurial profile of such a large country as Italy based on a limited number (five) of NUTS 1 regions. While the GDP of the two least wealthy Italian regions, Isole and Sud, is considerably behind the rest of the country, the regional entrepreneurial profiles do not mirror this divide. The two best Italian regions, Nord-Ovest and Centro occupy the 89th and 88th places while Sud, the least entrepreneurial region, is in 111th place in the REDI ranking. The pillar profile of the regions is very similar as well. Italy's major weaknesses concentrate on three pillars, namely Opportunity Startup, Human Capital and High Growth. All regions are affected by the low level of Cultural Support, however, on a less extent than the other thee pillars.. One of these pillars represents the severest limitation to the development as well for all regions (top national or regional policy issues. Financing signifies a low level issue hitting only the Nord-Est region. Networking and Startup Skills are on the watch list of two and one respectively regions.

Lithuania

Lithuania is one of those countries that constitute one NUTS 1 region. Lithuania's REDI score is 32.8 (91st place). In the ranking, Lithuania is surrounded by Spanish and Polish regions. The Cultural Support in Lithuania is critically low. Lithuania should concentrate solely and spend all its inputs on this pillar to achieve a 5 point REDI improvement.

Latvia

Latvia is very similar to Lithuania in many respects. It is also a small Baltic country constituting one NUTS 1 region. Its 36.7 REDI score is above of that of Lithuania's. Moreover, Cultural Support should be the most important policy concern in this country as well. Networking also belongs to the top policy priority category. Meanwhile, Opportunity Startup is just marginally below the 15% threshold value of the required new inputs. In addition, process innovation is a weakly binding constraint, on a watching list.

Netherlands

The four Dutch NUTS 1 regions rank between the 10th and the 37th places. The regional differences are moderate; all regions' REDI are between 63.5 and 51.8 REDI scores. Unlike many other regions, three Dutch regions are characterized by only one or two bottlenecks. Risk Perception is a bottleneck in the whole country and the lowest pillar for two out of the four regions. Indeed, West-Nederland should allocate all its extra inputs here to achieve a 5 point REDI increase. This pillar is assigned to the top country wide policy priority category. High Growth is also low for three regions, except West-

Nederland (top regional policy priority). Moreover, it represents the most critical pillar for Oost-Nederland and Zuid-Nederland. Besides these two pillars, Opportunity Perception and Process Innovation is problematic in Noord-Nederland (medium priority).

Poland

Polish regions' entrepreneurial level fits their economic development: The six NUTS 1 regions rank between the 66th and the 96th places. The four least developed Polish regions looks fairly similar between 36.7-31.8 REDI scores. With 43.0 and 40.5 REDI scores respectively, Region Centralny and Region Poludniowy are also close to each other and ahead of the other part of the country. The similarities continue when we look at the entrepreneurial profile of the regions. The most problematic pillars for all regions are in the entrepreneurial Abilities sub-index. Opportunity Startup pillar is the most limiting constraint of entrepreneurship followed by Competition. These two pillars are assigned to the top national level policy priority category. Process Innovation is acceptable only in Region Centralny. Technology absorption is problematic for three regions, but only problematic for Region Pólnocny. Thus, they are viewed as medium level regional policy priorities.

Portugal

The five Portugal NUTS 2 regions show diverse performance both on the level and on the profile of entrepreneurship. Lisboa, the best Portugal region is ranked 51st with a solid 48.1 REDI score. It is around Austrian, French, German, Danish, and Finnish regions and the best former socialist countries, Estonia and Slovenia. The other four regions are in between the 76th and 93rd place with 32.7–37.1 REDI scores. This performance is close to the result of some Italian, Spanish and the best Polish regions as well as Lithuania and Latvia. In general, the pillar structure of the Portugal regions is relatively well balanced. None of the regions should sacrifice more that 50% of its additional inputs on one single pillar and all regions should divide its additional inputs between five to seven pillars. Networking and Human Capital are the two country level boundaries of development. Both are top country level policy issues. Financing affects the whole country but Lisbon. Opportunity Perception and Technology absorption concern three regions. All are top regional policy priorities. Opportunity Startup and Product Innovations pillars draw back the entrepreneurial performance of two regions on a medium level. Competition and High Growth are also problematic for two Portuguese regions but to a lesser extent. Process Innovation withholds one region. These last three pillars constitute the low level regional policy priority group. Risk Perception is on Lisboa's watch list. The well balance pillar structure reacquires a relatively high amount of additional inputs, between 0.38 and 0.53.

Romania

Romania has four NUTS 1 regions with very similar, modest levels of entrepreneurial performance. Romania groups together with mostly Spanish, Croatian, Greek and Slovakian regions in the ranking. The entrepreneurial profile of the regions is very similar. The REDI scores of the Romanian regions range from 21.4 to 29.9. There are basically seven pillars that do not require improving: Opportunity Perception, Risk Perception, Human Capital, Product Innovation, High Growth, Globalization and Financing. Most of the times – in the case of Opportunity Startup, Startup Skills, Networking, and Cultural Support pillars- top level national policy actions are necessary. Technology absorption causes

some moderate problems for two regions (medium level regional policy priority). Competition and Process Innovation are marginally problematic for two regions (low regional policy priority). Macroregiunea trei needs only 0.25 while the other regions 0.42–0.45 of additional inputs to increase their REDI result by five points.

Spain

Spain is a large EU country characterized by diverse regional economic development. The REDI scores also mirror this diversity. Out of the 17 NUTS 2 Spanish regions, Castilla-la Mancha is the least entrepreneurial region with 24.7 and Madrid is the leader with 51.1 REDI scores. At the same time, the problematic pillars are about the same. The Aspiration sub-index related Globalization pillar requires country wide policy interventions. All regions are affected. Moreover, for thirteen regions low Globalization is the severest constraint. For the rest of the country the insufficient level of Process Innovation-affecting all but the capital region- represents the major impasse. These pillars are top national and regional respectively policy topics. Opportunity Perception and Product Innovation pull back 10 and 9 regions respectively. Therefore, these pillars are sorted to the medium regional priorities. Competition and Opportunity Startup bound six regions while Process Innovation and Risk Perception withhold three regions. These pillars are on the low level regional policy priority list. Human Capital limits only Illes Baleares and Cultural Support is on Madrid's watch list. Interestingly, financial problems are not present in Spain. Technology absorption and Startup Skills do not limit the entrepreneurial development of any Spanish regions either. Not surprisingly, the amount needed to develop the entrepreneurial profile by five points varies largely across regions; between 0.22–0.51.

Sweden

Most of the eight NUTS 2 level Swedish regions are in the top of the ranking. In fact, Stockholm is the most entrepreneurial region in Europe. Östra Mellansverige, Vastsverige, and Sydsverige are all in the first twenty regions of the EU with 65.8–59.8 REDI scores. Övre Norrland, Smaland med öarna and Norra Mellansverige are among the stronger half of EU regions with a still impressive 54.8, 45.6 and 45.5 REDI score respectively. The weakest Swedish regions, Mellersta Norrland reached 39.9 REDI point. While the entrepreneurial profile of the Swedish regions is rather similar, there is no pillar that is a binding constraint for all the eight regions. However, there are several top regional priority pillars. Startup Skills negatively influence seven out of the eight regions. Moreover, Östra Mellansverige should spend all its inputs on this pillar. The lack of Financing constrains six regions' entrepreneurial performance. Stockholm and Vastsverige should spend most of its additional inputs on the improvement of Financing. Startup Skills and Financing are the top regional policy priorities. High Growth limits three regions. This is the only problematic policy issue for Mellersta Norrland and the most important one for Norra Mellansverige. Meanwhile, Globalization withholds two regions. Globalization means the most restrictive matter for Övre Norrland and Smaland med öarna. These two pillars belong to the medium level regional policy priority list. Product Innovation should also be addressed by policy actions in Smaland med öarna. We think that these finding are rather surprising since Nordic countries are well-known for their good performance in innovation and globalization. Depending mostly on the number of bottlenecks, the additional amount necessary to reach a five point development ranges between 0.12 and 0.39.

Slovenia

Slovenia consists of two NUTS 2 regions. With its 50.0 REDI score, Zahodna Slovenija is the best performer among the former socialist countries. Vzhodna Slovenija, with a 43.0 point result, is also a relatively high performer post socialist region. Slovenia's entrepreneurial and innovation capacity is similar to level of some Austrian, German, and French regions. By no surprise, the two Slovenian regions face very similar problems to improve their level of entrepreneurship. Opportunity Perception, Financing and Opportunity Startup (top national priorities) followed by Cultural Support and Risk Perception (medium national priorities) are the lowest pillars.

Slovakia

Slovakia's four NUTS 2 regions show huge differences and remarkable similarities at the same time. The leading Bratislavský kraj has 44.2 REDI scores and ranks behind Bassin Parisien (FR) and Pohjois- ja Ita-Suomi (FI). On the contrary, the other three Slovakian regions are lagging behind. With REDI scores ranging between 26.0–26.7 they stick together toward the bottom of ranking around Italian, Spanish, Romanian, Croatian and Greek regions. Looking at the entrepreneurial profile of the regions, similar divide between the capital and the rest of the country can be noticed. Cultural Support is the most binding constraint for all the regions, hitting Bratislavský kraj especially hard. That is the only real bottleneck for the capital region and thus the only national policy issue (top national priority). Startup Skills and Competition, pulling back three regions significantly, are the high level regional policy priorities. We assign two pillars, Opportunity Startup and Opportunity Perception to the medium regional policy priority category. Finally, having a relatively lighter negative effect on entrepreneurial development, Risk Perception is put on the watch list. While Bratislavský kraj needs 0.12, the other regions should get 0.42-0.45 amount of additional inputs to increase their REDI scores by 5 points.

