Cross-sectional analysis of REDI and regional growth performance measures

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Document Identifier

D4.5 Cross-sectional analysis of REDI and regional growth performance measures

Version

1.0

Date Due

M30

Submission date

20-10-2017

WorkPackage

4

Lead Beneficiary

UU

Grant Agreement Number 649378

Change log

Version[1]	Date	Amended by	Changes
1.0	15-10-2017	László Szerb	Full Manuscript
1.1	17-10-2017	Erik Stam	Adding Executive Summary
1.2	18-10-2017	Mark Sanders	Compiling Report and Text Edits
1.3	20-10-2017	Mike Robinson	Cross check references and tables, add list of tables, figures, abbreviations and table of contents
2.0	20-11-2017	Mark Sanders	Addressing comments by reviewers. Also see response letter.
2.1	29-11-2017	Erik Stam	Final editing

Partners involved

Number	Partner name	People involved
1.0	UP	Balázs Páger, László Szerb
2.0	UU	Mark Sanders, Erik Stam

[1]Please start with version 0.1. All minor changes will lead to a new number (0.2, 0.3, 0.4 etc.). The first complete draft will get the number 1.0. Again all minor revisions will lead to a new decimal number (1.1, 1.2, 1.3 etc.). A major revision will become 2.0 etc. etc. Until there is a final version which will be called 'final'.

1. Executive summary

This paper seeks to put entrepreneurial ecosystems at the very centre of the processes of regional economic development. To do so, we develop the Regional Entrepreneurship and Development Index (REDI) to capture the quality of entrepreneurial ecosystems in European regions. This index captures the systemic nature of the context of entrepreneurship, and further develops the entrepreneurial ecosystem approach to economic development. We differentiate between different types of entrepreneurship, connecting these types to a distinction between overall (largely replicative), and Schumpeterian / innovative entrepreneurship. These types of entrepreneurship are both outputs of the entrepreneurial ecosystem and drivers of economic development. The entrepreneurial ecosystem provides the enabling context for entrepreneurship to take place, but entrepreneurs have to take actions in order to realize opportunities for new value creation. Overall entrepreneurship, proxied by the ratio of number of new entrants relative to the number of incumbent businesses, indicates the intensity of competition in a region. The Schumpeterian type of entrepreneurship, proxied by the ratio of innovativeness of entrants compared to that of incumbent firms, captures the process of creative destruction, and thus structural change of the economy.

In this report, we test for the direct effect of the quality of the entrepreneurial ecosystem on regional growth, and the direct effects of the prevalence of overall and Schumpeterian entrepreneurship. Our main hypothesis is that the entrepreneurial ecosystem enhances the productive effects of entrepreneurship, which we test with moderating effects of the quality of entrepreneurial ecosystems on the relation between the two types of entrepreneurship and regional economic performance. We measure regional economic performance in terms of gross value added per worker and employment growth.

By analysing 121 European Union regions between 2012 and 2014, we find that an enhanced entrepreneurial ecosystem yields superior regional economic performance. The results also reveal heterogeneous effects for the different types of entrepreneurship on regional performance: overall entrepreneurship is negatively related to regional performance (gross value added per worker), while Schumpeterian entrepreneurship is positively related to regional performance (employment growth). Schumpeterian entrepreneurship seems to have a destructive effect on employment growth in low quality entrepreneurial ecosystems. Nevertheless, it has productive effects in regions with low quality entrepreneurial ecosystems, in terms of gross value added per worker.

Overall, the quality of the entrepreneurial ecosystem and the prevalence of Schumpeterian entrepreneurship are positively related to regional economic growth in European regions. We provide a more fine grained picture of entrepreneurship regimes (based on indicators of the quality of entrepreneurial ecosystems and the prevalence of overall and Schumpeterian entrepreneurship) in European regions to improve insight into the nature of the context of entrepreneurship and economic growth.

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List of Abbreviations

GEM	Global Entrepreneurship Monitor
TEA	Total Early Stage Entrepreneurial Activity
EE	Entrepreneurial Ecosystem
GEI	Global Entrepreneurship Index
REDI	Regional Entrepreneurship and Development Index
GVA	Gross Value Added
GDP	Gross Domestic Product
EU	European Union
APA	Average Pillar Adjustment
FIRES	Financial and Institutional Reforms for the Entrepreneurial Society
VIF	Variance Inflation Factor

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2. Introduction

While entrepreneurship has long been believed to be a major determinant of economic outcomes, even the latest empirical studies provide mixed and unconvincing evidence on the relationship between various entrepreneurship and various economic performance metrics (Acs et al., 2017a; Acs and Varga, 2005; Nightingale and Coad, 2014, Bjørnskov and Foss, 2016). Moreover, in the literature results vary according to the selection of the performance measure chosen (e.g. growth, development, prosperity, productivity), the definition and proxies for entrepreneurship (single level/multidimensional, quality/quantity), the analysed geographic unit (country, macro-regional, micro-regional, city level), and the empirical modelling strategy.

A consistent finding in many studies is that both entrepreneurship, measured by activity, and the effect of entrepreneurship on performance, vary over level of economic development (Acs, 2006). Entrepreneurship is found to positively and significantly influence economic performance in developed countries; while no such clear relation exists in less developed countries (Van Stel et al., 2005).