United Kingdom

The UK's regional entrepreneurship performance is amongst the best in the EU. Two leading UK NUTS 1 regions, London and South East are in the top ten of the REDI ranking. These regions are followed by South West (13th) and Scotland (17th). Apart from the North East part of the country, the other UK regions rank between the 22–43 places with impressive, 58.7–50.4 REDI scores. Only North East lags behind the other regions with a still respectable 44.3 REDI score. Examining the entrepreneurial profile varieties, the two leading regions, Wales, Scotland and Northern Ireland seem to differ from the other ten regions. Apart from these regions, almost all the problematic pillars belong to the Aspiration sub-index. No doubt, that in general, the low level of Financing is the most binding constraints in UK. It affects all the regions except for South East and Wales. Three regions – North East, Yorkshire and The Humber and East of England– should devote all or most of their additional inputs on the development of this pillar. East Midland and West Midland should also spend more than half of its additional inputs to ease the financial bottleneck. Product Innovation withholds sevens regions' entrepreneurial performance. This pillar is the major impasse for the two best performing regions, London and South East. These two pillars are all subject to top level regional policy priority. Globalization and Process Innovation are seriously inadequate in six and four regions, respectively. Wales, Scotland and Northern Ireland face binding constraints that do not characterize

the other UK regions. Opportunity Perception is in the way of development for all three of them. Therefore, Opportunity Perception with the two lastly mentioned Aspiration pillars are all subject to medium level regional policy priority. Moreover, High Growth pulls back two regions (East Midland and Wales) and in Northern Ireland it is also necessary to improve Startup Skills pillars (low level regional policy priorities). The necessary amount to develop the entrepreneurial profile by five points varies largely across regions; between 0.11–0.48.

7. Summary and conclusion

In the last decades, entrepreneurship policy has been improved extensively both in terms of the use of evidence to support policy design and implementation, and also a shift towards more place-based holistic approaches tailor-made to particular locations. Another important aspect of the current stage of entrepreneurship policies is the encouragement and inclusion of experimentalism and self-discovery as part of the policy design and implementation (Hausmann and Rodrik 2003; Foray et al., 2015).

REDI is a novel and unique index which provides exactly the type of empirical framework useful for profiling the entrepreneurial environment of European regions which is amenable as pre-stage of the development of tailored policy settings. The power of the REDI framework is demonstrated by the fact that the REDI approach is used by the European Commission (European Union, 2014) for describing and benchmarking the entrepreneurial potential of each of the EU regions. As such, the REDI fills part of the evidence–gap which needs to be addressed and filled in order to best ensure that our entrepreneurship policy settings are as well-tailored to the regional context as is possible.

Even if the assumptions are restrictive and should be kept in mind, 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 to and highlighting system dynamics in Regional Systems of Entrepreneurship.*** This reinforces a systemic perspective to policy analysis and design over a traditional, siloed standpoint.

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APPENDICES

Appendix A: The applied individual and institutional variables and indicators in the new REDI

Pillars	Regional Driving Forces	Institutional pillar	Inst. Variable	Territorial level	Individual pillar
OPPORTUNITY PERCEPTION	*Agglomeration economies, size of the region, market potential*	**MARKET AGGLOMERATION**	Population change	regional	**OPPORTUNITY RECOGNITION**
			Urbanization (% of urban population)	country/regional	
			Accessibility	regional	
			BUSINESS FREEDOM * PROPERTY RIGHTS	country	
STARTUP SKILLS	*Education, creativity, talent*	**QUALITY OF EDUCATION**	PISA	country	**SKILL PERCEPTION**
			Creative Class	regional	
RISK ACCEPTANCE	*Protection of rights*	**BUSINESS RISK**	Business Extent of Disclosure Index	country	**RISK PERCEPTION**
NETWORKING	*Social Capital, networking, role model*	**SOCIAL CAPITAL**	Legatum Social Capital Subindex	country	**KNOW ENTREPRENEUR**
			Technology readiness	regional	
				regional	
CULTURAL SUPPORT	*Regulation (people), Corruption*	**OPEN SOCIETY**	Legatum Personal Freedom	country	**CARRIER STATUS**
			Corruption	regional	
OPPORTUNITY STARTUP	*Role of State, Governance*	**BUSINESS ENVIRONMENT**	Quality of Governance	regional	**OPPORTUNITY MOTIVATION**
			TAXATION	country	
TECHNOLOGY ADOPTION	*Knowledge spillover*	**ABSORPTIVE CAPACITY**	Firm-level technology absorption (WEF)	country	**TECHNOLOGY LEVEL**
			Employment in Knowledge and High-Tech Sectors	regional	
HUMAN CAPITAL	*Human Capital*	**EDUCATION AND TRAINING**	Higher education, training, life long learning	regional	**EDUCATIONAL LEVEL**
			LABOUR FREEDOM	country	

COMPETITION	*Competitive advantage*	**BUSINESS STRATEGY**	Nature of competitive advantage (WEF)	country	**COMPETITORS**
			Employment in sophisticated sectors (K_N)	regional	
			GVA in sophisticated sectors	regional	
			Foreign controlled firms in the EU	country	
PRODUCT INNOVATION	*Innovation*	**TECHNOLOGY TRANSFER**	Total patent application	regional	**NEW PRODUCT**
			Scientific publications	regional	
			High-tech patent applications	regional	
			ICT patent applications	regional	
			Biotech patent applications	regional	
PROCESS INNOVATION	*Innovation*	**TECHNOLOGY DEVELOPMENT**	GERD	regional	**NEW TECHNOLOGY**
	Knowledge institutions		Researchers/R&D employees in higher education sector?	regional	
HIGH GROWTH	*Clustering, Industrial Specialization, Diversity*	**CLUSTERING**	Availability of VC	country	**GAZELLE**
			Observatroy star rating	regional	
			State of Cluster Development	country	
GLOBALIZATION	*Physical accessibility*	**CONNECTIVITY**	Infrastructure sub-index	regional	**EXPORT**
			ECONOMIC COMPLEXITY INDEX	country	
FINANCING	*Financing*	**FINANCING INSTITUTIONS**	Depht of Capital Market	country	**INFORMAL INVESTMENT**
			Concentration of financial services	regional	

Red letters show the changes in the index structure as compared to the previous REDI version (see also appendices B and C for changes).

Appendix B: 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	REDI 2013	REDI 2017	Data availability	Notes
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	**2005-2012**	**2013-2015**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
		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	**2011; 2010-2011**	**2014 (for countries), 2011 (for regions)**	http://www.clusterobservatory.eu/index.html http://esa.un.org/unpd/wup/CD-ROM/	
		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 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.	Eurostat	**million EUR, 2010**	**2011-2013**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
			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	**2010**	**2011-2015**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
		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	**2013**	**average 2014-2015**	http://www.heritage.org/index/download	
		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 accumulate private property, secured by clear laws that are enforced effectively by the government.	Heritage Foundation	**average of 2007-2011**	**average of 2012-2016**	http://www.heritage.org/index/property-rights	
Quality of Education	The average of the three PISA	**PISA**	country	Low achievers in Reading of 15-year-olds.	OECD	**2006**	**2012**	http://gpseducation.oecd.org/IndicatorExplorer?	http://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/3369059

	variables was subtracted from 100. It was multiplied with the value of Creative Class.								1.pdf
				Low achievers in Science of 15-year-olds.					http://stats.oecd.org/#
				Low achievers in Math of 15-years-olds.					https://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/34002216.pdf
		Creative Class	regional	Employment in creative industries / 1000 population.	Cluster Observatory	**2005-2011**	***2005-2011***	http://www.clusterobservatory.eu/index.html#!view=mainMenu	
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. 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 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.	World Bank, World Development Indicator	**2012**	**2013-2015**	http://data.worldbank.org/indicator/IC.BUS.DISC.XQ	
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 organisations 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	**2011**	**2012-2015**	http://www.prosperity.com/#!/?opts=2Ekxmx-Ulx3y1	
		Technological Readiness	regional	Households with access to broadband.	Eurostat	**2011**	**2012-2015**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
			regional	Individuals who ordered goods or services over the Internet for private use.	Eurostat	**2011**	**2012-2015**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
			regional	Households with access to Internet.	Eurostat	**2011**	**2012-2015**	http://appsso.eurostat.e	

								c.europa.eu/nui/show.do	
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	**2011**	**2012-2015**	http://www.prosperity.com/#!/?opts=2Ekxmx-Ulx3y1	
		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 were forced to pay a bribe in the last 12 months to obtain any health care in the region/area.	EU QoG Corruption Index (EQI)	**2010**	**2013**	http://qog.pol.gu.se/data/datadownloads/qogeuregionaldata	RO3 = instead of 0 (technical) 0,05
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)	**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
		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	**average of 2010-2012**	**average of 2013-2016**	http://www.doingbusiness.org/data/distance-to-frontier	
Absorptive Capacity	Firm-level Technology	**Firm-level Technology Absorption**	country	*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	WEF	**GCI Report 2012/20**	**GCR Reports 2013-**	http://reports.weforum.org/global-	Average of 2012-2013 weighted average and 2013-2014 weighted

	Absorption variable was multiplied with the average of variables related to employment in Knowledge and high-Technology Sectors.			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).		**13**	**2014 and 2014-2015**	competitiveness-report-2015-2016/	average data, 2014-2015 weighted average data = 2013-2014 weighted average data
		Employment in Knowledge and High-Tech Sectors	regional	Employment in high-Technology Adoptions (high-tech manufacturing and knowledge-intensive services).	Eurostat	**2007-2008**	**2009-2013 (% of total employment)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	PT15 missing
			regional	Employment in technology and knowledge-intensive sectors.	Eurostat	**2011**	**2014 (% of total employment)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	PT15 missing
			regional	Researchers, % of total employment.	Eurostat	**2009**	**2010-2013 (% of active population)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	EL1, EL2, FR1-8 = missing
			regional	Annual data on Human resources in science and technology (HRST).	Eurostat	**2011**	**2012-2014 average (% of population)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
Education &Training		**Higher Education&Training and LLL**	regional	Share of population aged 25-64 years with higher educational attainment.	Eurostat	**2011**	**2012-2014 (%)**	http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tgs00109&plugin=1	
			regional	Share of population aged 25-64 years participating in education and training.	Eurostat	**2011**	**2012-2014 (%)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	
		Labour Freedom	country	The labor freedom component is a quantitative measure that considers various aspects of the legal and regulatory framework of a country's labor market, including regulations concerning minimum wages, laws inhibiting layoffs, severance requirements, and measurable regulatory restraints on hiring and hours worked, plus the labor force participation rate as an indicative measure of employment opportunities in the labor market.	Heritage Foundation	**average of 2007-2011**	**average of 2012-2016**	http://www.heritage.org/index/labor-freedom	

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 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, 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).	WEF	**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
		Employment, K-N sector	regional	Employment in the "Financial, real estate, professional, scientific and support activities" sectors (K-N) as % of total employment.	Eurostat	**2011**	**2012-2015**		earliler variable contained only J_K secotrs
		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	**2007**	**2010**		earliler variable contained only J_K secotrs
		Foreign control of enterprises	country	Foreign control of enterprises by economic activity and a selection of controlling countries (number of enterprises / population).	Eurostat	**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	Unweighted average of the five innovation related	**Total patent applications**	regional	Patent applications to the EPO. Number of applications per one million inhabitants.	Eurostat	**2008-2009**	**2010-2012 (per million inhabitants)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	

	indicators.	**Scientific publication**	regional	Publications per one million inhabitants (Thomson Reuters Web of Science & CWTS database (Leiden University).	EU Regional Competitiveness Report	**2010**	**2008-2010 (per one million inhabitants)**	http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/6th_report/rci_2013_report_final.pdf	
		High-tech inventors	regional	High-tech patent applications to the EPO. Number of applications per one million inhabitants.	Eurostat	**2008-2009**	**2010-2012 (per one million inhabitants)**	http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do	HR03 = missing
		ICT inventors	regional	PCT patent applications (fractional count by inventor and priority year) in ICT.	Eurostat	**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
		Biotechnology inventors	regional	PCT patent applications (fractional count by inventor and priority year) in biotech.		**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		**GERD**	regional	Gross Domestic Expenditure in Research & Development (GERD) as a percentage of GDP.	Eurostat	**2009**	**2010-2013 (% of GDP)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	earlier version: OECD, but available only 2011
		Researchers and R&D employees in higher education sector	regional	Researchers and R&D employees in higher education sector (% of active population).	Eurostat	**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		**Cluster**	regional		DG Regio	**no data**	**2011**		http://ec.europa.eu/Do

		Observatory Star Rating							csRoom/documents/17982 HR, SI, IE, FI1B, FI1C = missing
		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	**average of 2007-2011**	**average of 2012-2015**	http://reports.weforum.org/global-competitiveness-report-2015-2016	
		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	**2007-2012**	**2012-2016**	http://reports.weforum.org/global-competitiveness-report-2015-2016/	
Connectivity		**Infrastructure Sub-index**	regional	- Motorway density (average pop/area). EU27=100, Eurostat/DG TREN/EuroGeographics/National Statistical Institutes. - Railway density (average pop/area), EU27=100, Eurostat/DG TREN/EuroGeographics/National Statistical Institutes. - Number of passenger flights, daily number of passenger flights (accessible within 90-minute drive), Eurostat/EuroGeographics/National Statitical Institutes.	EU Regional Competitiveness Report	**2010**	**2013**	http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/6th_report/rci_2013_report_final.pdf	
		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	**2007-2011**	**2012-2014**	http://atlas.media.mit.edu/en/	
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 liquidity of the stock market, level of IPO, M&A and debt and credit market activity	The Global Venture Capital and Private Equity Country Attractiveness Index (2013)	**2013**	**2015**	http://blog.iese.edu/vcpeindex/	
		Concentration of Financial Sector	regional	Regional employment in financial services sector as percentage of total regional employment.	Cluster Observatory	**2005-2011**	**2012-2014 (Eurostat data)**	http://appsso.eurostat.ec.europa.eu/nui/show.do	PT15 = missing

Note: The new indicators are marked in brown.

Appendix C: NUTS – Nomenclature of Territorial Units for Statistics

The Nomenclature of Territorial Units for Statistics (hereinafter referred to as NUTS) was developed at the beginning of the 1970s by the Statistical Office of the European Communities (Eurostat) in close collaboration with the national statistical institutes of the EU Member States.

The NUTS system can be regarded as a geocode standard for dividing up the whole territory of the European Union. Currently it is defined only for the 27 Member States of EU. However, Eurostat has proposed a similar hierarchical classification for countries belong to the European Economic Area (EEA), Switzerland and the new candidate countries as well.

The main objective of the NUTS system is to ensure a uniform statistical classification of the territorial units of the EU Member States in order to collect, compile and disseminate comparable, harmonized regional statistics primarily for conducting socio-economic analyses. A decisive role of the NUTS system is to minimize the impact of fortuitous changes in the national administrative structures of different EU countries. However, the NUTS classification has been changed several times starting from 1981 to reflect the administrative changes of the Member States. All Member States' spatial statistics has been delivered to the European Commission should use the NUTS classification.

Furthermore, the hierarchical system of the NUTS nomenclature was developed for framing EU regional policies and it has a direct role of appraising eligibility for financial support from the EU Structural Fund.

Two criteria are used in subdividing the territory of the Member States into spatial units:

- "*normative regions* are the expression of political will; their limits are fixed according to the tasks allocated to the territorial communities, according to the sizes of population necessary to carry out these tasks efficiently and economically, and according to historical, cultural and other factors;
- *analytical (or functional) regions* are defined according to analytical requirements; they group together zones using geographical criteria (e.g. altitude or type of soil) or using socio-economic criteria (e.g. homogeneity, complementarities, or polarity of regional economies)." [*Regions in the EU* 2011, p. 5]

The NUTS classification is based on the institutional (normative) division of the territory of the EU Member States.

According to the NUTS nomenclature each Member State is divided into NUTS level 1 territorial units, each of which is subdivided into NUTS level 2 territorial units. While NUTS 2 spatial units are made up from NUTS level 3 spatial units. The NUTS classification determines the following minimum and maximum limits for population size of the regional units. The thresholds refer to average population size, which based on the number of those persons who have their usual place of residence in this area (*Table 24*).

From 2000 the Commission Regulation (EC) No 1059/2003 ensures legal status for the NUTS. This was entered into force in July 2003. The regulation can guarantee stability of the classification for at least three years. The current NUTS classification is valid from 1 January 2012 until 31 December 2014. It contains 97 regions at NUTS 1, 270 regions at NUTS 2 and 1294 regions at NUTS 3 level.

Administrative units of the EU Member States, which offer legal and institutional framework for a given geographical areas, indicate the first criterion used for the definition of NUTS territorial units.

Table 23. The characteristics of three NUTS level regions

Level	Characteristics	Minimum population	Maximum population
NUTS 1	Major socio-economic regions.	3 million	7 million
NUTS 2	Basic regions for the application of regional policies.	800 000	3 million
NUTS 3	Small regions for specific diagnoses.	150 000	800 000

Source: Regions in the EU 2011

Appendix D: List of REDI regions by country

AT1	Ostösterreich
AT2	Südösterreich
AT3	Westösterreich
BE1	Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest
BE2	Vlaams Gewest
BE3	Région wallonne
CZ	Czech Republic
DE1	Baden-Württemberg
DE2	Bayern
DE3	Berlin
DE4	Brandenburg
DE5	Bremen
DE6	Hamburg
DE7	Hessen
DE8	Mecklenburg-Vorpommern
DE9	Niedersachsen
DEA	Nordrhein-Westfalen
DEB	Rheinland-Pfalz
DEC	Saarland
DED	Sachsen
DEE	Sachsen-Anhalt
DEF	Schleswig-Holstein
DEG	Thüringen
DK01	Hovedstaden
DK02	Sjælland
DK03	Syddanmark
DK04	Midtjylland
DK05	Nordjylland
EE	Estonia
EL1	Voreia Ellada
EL2	Kentriki Ellada
EL3	Attiki
EL4	Nisia Aigaiou, Kriti
ES11	Galicia
ES12	Principado de Asturias
ES13	Cantabria
ES21	País Vasco
ES22	Comunidad Foral de Navarra
ES23	La Rioja
ES24	Aragón
ES30	Comunidad de Madrid
ES41	Castilla y León