Also, not all types of entrepreneurship are equally important (Grilo and Thurik, 2008; Stam, 2008). A wide range of measures like self-employment rates or the Global Entrepreneurship Monitor's (GEM) TEA (total early-stage entrepreneurial activity) are found to only moderately influence economic growth while innovation-related or high growth start-ups show a much stronger impact on economic growth (Wong et al., 2005; Stam et al., 2011; Stam & Van Stel, 2011). Acs et al. (2009) and Braunerhjelm et al. (2010) identify knowledge spillovers as the key mechanism that links entrepreneurship to growth. Minniti and Lévesque (2010) propose a model where indeed research-based, Schumpeterian entrepreneurship spurs growth in developed countries, while imitative entrepreneurship is more important in less developed countries. Audretsch et al. (2017) provide empirical evidence based on trade statistics that indeed high income countries specialized in early stage activities perform better while emerging economies benefit from capturing market share in mature markets. Still, evidence at the country level remains far from convincing. To paraphrase the late William Baumol (1968): It would seem that the Prince of Denmark is no longer expunged from Hamlet, but rather remains in hiding in the wings, shy to make his appearance.

Scholars have therefore proposed that national level research is not appropriate and the spillover effects of entrepreneurship can be more effectively captured at sub-national levels (Acs and Armington, 2004; Feldman, 2001). Besides, many studies have claimed that intermediate linkages (Carree and Thurik 2006; Wennekers and Thurik 1999), or contextual factors (Welter, 2011; Zahra et al., 2014) play an important role in the transmission mechanism. Yet, empirical evidence on the effect of entrepreneurship on economic growth at regional level also remains elusive (Müller, 2016).

Recent research on entrepreneurial ecosystems (EE) portrays entrepreneurship as the combination of the above-mentioned perspectives: the emergence of productive entrepreneurship is the result of interconnected actors and factors within a focal territory (Acs et al., 2014, Acs et al., 2017b, Bruns et al., 2017). Additionally, the EE approach differentiates between environmental, ecosystem elements and outcome measures. Local development then depends on how the EE supports the rise of high growth firms (Alvedalen and Boschma, 2017; Mason and Brown, 2014; Stam, 2015).

In this context, the Global Entrepreneurship Index (GEI) has emerged as a useful measure of the ability of the EE to support productive entrepreneurship (Acs et al., 2017a). It conceptualizes the entrepreneurial ecosystem as the complex interactions between entrepreneurial attitudes, abilities and aspirations (Acs et al., 2014, Szerb et al. 2017). Within the framework of the knowledge spillover theory, Lafuente et al. (2016) found that GEI is an important driver of national economic growth. Results are less convincing when GEI is applied in the traditional production function framework where GEI is proven to be important only for developing countries (Acs et al., 2017a).

Empirical papers mostly investigated the connection between entrepreneurship and performance at the country level. The scarcer regional studies are often limited to single countries, thus ignoring potential regional research across countries. Our paper attempts to shed light on the determinants of regional economic growth by connecting the entrepreneurial ecosystem to entrepreneurial activity in 121 European Union regions. More concretely, we study the function of the entrepreneurial ecosystem in two entrepreneurship ratios, which we refer to as overall and Schumpeterian entrepreneurship, that affect employment growth and GVA per worker.

3. Entrepreneurial ecosystem and the Regional Entrepreneurship and Development Index (REDI)

It has been widely acknowledged that not all types of entrepreneurship—in fact only a fraction of start-ups—are good for national prosperity and that the institutional context regulates the quality of entrepreneurial ventures (Baumol, 1996; Boettke and Coyne, 2009). In this sense, EE scholars opened a new entrepreneurship research direction by examining the systemic preconditions promoting the emergence of high impact ventures. Initially, EE research targeted practitioners, local policy makers and stakeholders and not the academic audience (Feld, 2012; Foster et al., 2013). The need for more rigorous research, theory-based concept creation, solid methodology development and proper measurement of key concepts have recently emerged (Alvedalen and Boschma, 2017; Spigel, 2017; Stam, 2015).

There are three distinctive features of EE research. First, while most conceptual approaches view the entrepreneurial environment as a bundle of different components, EE adopts a multi-context perspective by highlighting the interdependencies among the components. Second, EE clearly differentiates the entrepreneurial environment (ecosystem) and the entrepreneurial in- and outputs. Out of different types of entrepreneurial outputs the EE focuses on those opportunity recognition activities that result in high impact ventures[2] and neglects potentially marginal, non-growth, self-employment types of initiations. Finally, the performance of the EE depends on the interaction between the entrepreneur, the organisations and the institutions (Alvedalen and Boschma, 2017), where the entrepreneur is the most important agent potentially playing multiple roles in the ecosystem—as leader, mentor, and investor—next to creating and growing ventures.

[2] These ventures can be independent or employee initiated, intrapreneurial (Stam and Spigel, 2018).

The problem in EE research to date, however, is the challenge to find good empirical proxies for the essential attributes and characteristics of the EE. Among the many proposed alternatives, the GEI is probably among the most useful approaches, building on a sound theoretical base and introducing a novel index-building methodology that can measure the quality of the EE at the country and regional level (Acs et al., 2014; Acs and Szerb, 2009). In this report, following the FIRES-project approach, we propose to use the adjusted REDI-index to proxy for the quality of the entrepreneurial ecosystem in 121 EU regions. The REDI ultimately seeks to capture the ability of the regional entrepreneurial ecosystem to support regional development (Szerb et al., 2017).