ES42	Castilla-la Mancha
ES43	Extremadura
ES51	Cataluña
ES52	Comunidad Valenciana
ES53	Illes Balears
ES61	Andalucía
ES62	Región de Murcia
ES70	Canarias (ES)
FI19	Länsi-Suomi
FI1B	Helsinki-Uusimaa
FI1C	Etelä-Suomi
FI1D	Pohjois- ja Itä-Suomi
FR1	Île de France
FR2	Bassin Parisien
FR3	Nord - Pas-de-Calais
FR4	Est (FR)
FR5	Ouest (FR)
FR6	Sud-Ouest (FR)
FR7	Centre-Est (FR)
FR8	Méditerranée
HR03	Jadranska Hrvatska (Adriatic Croatia)
HR04	Kontinentalna Hrvatska (Continental Croatia)
HU10	Közép-Magyarország
HU21	Közép-Dunántúl
HU22	Nyugat-Dunántúl
HU23	Dél-Dunántúl
HU31	Észak-Magyarország
HU32	Észak-Alföld
HU33	Dél-Alföld
IE01	Border, Midland and Western
IE02	Southern and Eastern
ITC	Nord-Ovest
ITF	Sud
ITG	Isole
ITH	Nord-Est
ITI	Centro (IT)
LT	Lithuania
LV	Latvia
NL1	Noord-Nederland
NL2	Oost-Nederland
NL3	West-Nederland
NL4	Zuid-Nederland
PL1	Region Centralny
PL2	Region Poludniowy

PL3	Region Wschodni
PL4	Region Pólnocno-Zachodni
PL5	Region Poludniowo-Zachodni
PL6	Region Pólnocny
PT11	Norte
PT15	Algarve
PT16	Centro (PT)
PT17	Lisboa
PT18	Alentejo
RO1	Macroregiunea unu
RO2	Macroregiunea doi
RO3	Macroregiunea trei
RO4	Macroregiunea patru
SE11	Stockholm
SE12	Östra Mellansverige
SE21	Småland med öarna
SE22	Sydsverige
SE23	Västsverige
SE31	Norra Mellansverige
SE32	Mellersta Norrland
SE33	Övre Norrland
SI01	Vzhodna Slovenija
SI02	Zahodna Slovenija
SK01	Bratislavský kraj
SK02	Západné Slovensko
SK03	Stredné Slovensko
SK04	Východné Slovensko
UKC	North East (UK)
UKD	North West (UK)
UKE	Yorkshire and The Humber
UKF	East Midlands (UK)
UKG	West Midlands (UK)
UKH	East of England
UKI	London
UKJ	South East (UK)
UKK	South West (UK)
UKL	Wales
UKM	Scotland
UKN	Northern Ireland (UK)

Appendix E: Summary table of the changes in the institutional variables

Pillar	Institutional variable	Description
Opportunity Perception	**Market Agglomeration**	In the case of original institutional variables such as *Population, Urbanization* and *Accessibility* we collected data for the latest available year or time period. We completed the pillar with new variables such as *Business Freedom* and *Property rights* institutional variables.
Startup Skills	**Quality of Education**	We used the latest (2012) *PISA* data. On the other hand, instead of *ESPON Creative Class* variable, we used *Creative Class* variable created by Clusterobservatory, because ESPON dataset does not offer these data for additional years.
Risk Acceptance	**Business Risk**	In the case of this institutional pillar we collected data for the latest available time period.
Networking	**Social Capital**	We used the same institutional variables (*Social Capital* and *Technological Readiness*), but we updated the data.
Cultural Support	**Open Society**	We used the same institutional variables (*Legatum Personal Freedom* and *QoG Corruption*), but we updated the data.
Opportunity Startup	**Business Environment**	We removed country-level *Business Freedom* from the opportunity startup pillar and move to opportunity pillar. We introduced *Taxation* as a new institutional variable of Business Environment institutional pillar. As another aspect of the quality of state/regulation we used *Quality of Governance* in this new version as well, but the variable was updated.
Technology Sector	**Absorptive Capacity**	We used the same institutional variables as in the original version of the REDI, but both *Firm-level Technology Absorption* and all four indicators of *Employment in Knowledge and High-Tech Sectors* variables were updated for the latest available time period.
Human Capital	**Education and Training**	*Higher Education, Training and Life Long Learning* related variables were updated for the latest available years/ time periods. On the other hand, the *Higher Education Attainment* and the Participation in Education and Training institutional variables just only partially captures labor market characteristics, so we complete the institutional pillar with a further institutional variable that measures *Labor Market* conditions.
Competition	**Business Strategy**	We used the same institutional variables were applied in the original version of the REDI, but data were updated for the latest years or time periods. On the other hand, instead of *New foreign firms* variable (Annoni – Kozovska, 2010), we had to use *Foreign control of enterprises* variable offered by the Eurostat, because the earlier used dataset does not offer the data for the additional years.
Product Innovation	**Technology Transfer**	We used the same five institutional variables were applied in the original version of the REDI, but data were updated for the latest years or time periods.

Process Innovation	**Technology Development**	On the one hand, originally used *GERD* data were updated for the latest time period. However GERD just only partially captures the different aspects of innovation. Therefore we completed the institutional pillar with a further variable which can express the role of knowledge institution in the creation process of knowledge.
High Growth	**Clustering**	We replaced the earlier used cluster institutional variable ("Cluster Mix" index, offered by DG Regio Individual Dataset), because (1) no data are available for the additional years, (2) other variables are available which capture and measure industrial specialization as well. We also assume that beside of the effects of clustering the Availability of VC is also important regarding high growth. Therefore, we completed this pillar with a further institutional variable capturing the availability of VC.
Globalization	**Connectivity**	Earlier used institutional variable, *Infrastructure sub-index* (offered by Annoni and Kozovska, 2010) was updated for the latest available data. On the other hand, Infrastructure sub-index as institutional variable just only partially captures the importance of globalization, so we complete this institutional pillar with a further institutional variable. This was *Economic Complexity* index.
Financing	**Financing institutions**	Both institutional variables – Depth of Capital Market and Concentration of Financial Services – were used in this new version of the REDI, however the data were updated for the latest year or time period.

Appendix F: Handling of skewness

The authors used the Box-Cox transformation in the cases the absolute value of skewness – a measure of the asymmetry of distribution – exceeds the absolute value 1. We apply this Box-Cox transformation method to improve the distribution of those indicators that are out of the [-1,1] range of skewness (Annoni – Kozovska, 2010, pp. 52-53), namely Accessibility, Pisa results, Creative class, Personal freedom, Business sophistication, GERD, Research and R&D employees, Cluster star rating* Cluster development, Infrastructure and Concentration of financial sector.

The skewness, the degree of the asymmetry of distribution is calculated as the following:

$$\kappa = \frac{n}{(n-1)(n-2)} \sum^{n} \frac{(x_i - \bar{x})^3}{s^3} \qquad \text{(F1)}$$

κ is the skewness, $^{i=1}$
n is the number observed values for the indicator,
x is the arithmetic mean
s is the standard deviation.

The Box-Cox transformations are a set of power transformations for skewed data, and depend on parameter λ.

$$\Phi_\lambda(x) = \frac{x^\lambda - 1}{\lambda} \quad \text{if } \lambda \neq 0 \qquad \text{(F2)}$$

$$\Phi_\lambda(x) = \log(x) \quad \text{if } \lambda = 0$$

Following Annoni and Kozovska (2010) we set

λ = 2	if	κ ≤ -1 (left or negative skewness)
λ = -0.05	if	κ ≥ +1 (right or positive skewness)

Appendix G: The characteristics of the penalty function

In the previous version of the PFB, we have used the natural logarithm penalty function (Acs et al., 2013). Tarabusi and Palazzi (2004) and Tarabusi and Guarini (2012) have also developed a family of penalization methodology. We can define the penalty as the difference between the original and the after penalty pillar values. Following Tarabusi and Palazzi (2004), Tarabusi and Guarini (2012) and Acs et al. (2011) we can define the required characteristics of the penalty functions. Most importantly, the penalty function should reflect to the magnitude of the penalty, lower difference implies lower penalty while higher unbalance implies higher penalty. The penalty function should also reflect to the compensation of the loss of one pillar for a gain in another pillar.

The Marginal Rate of Compensation (MRC) is defined as:

$$MRC_{i,j} = \frac{dy_i}{dy_j} \qquad \text{(G1)}$$

Full compensability means that a loss in one pillar can be compensated by the same increase in another pillar. However, this is not realistic. The MRC is the same concept as the Marginal Rate of Substitution for goods and to the Marginal Rate of Technical Substitution of inputs (Tarabusi and Guarini 2012), that are reflected to the law of diminishing return. Therefore, the effect of the change of the penalty should not be proportional reflecting to the increasing rate of (MRC). It means that we require higher compensation for the loss in one pillar if the difference between another pillar value and the particular pillar is higher as compared to the situation when the difference between the pillars is lower. The required positive value of the second derivative means that the pillars just only partially and not fully compensable with each other. So the penalty should increase in an increasing rate:

$$\frac{dMRC_{i,j}}{dy_j} > 0 \qquad \text{(G2)}$$

Tarabusi and Palazzi (2004) suggested a correction form of an exponential function of ae^{-bx}. In a recent article Tarabusi and Guarini (2012) used another adjustment function that refers to the deviation from the mean pillar value. For our purposes the mean adjustment is not really suitable so it is better to use the exponential form. Modifying Tarabusi and Palazzi (2004) original function for our purposes, we can define a penalty function family as

$$h_i = y_{min} - a(1 - e^{-b(y_i - y_{min})}) \qquad \text{(G3)}$$

where $h_{i,j}$ is the modified, post-penalty value of index component j in region i

$y_{i,j}$ is the normalized value of index component j in region i

y_{min} is the lowest value of $y_{i,j}$ for region i.