The REDI index incorporates three sub-indices, 14 different pillars, 28 variables (14 institutional and 14 individual), 44 indicators and 60 sub-indicators.[3] A valid criticism of many EE models is that component collection is rather ad-hoc. For creating REDI, the sub-indicator selection was based on 1) a thorough review of theoretical and empirical literature to find sub-indicators that connect best to the entrepreneurial phenomenon, 2) the potential of sub-indicators to assign clear benchmarks to evaluate performance, 3) the established link to economic development, and 4) the availability of data over the period 2007-2014. A drawback of the REDI sub-indicators is that some potentially important EE attributes are missing. While the market, the regulatory, the human capital and education, the cultural, the network, the knowledge creation and dissemination, the infrastructure and the finance dimensions are mostly captured, there is no indicator on the supporting services and mentoring and the leadership dimensions. Moreover, the effect of universities is only partially incorporated in the educational variables. The structure of the REDI index and the assigned EE attributes are depicted in Table 1.

While EE scholars have primarily focused on the interrelation between system components, the identification and description of the nature of these connections have been largely side-lined. Ignoring for the moment more complex and sophisticated ways of linking the ecosystem components together, the REDI index uses two distinct ways to capture the essence of ecosystem component interactions. System components can have an additive(weighted) —the effect of the individual components depends on their weight—or a multiplicative—that is, a combined, interrelated impact on the system performance—influence on the overall system performance. The additive and multiplicative connections of the elements vary at different levels of the REDI. Indicator and variable calculations are case-dependent. Most indicators are calculated as the average of sub-indicators and most variables are calculated as the average of the indicators assuming *additive* effects.[4] A notable exception is the computation of the Freedom indicator that is the result of the multiplication of the Business freedom and the Property rights sub-indices. Each pillar is then created as the product of an individual-level and an institutional level variable implying a joint, *multiplicative* effect.

[3] The detailed description of the REDI components is presented in Szerb et al. (2017).

[4] For example, in the Quality of education institutional variable there are four sub-indicators: three of them comes from the PISA survey (low achievers in reading, math and science) and one is the creative class sub-indicator. The PISA indicator is calculated as the average of the three PISA sub-indicators.

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

REGIONAL ENTREPRENEURSHIP INDEX	Sub-indexes	Pillars	Variables (*ind.*/inst.)	Entrepreneurship attributes
	ATTITUDES SUB-INDEX	Opportunity Perception	*Opportunity Recognition*	**Market and Regulation**
			Market Agglomeration	
		Start-up Skills	*Skill Perception*	**Human capital/education**
			Quality of Education	
		Risk Acceptance	*Risk Perception*	**Cultural, Regulation**
			Business Risk	
		Networking	*Know Entrepreneur*	**Networks**
			Social Capital	
		Cultural Support	*Career Status*	**Cultural**
			Open Society	
	ABILITIES SUB-INDEX	Opportunity Start-up	*Opportunity Motivation*	**Regulation**
			Business Environment	
		Technology Adoption	*Technology Level*	**Knowledge creation/dissemination**
			Absorptive Capacity	
		Human Capital	*Educational Level*	**Human capital/education**
			Education and Training	
		Competition	*Competitors*	**Infrastructure**
			Business Strategy	
	ASPIRATION SUB-INDEX	Product Innovation	*New Product*	**Knowledge creation/dissemination**
			Technology Transfer	
		Process Innovation	*New Technology*	**Knowledge creation/dissemination**
			Technology Development	
		High Growth	*Gazelle*	**Infrastructure and Finance**
			Clustering	
		Globalization	*Export*	**Market**
			Connectivity	
		Financing	*Informal Investment*	**Finance**
			Financial Institutions	

Source: Szerb et al. (2017, p. 13).

The key idea of REDI is that system performance at region level is 'co-produced' by its constituent elements, meaning that the 14 pillars are interrelated and all support the functioning of the EE, that is, the 14 pillars act as complements for each other. In the proposed EE approach, the combination of pillar components determines whether the entrepreneurial ecosystem of a region functions well or not. We implement this notion by penalizing the value of each pillar by linking it to the score of the 'bottleneck' pillar with the weakest performance. The penalty is higher if differences are higher, and pillar components are only partially substitutable with each other. An improvement in the weakest pillar would yield to a significant increase in the focal sub-index and, ultimately, the overall REDI score. On the contrary, improving a high performing pillar would enhance the value of the pillar itself, and in this case the increase in the REDI index will be smaller. We interpret a system with a homogeneous pillar configuration (no weak pillar) as an EE that is efficiently channelling and utilizing the region's resources.[5]

[5] For more details about the calculation methodology, see Appendix 1.

Some EE scholars argue that each ecosystem is unique in terms of the configuration and the combination of its many components. Therefore, local administrations should not replicate successful policies adopted by other regions; but rather follow a distinctive development strategy based on their own strengths and weaknesses (Mason and Brown, 2014; Spigel, 2017). The REDI adopts a partially different view by assuming a one-size-fits-all measure of EE is useful to diagnose important weaknesses in the regional ecosystem. Of course, then policy interventions should be tailor-made by identifying local bottlenecks and by narrowing (or eliminating) gaps that prevent a given region from fully exploiting its entrepreneurial potential. To alleviate system failures, a REDI-based entrepreneurship policy reflects well the traditional economic view linked to overcoming market failures and to the innovation system approach that aims to improve the weak parts of the innovation system components (Stam, 2015).

4. Measuring Entrepreneurial Outputs

EE scholars maintain that local development can be enhanced by improving the ecosystem; however, this effect may well be moderated by entrepreneurial outputs. While several competing definitions of entrepreneurship reflecting the multifaceted nature of entrepreneurship exist (Acs et al., 2014; Wennekers and Thurik, 1999), we narrow our definition to those centred around opportunity pursuit via the creation of new ventures (Vivarelli, 2013). In this sense, entrepreneurial activity refers to the process of recognizing and exploiting valuable business opportunities (Kirzner, 1997; Shane, 2009). Although opportunity exploitation can be linked to intrapreneurship or employee-initiated entrepreneurship as well, in this paper we will concentrate on independent start-ups.

New business entry intensifies competition by challenging the market position of established firms (Fritsch and Mueller, 2004; Kirzner, 1973). In a scenario of high entry rates, incumbent firms may either downgrade/terminate their operations faster or adapt to the new market conditions. If the overall output remains unchanged the increased competition may lead to high churning—high entry and exit rates at the same time—and the total employment effect could go either way (Fritsch and Mueller, 2004; Vivarelli, 2013). Such high intensity competition may motivate innovation to try and escape competition (Aghion, 2017; Aghion and Howitt, 1992). Such innovation leads to new markets and/or new product/service solutions, thus increasing regional competitiveness by stimulating growth and productivity (Fritsch and Mueller, 2004).

The importance of regional entrepreneurial activity has therefore long been recognised; however, the direction and magnitude of its economic impact has been debated (Audretsch and Fritsch, 2002; Feldman, 2001; Lee et al., 2004). Various factors have been proposed to explain the conflicting findings in prior research, including differences in development, industry composition, the inclusion of contextual factors, and the measurement of entrepreneurial activity (Audretsch et al., 2012; Fritsch and Storey, 2014). We propose making progress on the latter, as it is likely to be most needed.

Entrepreneurial firms are clearly not homogeneous. From the novelty of opportunity recognition perspective, start-ups can be grouped basically into three categories: a large group that merely copies existing ideas, a small fraction that introduces minor innovations, and an even smaller number of Schumpeterian new firms with breakthrough innovative ideas (Baumol, 2010). The contribution of start-ups to local economic performance is likely to vary according to this typology (Hessels et al., 2008; Nightingale and Coad, 2014). Recent research shows that only a small proportion of start-ups and young businesses are responsible for economic growth, job creation or increased productivity (Acs et al., 2016; Mueller, 2007; Stam et al., 2011; Stam, 2015).

Different types of start-ups coexist in economies, and their overall effect also depends on the composition of the population of start-ups (Vivarelli, 2013). Moreover, the relationship between the number of businesses and their quality may well be inverse (Fritsch and Schroeter, 2009), which calls for a careful policy application to boost the intensity of start-ups (Acs et al., 2016; Shane, 2009). The uneven, unknown distribution of start-ups and their potential substitution effects make it ineffective to develop a combined, one-size-fits-all entrepreneurship policy (Marcotte, 2013; Vivarelli, 2013). Moreover, our entrepreneurial activity measures should be differentiated and concept-based (Marcotte, 2013) to make broader, more encompassing and quantity-based measures of entrepreneurship. In this sense, the low specificity of the GEM's Total Entrepreneurial Activity (TEA) rates makes this variable less suitable for our purposes.

The popularity of GEM based measures is due to the consistent and rigorous data collection that includes multiple years, many countries, regions and different levels of development. Yet, the TEA simultaneously includes the 'speculative' nascent businesses with young firms with less than 3.5 years (Stam and Van Stel, 2011),[6] opportunity and necessity start-ups, marginal and high growth potential ventures. Consequently, the TEA turns out to be negatively correlated with GDP per capita in global samples, which suggests that development is linked to low levels of entrepreneurial activity.

Out of the many alternative GEM-based entrepreneurship measures (Levie et al., 2014; Marcotte, 2013) the opportunity and necessity entrepreneurship rates (Acs, 2006; Reynolds et al., 2005) and the high aspiration or high growth entrepreneurship rates (Stam and Van Stel, 2011; Wong et al., 2005) are shown to provide a better (but still limited) capacity to explain the variance in economic development outcomes. The limited explanatory power of the GEM-based indices may well result from its encompassing approach that includes all types of start-ups in the analysis, regardless the type of new venture. Given that data collection is done by surveying the adult population, samples would have to become very big if results are to be representative for more targeted, but therefore more rare types of entrepreneurship. As a consequence, GEM variables do reflect the quantity of entrepreneurial activity broadly defined, but fail to accurately capture the role of competition by new entrants on aggregate growth dynamics (Boettke and Coyne, 2003; Kirzner, 1973).

This calls for developing new entrepreneurship measures that may capture the direct and indirect impacts of the quantity and quality of entrepreneurial outcomes (Acs et al., 2014). Direct effects—e.g., increased output and employment—are likely observable in the short run, while indirect effects—e.g., superior productivity and innovation—will become evident in the long term (Acs, 2006; Wennekers and Thurik, 1999).

[6] The TEA rate is the ratio of 18-64-year-old adult population who is in an active phase of start-up (nascent) or owns and manages a start-up aged less than 42 months.