i = 1, 2, …, n = the number of regions

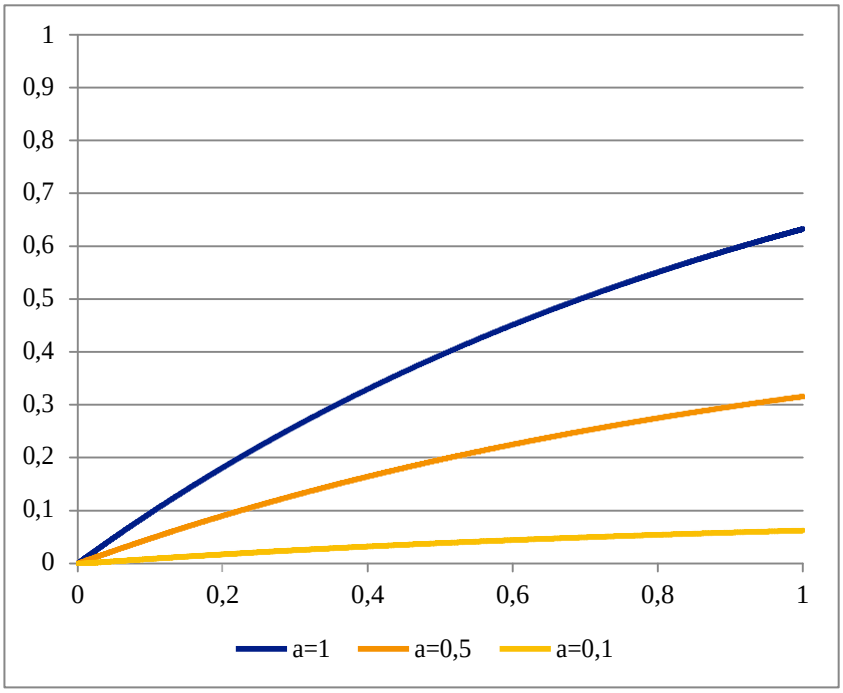
j= 1, 2, …, m= the number of index components

a, and b are parameters are calibrated to be between 0 and 1 to provide the penalty from 0 to 1.

$$0 \leq a, b \leq 1$$

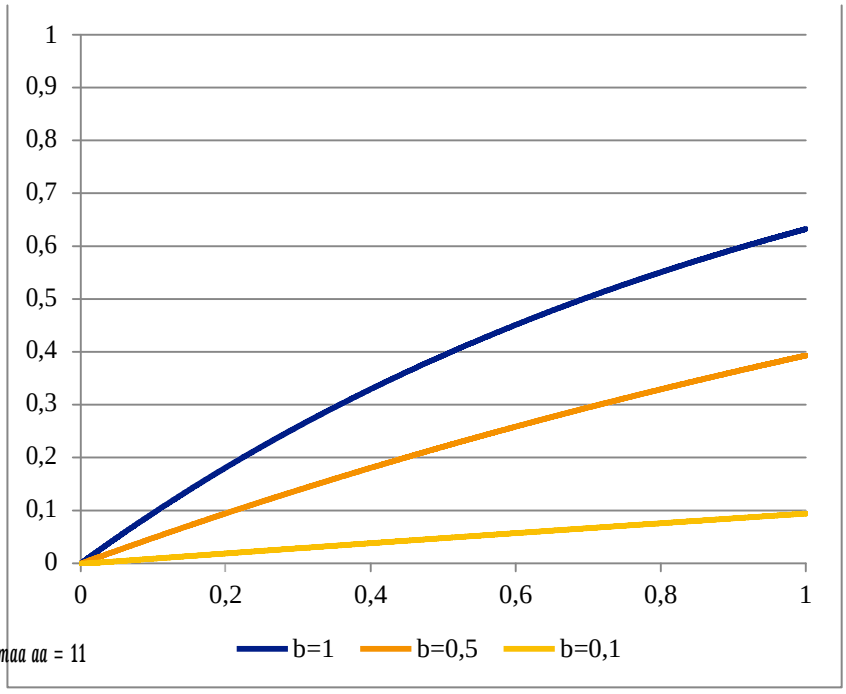
With the combination of the two parameters different kinds of penalty functions can be created. *Figure 16 and 17* show the effect of parameters "a" and "b".

Figure 16. The effect of changing parameter "a" in the penalty function



Note: yy_{mmmmmm} = 00 *aammaa bb* = 11

Figure 17. The effect of changing parameter "b" in the penalty function



Note: yy_{mmmmmm} = 00 *aammaa aa* = 11

When parameter a=1 then the penalty is minimal: After the penalty, the 0.2 original pillar value is going to be 0.18, so the penalty is 0.02. At higher pillar values the penalty is higher. If the original pillar value is 1, then the penalized pillar value is 0.63, so the maximum penalty is 0.37. The decrease of the parameter “a” has an effect of increasing penalty. For example, if parameter a=0.5 then the maximum penalty is 0.68, at a=0.1 the maximum penalty is 0.94. At a=0, the maximum penalty is 1. It means that the performance of the system is solely depending on the minimum pillar value. Since the minimum pillar value here is 0, all the other penalized pillar values are also restricted to be 0 from the system perspective.

Appendix H: The calculation of the REDI scores

1) Pillar values were capped at the 95 percent value. By the application of this technique we got a proper benchmarking for each of the pillars. In this case not a potential outlier serves as a reference, but at least the best six regions have the same maximum value.

2) Capped pillar values were normalized by using the distance method. While this method transforms variables to be in the [0,1] range, does not restrict the worse region to have a zero value as in the case of the min-max normalization.

$$x_{i,j} = \frac{z_{i,j}}{\max z_{i,j}} \qquad \text{(H1)}$$

for all j= 1, ..., m the number of pillars

where $x_{i,j}$ is the normalized score value for region i and pillar j

$z_{i,j}$ is the original pillar value for region i and pillar j

$\max_i z_{i,j}$ is the maximum value for pillar j

3) Original normalized pillar value averages range from 0.38 (Opportunity Perception and Financing) to 0.63 (Product Innovation). We believed that these values reflect to the difficulty to reach good performance; i.e. it is more difficult to attain good performance in Product Innovation as compared to Finance. For proper public policy application we equated the fourteen pillar averages to have the same marginal effect. While this technique does not handle the cost differences over size and countries it definitely reduces potential biases.

The arithmetic average of pillar j for number n regions is:

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{i,j}}{n} \text{ for all j} \qquad \text{(H2)}$$

We want to transform the $xx_{ii,jj}$ values such that the potential values to be in the [0,1] range.

$$yy_{ii,jj} = xx_{ii,jj}^{kk} \qquad \text{(H3)}$$

where k is the "strength of adjustment", the k-th moment of xx_{jj} is exactly the needed average, $\bar{y}_j$

We have to find the root of the following equation for k:

$$\sum_{ii=1}^{m} xx_{ii,jj}^{kk} - m\bar{y}_j = 0 \qquad \text{(H4)}$$

It is easy to see based on previous conditions and derivatives that the function is decreasing and convex which means it can be quickly solved using the well-known Newton-Raphson method with an initial guess of 0. After obtaining k, the computations are straightforward. Note that if

$$\bar{x}_j < \bar{y}_j \qquad kk < 1$$
$$\bar{x}_j = \bar{y}_j \qquad kk = 1$$
$$\bar{x}_j > \bar{y}_j \qquad kk > 1$$

that is k be thought of as the strength (and direction) of adjustment.

4) We have defined entrepreneurship as the dynamic interaction of entrepreneurial attitudes, abilities, and aspiration across different levels of development. One issue this definition raises is how to bring the system perspective of dynamic interaction into the model. Following the Theory of Weakest Link and the Theory of Constraints we developed the Penalty for Bottleneck method

to determine the optimum configuration. We hold that all the fourteen pillars constituting the system of entrepreneurship should be equal for optimalizing the use of the available resources. The performance of a particular region depends on its worst performing pillar, called the bottleneck. With respect to entrepreneurship, bottleneck means a shortage or the lowest level of a particular entrepreneurial pillar, relative to other pillars. This notion of a bottleneck is important for policy purposes. Our model suggests that pillars interact; if they are out of balance, entrepreneurship is inhibited. The pillar values should be adjusted in a way that takes into account this notion of balance. After normalizing the scores of all the pillars, and equalizing the averages of the pillars the value of each pillar of a region is penalized by linking it to the score of the pillar with the weakest performance in that region.

We defined our penalty function following as:

$$h_{(i),j} = \min y_{(i),j} + 1 - e^{-|y_{(i)j} - \min y_{(i),j}|} \quad \text{(H5)}$$

where $h_{i,j}$ is the modified, post-penalty value of pillar j in region i
$y_{i,j}$ is the normalized value of index component j in region i

y_{min} is the lowest value of $y_{i,j}$ for region i
i = 1, 2, …, n = the number of regions
j = 1, 2, …, m= the number of pillars

5) The pillars are the basic building blocks of the sub-index: entrepreneurial attitudes, entrepreneurial abilities, and entrepreneurial aspirations. The value of a sub-index for any country is the arithmetic average of its PFB-adjusted pillars for that sub-index multiplied by a 100. The maximum value of the sub-indices is 100 and the potential minimum is 0, both of which reflect the relative position of a country in a particular sub-index.

$$ATT_i = 100 \cdot \sum_{j=1}^{5} h_j \quad \text{(H6a)}$$

$$ABT_i = 100 \cdot \sum_{j=6}^{10} h_j \quad \text{(H6b)}$$

$$ASP_i = 100 \cdot \sum_{j=11}^{14} h_j \quad \text{(H6c)}$$

where $h_{i,j}$ is the modified, post-penalty value of pillar j in region i
i = 1, 2, …, n = the number of regions
j = 1, 2, …, 14= the number of pillars

The super-index, the Regional Entrepreneurship and Development Index, is simply the average of the three sub-indices.

$$REDI_i = \frac{1}{3}(ATT_i + ABT_i + ASP_i) \quad \text{(H7)}$$

where i = 1, 2, …, n = the number of regions

Appendix I: Robustness test for the five cluster categorization

It is important to see if the indicated development stages perform real differences at the lower levels of the REDI as well. One way analysis of variance was implemented to see if the groups of regions indeed show differences in the average value of the sub-indices, the original and the penalty weighted pillars.