In this paper we zoom in on the direct effects and contribute to the literature by proposing two new proxies for the relevant quantity and quality of entrepreneurship, respectively. The proposed measures use GEM regional data during 2012-2014, so we may benefit from the broad coverage and rigorous direct data collection GEM provides. We first exclude the 'speculative' nascent businesses and use a different temporal horizon to split the analysed businesses (baby businesses and established ventures).

Our first suggested measure then aims to reflect exclusively the quantity characteristics of new business formation. That is, it measures the rate of new business formation relative to the population of existing businesses. As this measure picks up the rate at which new firms enter the economy, but does not distinguish between innovative and imitative firms, we refer to this as overall entrepreneurship (equation 1):

$$OE_i = \frac{Number\ of\ new\ businesses_i}{Number\ of\ incumbent\ businesses_i} \quad (1)$$

where, for each region (*i* = 1, …, m), the number of new businesses refers to those firms with less than 18 months of market experience; and the number of incumbent businesses includes the number of businesses with more than 18 months of market experience (both as observed in the GEM-sample). GEM uses 3.5 years or 42 months as the cut-off point between new entrants and incumbent businesses. We chose to use the 18 month cut-off point, because it captures business regeneration, and we believe that the effects of new entry to markets are likely to wear off in less than 42 months.

This measure shows the importance of start-ups compared to incumbent firms, and thus, it measures the competitive pressure of start-ups on already existing ventures. While this measure corrects for competitive effects it still contains many different types of businesses including necessity and low growth potential start-ups. An important reason behind the creation of such an entrepreneurship indicator is to evaluate the possibility of a one-size-fits-all activity measure and the associated uniform entrepreneurship policy to increase start-up rate. Because this measure incorporates different types of businesses including necessity and low growth potential start-ups, this measure will capture mostly competition and composition, not innovation effects.

The second proxy approaches start-up rates from a quality perspective, and measures the relative innovativeness of new firms compared to that of incumbent ventures. The innovativeness of a business is calculated as the average of three GEM-based variables: 1) the newness of the product (how many customers consider the product of the firm new or unfamiliar), 2) the newness of technology (whether the firm uses old, new or the latest available technology), and 3) operating in a high impact sector (whether the firm operates in a low tech/low impact, medium/high or high-impact, technological sector). These questions are asked to all business owners in the sample and we can distinguish them as new businesses that are less than 18 months old and incumbents businesses that are older. To compute the regional innovation capacity of start-up/ incumbent businesses, we then compute the weighted arithmetic average over all (new) firms. After calculating the innovativeness of both new and incumbent businesses, we refer to the ratio loosely as our Schumpeterian entrepreneurship measure is given by (equation 2):

$$SE_i = \frac{Innovativeness\ of\ new\ businesses_i}{Innovativeness\ of\ incumbent\ businesses_i} \quad (2)$$

where, for each region (*i* = 1, …, m), the innovativeness of new businesses is the innovation level of firms with less than 18 months of market experience, while the innovativeness of incumbent businesses refers to the innovation level of businesses with over 18 months of market experience.

This quality measure shows the innovativeness of start-ups compared to that of incumbent businesses. This variable also captures the competitive pressure of innovative new businesses over existing businesses, that is, it measures what Schumpeter called 'creative destruction' (Schumpeter, 1934). We, therefore, name this indicator Schumpeterian entrepreneurship.[7]

5. Research framework and hypotheses

With the above defined indicators in hand we can now proceed to develop our hypotheses. We first propose that the EE is conducive to economic performance and, thus, we hypothesise:

H1: There is a positive relationship between the quality of the entrepreneurial ecosystem and regional economic performance.

Strictly speaking this hypothesis might seem like a tautology, as the quality of the entrepreneurial ecosystem is measured as the ability to support productive entrepreneurship that contributes to regional economic performance, by definition. Still, it is important to test whether this association is positive or not.

We also differentiated quality- and quantity-based start-up measures seeking to capture the importance of competition between businesses at different stages of the life cycle. Recent empirical findings underpin the need for incorporating the effects of market competition on territorial economic performance. For example, Fritsch and Changoluisa (2017) find that new firms, irrespectively to their innovation and technology level, contribute to higher productivity of established businesses operating in the region. The authors consider four potential effects of business entry on the productivity of established firms (output market competition, input market competition, knowledge spillover from new to established firms, and provision of better inputs), and their results indicate that only output and input market competition have a significant positive effect. Therefore, start-ups and incumbent businesses can be hypothesised to complement each other, regardless of the industry sectors where these businesses operate.

However, we wish to distinguish here between the effects of overall entrepreneurship—characterised by competitive pressure—and Schumpeterian entrepreneurship—that is, innovation and creative destruction. First, as overall entrepreneurship is based on increases in the quantity of businesses, higher young business density increases economic performance due to intense competition, a more efficient allocation of resources

[7] Again, we concede this is a loose interpretation of the concept, as Schumpeter envisioned entrepreneurs as those bringing novelty to the market while destroying existing market positions. Our measure captures the former but is only loosely connected to the latter element.

and lower rents in the region. On the contrary, innovative businesses are more competitive and, therefore, they can create new profit opportunities and break into market niches within and/or outside the region. Thus, the following hypotheses emerge:

H2: Overall entrepreneurship has a positive effect on regional economic performance.

H3: Schumpeterian entrepreneurship has a positive effect on regional economic performance.