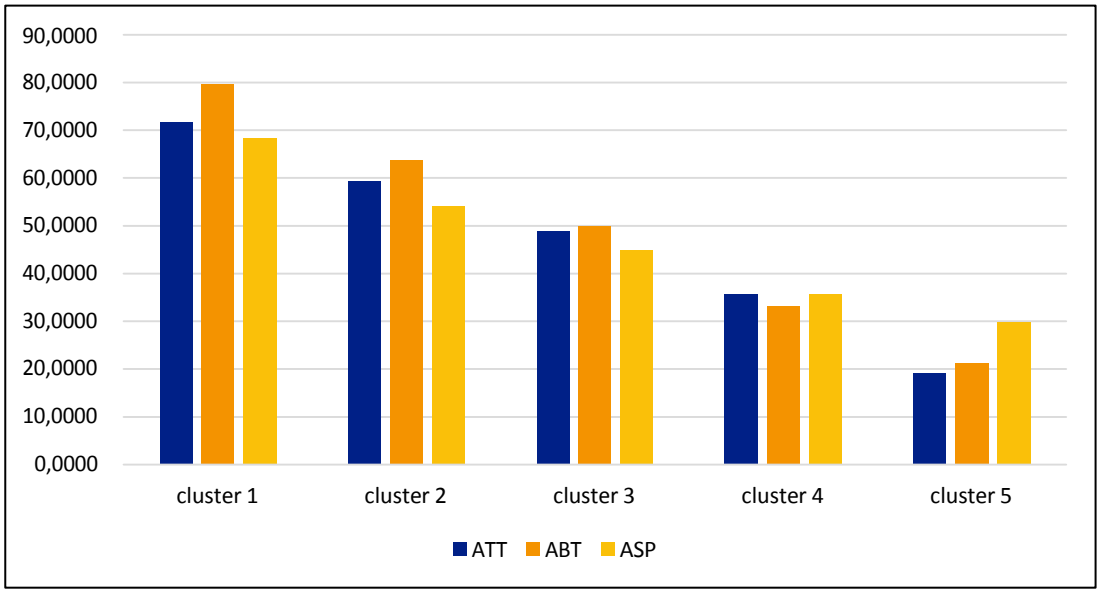
First let us see the results of the different groups from the point of view of the REDI 2017 sub-indices. The following table (*Table 25*) summarizes the ANOVA results.

Table 24. Results of ANOVA for the REDI 2017 sub-indices

Sub-indices	F	p-value	Deviation ratio
ATT	167.82	0.000	0.85
ABT	220.74	0.000	0.88
ASP	50.307	0.000	0.63

Each sub-index justifies the created clusters, as the means of the regions of the groups are significantly different in all three cases. (The Independent-Samples Kruskal-Wallis test presents the same conclusions.) The deviation ratio[14] indicates the strength of the relationship between the sub-index and the cluster membership. As its value is above 0.7 (ATT and ABT) or 0.3 (ASP), we can conclude that the clusters and the sub-indices are in respectively strong or moderate stochastic relationship.

Figure 18. The comparison of the mean of the REDI 2017 sub-indices by cluster membership



Tukey HSD post-hoc tests indicated that, apart from the ASP pillar values of the two clusters with the lowest REDI 2017 scores, there are significant differences (p-value is below 0.01 in every

[14] Deviation ratio = $\eta^2 = \frac{SSS_{BBBB}}{SSS_{TT}}$, where SS_{BG} is the sum of squares between the groups, and SS_T is the total sum of squares.

case) between every group pairwise. The mean values of the sub-indices are presented in *Figure 18* by the clusters.

Moving on with the analysis, we examine the situation of the penalty adjusted pillars. The results of the one-way analysis of variance seem to support our classification (*Table 26*).

Table 25. Results of ANOVA for the penalty adjusted REDI 2017 pillar values

Penalty adjusted pillars	F	p-value	Deviation ratio
Opportunity Perception	72.52	0.000	0.71
Startup Skills	23.54	0.000	0.44
Risk Acceptance	24.59	0.000	0.45
Networking	66.97	0.000	0.69
Cultural Support	73.30	0.000	0.71
Opportunity Startup	79.63	0.000	0.73
Technology Adoption	89.02	0.000	0.75
Human Capital	56.23	0.000	0.65
Competition	84.32	0.000	0.74
Product Innovation	14.90	0.000	0.33
Process Innovation	21.81	0.000	0.42
High Growth	16.73	0.000	0.36
Globalization	11.20	0.000	0.27
Financing	13.95	0.000	0.32

According to the p-values (p = 0.000), the mean pillar values are different among the five groups. (The Independent-Samples Kruskal-Wallis test presents the same conclusions.) The strength of the stochastic relationships between the pillars and the cluster membership are still strong in a few cases. However, it is usually moderate (between 0.3–0.7) and for the Globalization pillar the relationship is weak (below 0.3). Pairwise comparison was carried out to see the underlying structure of the different pillars. *Table 27* summarizes the p-values of the Tukey HSD post-hoc tests.

Table 26. Significance values of the Tukey HSD post hoc tests of the REDI 2017 penalty adjusted pillars

Penalty adjusted pillars	1-2	1-3	1-4	1-5	2-3	2-4	2-5	3-4	3-5	4-5
Opportunity Perception	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Startup Skills	0.003	0.001	0.000	0.000	0.364	0.017	0.000	0.683	0.000	0.000
Risk Acceptance	0.192	0.015	0.000	0.000	0.573	0.000	0.000	0.000	0.000	0.077
Networking	0.206	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Cultural Support	0.643	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Opportunity Startup	0.429	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Technology Adoption	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Human Capital	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
Competition	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018
Product Innovation	0.345	0.004	0.000	0.000	0.070	0.000	0.000	0.361	0.003	0.230
Process Innovation	0.064	0.001	0.000	0.000	0.316	0.000	0.000	0.022	0.000	0.600
High Growth	0.031	0.000	0.000	0.000	0.025	0.000	0.000	0.137	0.292	1.000
Globalization	0.484	0.089	0.000	0.000	0.669	0.000	0.000	0.015	0.010	0.987
Financing	0.158	0.001	0.000	0.000	0.097	0.002	0.000	0.667	0.008	0.154

Most of the cases, the p-values in *Table 27* are significant. However, for nine pillars, the difference is not significant for all neighboring groups (marked in red). Based on the post hoc test results, *Risk Acceptance*, *Product* and *Process Innovations*, *High Growth*, *Globalization* and *Financing* are the less heterogeneous pillars. Those pillars are similar for some of the different developmental stages, i.e. clusters. Apart from *Startup Skills* those pillars belong to the ASP sub-index.

Following, we examine the original pillar values (*Table 28*).

Table 27. Results of ANOVA for the REDI 2017 original pillar values

Original pillars	F	p-value	Deviation ratio
Opportunity Perception	33.90	0.000	0.53
Startup Skills	16.59	0.000	0.36
Risk Acceptance	15.34	0.000	0.34
Networking	37.29	0.000	0.55
Cultural Support	46.89	0.000	0.61
Opportunity Startup	47.40	0.000	0.61
Technology Adoption	61.29	0.000	0.67
Human Capital	21.12	0.000	0.41
Competition	52.77	0.000	0.64
Product Innovation	6.21	0.000	0.17
Process Innovation	11.11	0.000	0.27
High Growth	8.72	0.001	0.23
Globalization	6.33	0.001	0.17
Financing	7.86	0.000	0.21

Table 28. Significance values of the Turkey HSD post-hoc tests of the REDI 2017 original pillar values

Original pillars	1-2	1-3	1-4	1-5	2-3	2-4	2-5	3-4	3-5	4-5
Opportunity Perception	0.036	0.000	0.000	0.000	0.004	0.000	0.000	0.002	0.000	0.269
Startup Skills	0.113	0.023	0.002	0.000	0.907	0.313	0.000	0.828	0.000	0.000
Risk Acceptance	0.719	0.328	0.000	0.000	0.885	0.000	0.000	0.004	0.000	0.208
Networking	0.590	0.009	0.000	0.000	0.040	0.000	0.000	0.000	0.000	0.008
Cultural Support	0.983	0.028	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Opportunity Startup	0.966	0.028	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.001
Technology Adoption	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.049
Human Capital	0.046	0.000	0.000	0.000	0.007	0.000	0.000	0.427	0.004	0.196
Competition	0.175	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.084
Product Innovation	0.959	0.229	0.074	0.004	0.225	0.033	0.000	0.936	0.133	0.426
Process Innovation	0.522	0.091	0.001	0.000	0.619	0.004	0.000	0.170	0.001	0.256
High Growth	0.078	0.001	0.000	0.000	0.163	0.003	0.059	0.614	0.971	0.964
Globalization	0.807	0.523	0.009	0.012	0.961	0.007	0.015	0.042	0.069	1.000
Financing	0.603	0.026	0.003	0.000	0.141	0.009	0.000	0.856	0.220	0.713

The p-values are below 0.01 in every case, reinforcing the proper selection of such categorization (*Table 28*). (The Independent-Samples Kruskal-Wallis test presents the same conclusions.) However, the strength of the relationships is not so convincing. All the other pillars show medium-strong, moderate or weak relationship. Pairwise comparison is necessary again to see the significance of the differences between the four clusters. *Table 29* summarizes the p-values of the Tukey HSD post-hoc

tests. The red cells include those p-values that are above 0.05. Similarly to the earlier results, the pillars of the ASP sub-index are the most homogeneous.