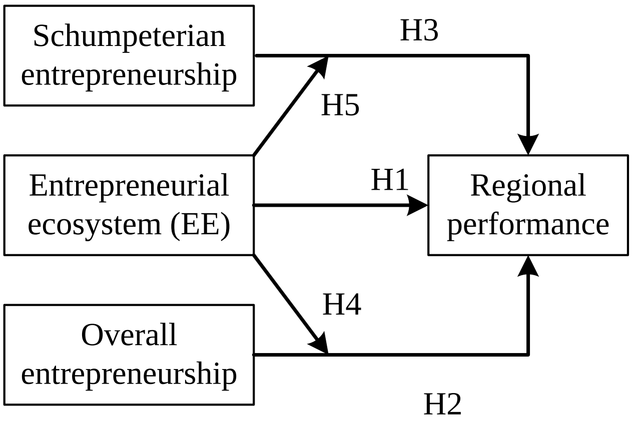
Finally, the quantity and quality of entrepreneurial activity cannot be seen as independent from the environment within which businesses operate. The regional EEs take a significant role in shaping quantity- and quality-related business structures, and they are the hotbed of start-ups (Acs et al., 2016). The regional context thus conditions the outcome of overall and Schumpeterian business dynamics, potentially in different ways. In the case of overall entrepreneurship, it seems logical that a healthy, supportive EE favours a more intense business entry. A higher REDI value also arguably points to more favourable conditions for higher quality, more innovative start-ups. The context effect of Schumpeterian entrepreneurship, however, also depends on the innovativeness existing businesses. Aghion et al. (2005) show that innovation can stem not only from increased business entry rates, but also from the response of incumbent businesses to (innovative) entrants. They propose that this effect is conditional on their distance to the existing technological frontier. Therefore, as a reaction to new entry, 'frontier firms' likely make additional efforts to innovate ('escape competition effect'), while 'laggard firms' that are far from the frontier face further difficulties and they have no incentives to introduce further improvements ('discouragement effect'). These two effects suggest an ambiguous and possibly inverse U-shaped effect of increased competition on innovation and, indirectly, on economic growth (Aghion et al., 2005; Aghion et al., 2009). If incumbents become less innovative in response to highly innovative entrants, our measure will be high, all else equal biasing the estimated impact on regional growth down. If they become more innovative, the effect will be a bias up. The effect should remain positive, however, and is then moderated by the EE. Thus, we complement our previous assumptions, and formulate the following hypotheses:

H4: The entrepreneurial ecosystem moderates the relationship between overall entrepreneurship and regional economic performance.

H5: The entrepreneurial ecosystem moderates the relationship between Schumpeterian entrepreneurship and regional economic performance.

Figure 1 presents the resulting research framework and hypotheses

Figure 1: Concepts and Hypotheses



With REDI as our indicator of the entrepreneurial ecosystem quality, and the above defined GEM-based proxies for Schumpeterian and overall entrepreneurship, we can now proceed to present our data and estimation strategy.

6. Data, variable definition and method

The data used in this study come from three sources. First, regional data related to gross value added (GVA) per worker, GDP per capita, unemployment, and population density were obtained from Eurostat. Second, information on business formation rates was collected from the Global Entrepreneurship Monitor (GEM) databases. Third, the variables measuring the quality of the entrepreneurial ecosystem across European regions were gathered from the Regional Entrepreneurship and Development Index (REDI) databases. With the support of the European Union ('Financial and Institutional Reforms to build an Entrepreneurial Society' (FIRES), Horizon 2020 project), an updated REDI index was created by researchers from the University of Pécs (Hungary) to assess the quality of the entrepreneurial ecosystems in Europe at the regional level (Szerb et al., 2017).

The unit of analysis is the region and the final sample includes information for 121 EU regions (NUTS 1 and NUTS 2). For all variables, values refer to averages between 2012 and 2014. Note that the sample is representative for the EU insofar as it includes 24 European countries: Austria (3 regions), Belgium (3 regions), Croatia (3 regions), Czech Republic (1 region), Denmark (5 regions), Estonia (1 region), Finland (5 regions), France (8 regions), Germany (16 regions), Greece (3 regions), Hungary (7 regions), Ireland (2 regions), Italy (4 regions), Latvia (1 region), Lithuania (1 region), Netherlands (4 regions), Poland (6 regions), Portugal (3 regions), Romania (4 regions), Slovak Republic (4 regions), Slovenia (2 regions), Spain (15 regions), Sweden (8 regions), and the United Kingdom (12 regions). The full list of regions included is presented in Appendix 2.

This study measures regional economic performance via two variables. First, we use the rate of gross value added (GVA) per worker, which represents the total value of goods and services produced by workers of industry sectors in a focal economy. Second, we employ the employment growth rate.[8]

The measurement of the quality of the regional entrepreneurial ecosystem is critical for this study. Given the complexity that most EE measures entail, REDI is a suitable option in the context of our analysis (see section 2). The REDI is an index that ranges from 0 to 100, where higher scores indicate a higher quality of the entrepreneurial ecosystem.

We use data from the GEM databases to create our overall (quantity) and Schumpeterian (quality) entrepreneurship indicators. From the GEM databases, it is possible to identify the exact start-up year for the surveyed entrepreneurs, and distinguish businesses created in the same year of the survey (firms with less than 6 months of market experience) from firms created in years prior to the survey. In this study, we define new businesses as those firms with less than 18 months of market experience for reasons we have eluded to above. Besides, the choice of this cut-off point enables us to analyse business regeneration. Still, to compare the differentiating effects, we provide our analyses applying a 42-month cut-off in Appendix 4 (for gross value added per worker) and Appendix 5 (for employment growth).

We control for various economic and demographic factors at the regional level in the different model specifications. First, we include two variables related to urbanization. Urbanization economies are a type of agglomeration externality that helps firms to capitalize on advantages such as increased local demand and (Bottazzi and Gragnolati, 2015), knowledge spillovers (Glaeser et al., 1992), and more efficient regional innovation systems. Additionally, being located in large or densely populated cities may prove critical to access skilled labour resources (Meliciani and Savona, 2015). In our study, we follow the practice by Meliciani and Savona (2015) and assess the role of urbanization by introducing regional population density and a dummy for regions with a capital city. Finally, we include the Gross Domestic Product (GDP) per capita as an indicator of regional economic development (Lafuente et al., 2016). Descriptive statistics are presented in Table 2 and the associated correlation matrix is in Appendix 6. In contrast to our expectation, the REDI score is not positively and statistically significantly related to either overall entrepreneurship nor Schumpeterian entrepreneurship.

Table 2: Descriptive Statistics

Descriptive Statistics				
	Mean	Std. dev.	Q1	Q3
GVA per worker	60.19	22.70	41.74	75.83
Employment growth rate	–0.0010	0.0197	–0.0163	0.0099
REDI score	44.57	14.84	33.20	55.90
Overall entrepreneurship	0.1738	0.0924	0.1080	0.2250
Schumpeterian entrepreneurship	2.0308	1.4573	1.4230	2.1410
Capital city (dummy)	0.1983	0.4004	0.0000	0.0000
Population density	349.80	907.56	73.37	285.83
Unemployment rate	0.1085	0.0652	0.0650	0.1307

[8] We also ran our analyses using the real GDP per capita growth rate as an independent variable but considering the potential problematic issues of applying regional level GDP data, we only included it in Appendix 3.

GDP per capita	25.96	9.15	19.60	30.35

Monetary values (GVA per worker and GDP per capita) are expressed in thousands of euro. Number of observations: 121 regions.

We employ OLS regression models to estimate the conditional correlation of entrepreneurial ecosystem quality and the types of entrepreneurship on our territorial performance measures. The full model used in this study has the following form:

$$Performance_i = b_0 + b_1 REDI_i + b_2 OE_i + b_3 SE_i + b_{12} REDI_t \times OE_i + b_{13} REDI_i \times SE_i + \sum_{j=4}^{m} b_j C_i^j \quad + \varepsilon_i \qquad (3)$$

In equation (3) *Performance* refers to the GVA per worker and the employment growth rate at the regional level, b_j are parameter estimates estimated for the independent variables (*j*), C is the vector of control variables, and ε is the normally distributed error term that varies across regions. Note that we run a cross sectional model. This may raise concerns on causality and endogeneity. We therefore do not claim causality and at this stage investigate conditional correlations. The limited availability of cross-country regional data simply precludes more advanced econometric analyses to date.

In a second stage, we propose a cluster analysis (Everitt, 1980) to further evaluate regions' performance, given their differences in terms of the quality of their entrepreneurial ecosystem and of their entrepreneurial activity. The variables included in the cluster model are the analysed regional performance metrics (GVA per worker and employment growth), the REDI score, and the variables linked to the overall and Schumpeterian regional entrepreneurial activity. This complementary analysis seeks to identify specific patterns among European regions.

To perform this second stage analysis, we apply a non-hierarchical cluster analysis (K-means) using the above variables as inputs. However, the efficient optimization of the within-cluster homogeneity and between-cluster heterogeneity implies that the number of clusters is specified prior to the estimation. This represents the main pitfall of non-hierarchical cluster analysis, because in many research fields (including social sciences) cluster analyses are often exploratory. Consequently, we conducted two robustness checks to corroborate the number of clusters and the validity of our analysis. First, we computed the Calinski and Harabasz (1974) statistic over different numbers of clusters *k*=(1,2,…,121). This index is then obtained as $CH(k) = \frac{B(k)/_{k-1}}{W(k)/_{n-k}}$, where *B(k)* and *W*(*k*) are the between and within-cluster sums of squares, with *k* clusters and *n* observations. Since the between cluster difference should be high, and the within cluster difference should be low, a largest *C*H(*k*) value indicates the best clustering. From our data, the number of clusters that maximizes the *C*H(*k*) index is 5 (*pseudo-F value*: 488.35). Therefore, the final non-hierarchical clustering asks for a five-way division. Second, a discriminant analysis further validates the cluster analysis. Results from the discriminant analysis are presented in Appendix 7 and indicate that our approach to cluster the data in 5 groups is appropriate.

7. Results and analysis
7.1 Regression results

The findings for the effect of the entrepreneurial ecosystem and different types of entrepreneurship on regional performance (GVA per worker and employment growth) are presented in this section. In Tables 3 and 4, Model 1 shows the results for the baseline model estimating regional performance as a linear function of the analysed types of entrepreneurship (overall and Schumpeterian) including only the main effect of the EE-quality as measured by the REDI-score. Specification 2 considers the potentially differentiating effect of low and high quality EE splitting the REDI-scores at the median, while Model 3 reports the results for the full model, including interaction terms between the low and high quality of the regional entrepreneurial ecosystem and the analysed types of entrepreneurship.