In general, the original pillars justify the results of the cluster analysis. In addition, the five different groups (development stages) represent significantly different mean values at the level of the sub-indices and of most of the penalty weighted pillars.

The level of the performance of the regions seems to be captured correctly by the penalized pillars and the sub-indices. These facts underline the results of the REDI index calculation methodology.

Appendix J: The examination of the Institutional REDI 2017 and the REDI 28 index versions

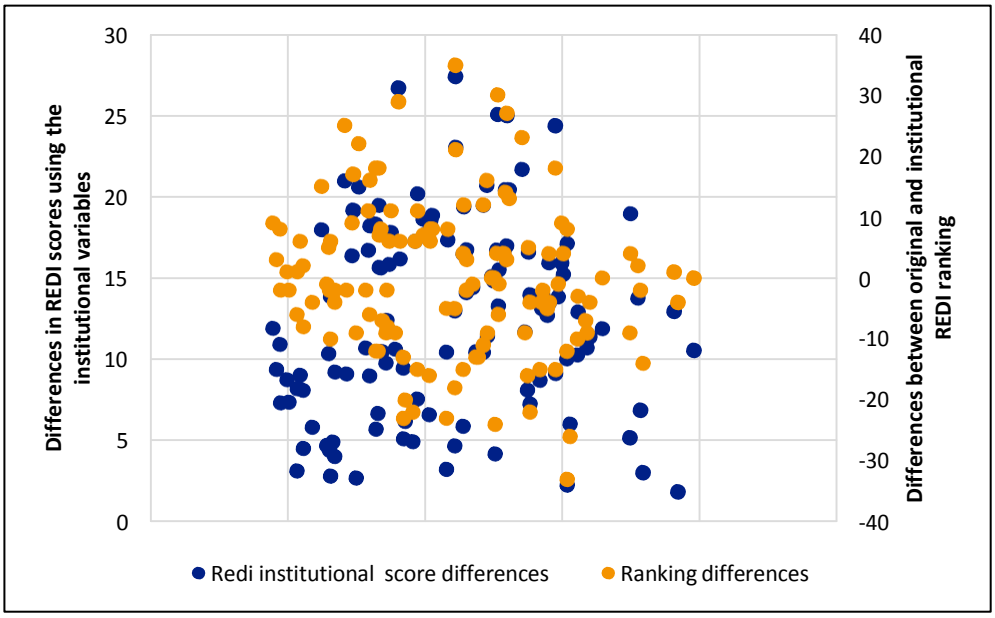
If we compare the descriptive statistics of the original REDI 2017 and institutional REDI 2017 scores, we can see that the institutional scores are higher than the original ones, but the ranges and the interquartile ranges are similar (*Table 30*).

Table 29. Descriptive statistics of REDI 2017 and Institutional REDI 2017

	REDI scores	Institutional REDI scores
Average	43.54	56.4
Median	44.07	58.9
Minimum	17.72	20.62
Maximum	78.29	93.65
Range	60.57	73.03
Interquartile range	22.90	26.88

The average difference between the original and institutional scores was 12.63 points, the minimum difference was 1.81 and the maximum difference was 27.43. As we have already shown by the descriptive statistics, the institutional REDI scores are higher than the original ones meaning that all of the regions got higher scores than in the original case. The correlation between the score and the ranking differences is high and significant (correlation value: 0.85, p=0.000). In general, the magnitude of variations between the institutional and the original REDI 2017 values is much smaller than the variations between the individual and original REDI 2017 values. *Figure 19* demonstrates that the changes in ranking are more important than the changes in scores. It also shows that regions with high and low REDI points react about the same to the removal of individual variables.

Figure 19. The differences between original and the institutional REDI 2017 scores and ranking



The differences in the ranking are the lowest if we compare REDI with the 28 variable REDI versions. The maximum gain was in the case of the West Midlands (UK). This territory improved by 15 places.

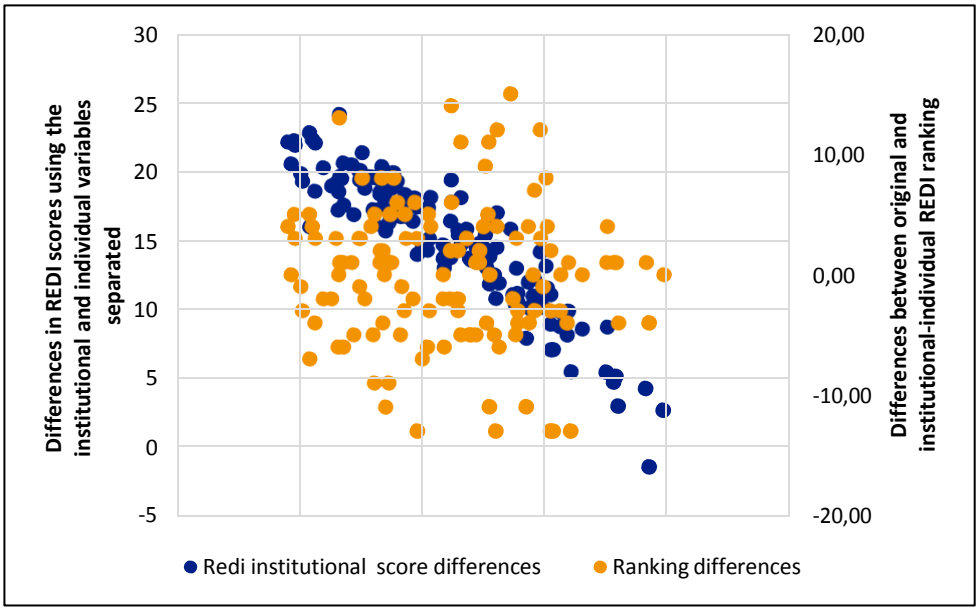
At the same time two Belgian, one Danish, one Irish region and Czech Republic dropped 13 places. We can see on *Table 31* that if we use the individual and institutional variables separately to compute the REDI 2017 scores, the average and median values of the new scores are considerably higher. The interquartile range declined. That means that the medium 50% of scores are in a narrower range than in the original case.

Table 30. Descriptive statistics of REDI 2017 and "28 variables" REDI 2017

	REDI scores	28 variables REDI scores
Average	43.54	58.66
Median	44.07	59.18
Minimum	17.72	37.32
Maximum	78.29	81.80
Range	60.57	44.49
Interquartile range	22.90	16.54

If we check the differences between the original and the 28 variables REDI in scores and ranking, we can see that all of the 28 variables REDI scores are higher than in the original case. It can be seen on *Figure 20* that the minimum value of score difference is -1.51 and it diminishes as the REDI 2017 value increases.

Figure 20. The differences between original and the 28 variables REDI 2017 scores and ranking



The REDI points and the ranking of all the 125 regions with all four versions can be found in *Table 29*.

Table 31. The scores and the ranking of the countries with the four different REDI 2017 versions

Code	Region	REDI scores	REDI Rank	REDI 28 score	REDI 28 Rank	REDI Individual Score	REDI Individual Rank	REDI Institutional Score	REDI Institutional Rank
AT1	Ostösterreich	56.9	28	68.96	24	67.80	26	70.11	32
AT2	Südösterreich	47.6	52	61.26	57	64.42	44	58.09	65
AT3	Westösterreich	49.0	48	63.84	46	67.17	29	60.50	57
BE1	Région de Bruxelles-Capitale	63.2	11	69.46	23	63.55	56	75.36	14
BE2	Vlaams Gewest	51.3	39	62.49	52	52.82	103	72.15	25
BE3	Région wallonne	50.3	44	62.47	53	60.99	66	63.95	48
CZ	Czech Republic	38.8	73	52.84	86	59.22	76	46.45	88
DE1	Baden-Württemberg	62.0	14	70.90	17	69.34	15	72.46	24
DE2	Bayern	60.6	16	69.57	21	68.45	20	70.69	30
DE3	Berlin	62.4	12	71.49	16	68.26	23	74.72	19
DE4	Brandenburg	35.1	81	52.84	85	42.84	125	62.85	51
DE5	Bremen	57.1	27	67.25	31	63.40	58	71.10	29
DE6	Hamburg	69.5	8	75.25	7	75.51	1	75.00	17
DE7	Hessen	58.9	21	69.54	22	65.83	38	73.25	22
DE8	Mecklenburg-Vorpommern	40.2	70	58.06	64	57.40	82	58.73	63
DE9	Niedersachsen	50.3	45	64.13	43	63.47	57	64.78	47
DEA	Nordrhein-Westfalen	54.8	33	66.45	33	63.62	54	69.28	34
DEB	Rheinland-Pfalz	44.6	60	62.24	54	56.98	88	67.50	39
DEC	Saarland	56.7	29	64.62	40	63.81	52	65.43	44
DED	Sachsen	50.5	41	64.58	41	62.90	59	66.25	42
DEE	Sachsen-Anhalt	38.2	74	56.59	68	57.40	81	55.78	68
DEF	Schleswig-Holstein	49.8	47	65.41	37	66.01	36	64.81	46
DEG	Thüringen	41.1	67	55.96	71	52.55	105	59.36	60
DK01	Hovedstaden	76.6	2	75.36	6	72.04	7	78.68	6
DK02	Sjalland	48.4	50	61.87	55	55.82	91	67.92	38
DK03	Syddanmark	61.6	15	68.17	28	69.20	17	67.14	41
DK04	Midtjylland	58.2	24	68.54	27	65.54	40	71.54	28
DK05	Nordjylland	56.5	30	65.58	36	64.96	42	66.20	43
EE	Estonia	45.3	59	59.80	62	68.19	24	51.41	74
EL1	Voreia Ellada	22.0	116	40.77	120	51.25	110	30.30	114
EL2	Kentriki Ellada	20.0	120	39.42	123	51.34	109	27.50	122
EL3	Attiki	28.3	103	45.37	108	53.11	100	37.63	105
EL4	Nisia Aigaiou. Kriti	21.3	119	37.32	125	45.09	123	29.54	117
ES11	Galicia	29.5	100	49.66	97	50.57	113	48.74	83
ES12	Principado de Asturias	30.3	98	49.09	100	47.27	122	50.90	76
ES13	Cantabria	32.7	92	51.13	92	51.15	111	51.11	75
ES21	País Vasco	38.8	72	56.30	69	53.52	99	59.07	61
ES22	Comunidad Foral de Navarra	36.2	79	53.93	80	55.36	95	52.51	73
ES23	La Rioja	28.2	104	48.71	103	48.21	121	49.21	79
ES24	Aragón	31.9	95	51.52	89	52.87	102	50.17	78
ES30	Comunidad de Madrid	51.1	40	63.97	45	59.81	73	68.14	36
ES41	Castilla y León	34.6	83	53.53	82	56.50	90	50.56	77
ES42	Castilla-la Mancha	24.7	113	43.84	115	44.78	124	42.89	98
ES43	Extremadura	26.1	108	45.83	107	51.58	108	40.09	102
ES51	Cataluna	40.9	68	59.18	63	58.45	78	59.92	59
ES52	Comunidad Valenciana	34.9	82	54.94	74	57.04	85	52.83	71
ES53	Illes Balears	34.3	85	53.27	84	59.70	74	46.84	87
ES61	Andalucía	33.2	90	52.80	87	56.61	89	48.98	82
ES62	Región de Murcia	29.3	101	48.85	102	49.06	119	48.64	84
ES70	Canarias (ES)	29.2	102	49.38	99	53.03	101	45.72	93
FI19	Länsi-Suomi	48.9	49	63.37	48	57.03	86	69.70	33

FI1B	Helsinki-Uusimaa	70.0	6	75.70	5	66.62	34	84.78	4
FI1C	Etelä-Suomi	52.4	36	64.16	42	55.61	93	72.70	23
FI1D	Pohjois- ja Ita-Suomi	43.2	64	56.26	70	51.90	107	60.61	56
FR1	Île de France	70.8	5	76.48	4	74.73	2	78.23	7
FR2	Bassin Parisien	44.1	63	60.72	60	64.14	48	57.31	67
FR3	Nord - Pas-de-Calais	46.4	54	62.76	51	64.16	46	61.35	55
FR4	Est (FR)	45.5	56	60.69	61	61.26	65	60.11	58
FR5	Ouest (FR)	46.6	53	61.12	58	64.36	45	57.88	66
FR6	Sud-Ouest (FR)	37.6	75	54.58	77	66.00	37	43.15	97
FR7	Centre-Est (FR)	58.5	23	69.98	19	71.82	9	68.13	37
FR8	Méditerranée	45.4	58	64.12	44	65.46	41	62.77	52
HR03	Jadranska Hrvatska	23.5	114	43.82	116	58.24	80	29.40	118
HR04	Kontinentalna Hrvatska	25.6	112	44.79	109	59.23	75	30.35	113
HU10	Közép-Magyarország	31.1	97	50.93	93	59.83	72	42.02	99
HU21	Közép-Dunántúl	18.8	123	41.04	118	52.34	106	29.75	115
HU22	Nyugat-Dunántúl	21.7	117	44.11	113	57.40	83	30.83	111
HU23	Dél-Dunántúl	19.8	121	39.70	122	50.77	112	28.62	120
HU31	Észak-Magyarország	18.9	122	40.82	119	55.38	94	26.27	124
HU32	Észak-Alföld	18.2	124	38.85	124	50.01	116	27.68	121
HU33	Dél-Alföld	17.7	125	39.94	121	50.15	114	29.72	116
IE01	Border. Midland and Western	60.4	18	67.73	30	72.50	6	62.95	50
IE02	Southern and Eastern	71.3	4	74.69	8	74.61	3	74.77	18
ITC	Nord-Ovest	33.5	89	50.66	94	48.59	120	52.73	72
ITF	Sud	25.7	111	43.12	117	49.94	117	36.30	106
ITG	Isole	26.7	106	44.43	111	52.76	104	36.11	107
ITH	Nord-Est	32.6	94	48.93	101	49.45	118	48.41	85
ITI	Centro (IT)	33.5	88	51.73	88	54.33	98	49.13	80
LT	Lithuania	32.8	91	53.46	83	67.15	30	39.77	103
LV	Latvia	36.7	77	55.19	72	68.40	21	41.98	100
NL1	Noord-Nederland	55.3	31	65.79	35	69.03	18	62.55	53
NL2	Oost-Nederland	51.8	37	66.37	34	63.87	51	68.87	35
NL3	West-Nederland	63.5	10	73.47	10	72.64	5	74.30	20
NL4	Zuid-Nederland	57.6	26	68.74	26	66.99	32	70.49	31
PL1	Region Centralny	43.0	66	56.82	67	60.07	71	53.57	70
PL2	Region Poludniowy	40.5	69	54.84	76	62.52	61	47.17	86
PL3	Region Wschodni	31.8	96	48.05	104	55.22	96	40.87	101
PL4	Region Pólnocno-Zachodni	34.2	86	50.54	95	57.03	87	44.05	95
PL5	Region Poludniowo-Zachodni	36.7	78	53.53	81	60.81	68	46.25	91
PL6	Region Pólnocny	33.7	87	49.39	98	54.57	97	44.21	94
PT11	Norte	34.3	84	54.13	79	62.14	63	46.12	92
PT15	Algarve	35.4	80	54.92	75	63.57	55	46.26	90
PT16	Centro (PT)	32.7	93	51.35	90	64.14	47	38.56	104
PT17	Lisboa	48.1	51	63.03	50	67.19	28	58.88	62
PT18	Alentejo	37.1	76	55.10	73	66.93	33	43.26	96
RO1	Macroregiunea unu	26.1	109	50.32	96	71.61	11	29.02	119
RO2	Macroregiunea doi	21.4	118	44.10	114	63.76	53	24.43	125
RO3	Macroregiunea trei	29.9	99	51.27	91	69.91	14	32.63	108
RO4	Macroregiunea patru	22.3	115	44.30	112	61.83	64	26.78	123
SE11	Stockholm	78.3	1	81.80	1	73.89	4	89.72	1
SE12	Östra Mellansverige	59.9	19	71.67	15	67.99	25	75.35	15
SE21	Smaland med öarna	45.6	55	61.01	59	57.04	84	64.98	45
SE22	Sydsverige	65.8	9	74.37	9	71.04	12	77.70	9
SE23	Vastsverige	59.8	20	73.01	12	70.22	13	75.81	11
SE31	Norra Mellansverige	45.5	57	61.28	56	60.54	70	62.02	54
SE32	Mellersta Norrland	39.9	71	54.20	78	50.06	115	58.34	64
SE33	Övre Norrland	54.8	34	65.23	38	67.44	27	63.02	49
SI01	Vzhodna Slovenija	43.0	65	57.80	66	69.24	16	46.36	89
SI02	Zahodna Slovenija	50.0	46	63.19	49	71.99	8	54.38	69
SK01	Bratislavský kraj	44.2	62	58.04	65	67.08	31	48.99	81
SK02	Západné Slovensko	26.7	105	47.42	105	64.00	50	30.85	110

SK03	Stredné Slovensko	26.5	107	46.01	106	60.57	69	31.45	109
SK04	Východné Slovensko	26.0	110	44.58	110	58.68	77	30.47	112
UKC	North East (UK)	44.3	61	63.79	47	55.73	92	71.85	26
UKD	North West (UK)	50.4	43	67.03	32	58.43	79	75.63	13
UKE	Yorkshire and The Humber	51.8	38	68.94	25	60.97	67	76.91	10
UKF	East Midlands (UK)	57.9	25	70.20	18	66.45	35	73.96	21
UKG	West Midlands (UK)	54.0	35	69.92	20	64.05	49	75.79	12
UKH	East of England	58.7	22	73.11	11	62.86	60	83.36	5
UKI	London	75.5	3	80.51	2	71.77	10	89.24	2
UKJ	South East (UK)	69.6	7	78.63	3	68.37	22	88.88	3
UKK	South West (UK)	62.3	13	72.10	13	68.99	19	75.22	16
UKL	Wales	50.4	42	64.69	39	62.25	62	67.14	40
UKM	Scotland	60.5	17	71.76	14	65.71	39	77.81	8
UKN	Northern Ireland (UK)	55.0	32	68.05	29	64.43	43	71.67	27