To evaluate potential collinearity, we computed the average variance inflation factor (VIF) for all variables. The only VIF values that exceed 10—a generally accepted rule of thumb for assessing collinearity—were observed for the interaction terms between the REDI and the entrepreneurship measures. By construction these terms are correlated and this would explain the VIF results (Greene, 2003). We also computed VIFs for the variables used in models 1 and 2, and the resulting average VIF is 1.43 (range: 1.07-2.49) and 1.45 (range: 1.11-2.10), respectively. The results for these diagnostic tests do not raise collinearity concerns.

Concerning the results of the study, from models 1 and 2 in Tables 3 and 4 we observe that the variable linked to the entrepreneurial ecosystem (REDI) consistently positively impacts regional GVA per worker, and explains the increased employment growth only among high-REDI regions. This result is consistent with prior studies emphasizing that a healthy entrepreneurial ecosystem is conducive to territorial performance (see e.g., Acs et al., 2014; Lafuente et al., 2016). Therefore, we find support for our first hypothesis (**H1**) that proposes a positive relationship between the quality of the regional entrepreneurial ecosystem as measured by the REDI and territorial performance for GVA per worker. When looking at employment growth, the result is more nuanced. Model 2 in Table 4 does suggest a positive association when the REDI-score is above the median, but this relationship is negative for below median levels of EE quality. The latter would suggest that improving the quality of the EE reduces employment growth in regions that have a below median quality of the EE. One should realize, however, that we cannot rule our reverse causality here. When low employment growth causes a lot of people to enter into necessity entrepreneurship, this may get picked up in the REDI-scores as increased quality in low quality environments.

In case of overall entrepreneurship Models 1 and 2 in Table 3 show that this variable is negatively correlated with regional GVA per worker, while the association is insignificant in the employment growth model (Table 4). We therefore cannot confirm our second hypothesis (**H2**) that overall entrepreneurship positively impacts regional performance. In fact, we find evidence to the contrary when correlating it with GVA per worker. A possible explanation for this finding is the fact that high levels of new firm formation may correlate with high labour churning, which may reduce productivity by reducing on-the-job-training incentives and imposing higher hiring and firing costs.

Results for Models 1 and 2 in Tables 3 and 4 also show how the effect of the Schumpeterian entrepreneurship variable is positive and significant for employment growth but insignificant for GVA per worker. Thus, we only find partial support for our hypothesis 3 (**H3**) that proposes a positively relationship between Schumpeterian entrepreneurship and regional performance.

The results in Model 3 in Table 3 show that the interaction term between the REDI levels and overall entrepreneurship is not significant. That is, creating more businesses itself do not contribute to productivity levels only in regions with an underperforming entrepreneurial ecosystem. Similarly, Model 3 in Table 4 shows that overall entrepreneurship is unrelated to regional employment growth as well. Therefore, we cannot support our hypothesis 4 (**H4**) that assumes a moderating role between overall entrepreneurship and the regional economic performance. In spite of this finding, in our productivity regressions, we get a positive and significant interaction effect with Schumpeterian entrepreneurship for below median REDI-scores. Thus, improvements in a low quality entrepreneurial ecosystem seems to improve the conditions that help materialize the effects of high business formation rates, and more innovative entrepreneurship. Consequently, we find nuanced support for hypothesis 5 (**H5**) that states that the regional entrepreneurship system moderates the relationship between Schumpeterian entrepreneurship and regional performance. This hypothesis is only confirmed for the model using GVA per worker as dependent variable and for low quality EE, while we find little support for this hypothesis when the dependent variable is employment growth.

Table 3: Regression Results Productivity

	Gross Value Added/Worker		
	Model 1	Model 2	Model 3
REDI	3.0765*** (0.2085)		
Low REDI		3.8530*** (0.3570)	1.2447 (1.2013)
High REDI		2.3847*** (0.2831)	3.1042*** (0.8388)
Overall entrepreneurship	−0.8050*** (0.3153)	−0.7840*** (0.2848)	−0.4929 (0.3815)
Overall entrepreneurship X Low REDI			5.7453 (3.8503)
Overall entrepreneurship X High REDI			1.6850 (2.8814)
Schumpeterian entrepreneurship	−0.0113 (0.0716)	−0.0097 (0.0617)	0.1158 (0.0761)
Schumpeterian entrepreneurship X Low REDI			1.4652* (0.7800)
Schumpeterian entrepreneurship X High REDI			−0.9237** (0.4495)
Capital city dummy	−0.2136*** (0.0558)	−0.2028*** (0.0598)	−0.2303*** (0.0601)
Population density	−0.0179 (0.0246)	−0.0102 (0.0245)	−0.0122 (0.0259)
Unemployment rate	2.6052*** (0.3862)	2.7519*** (0.3901)	2.3748*** (0.4323)
Country dummies	Yes	Yes	Yes
Intercept	2.5920*** (0.1630)	3.9985*** (0.1489)	3.8726*** (0.2018)

F-test	41.52***	55.97***	35.76***
Adjusted R2	0.7631	0.7776	0.7872
RMSE	0.2199	0.2131	0.2084
Average VIF	1.43	1.45	7.51
Observations	121	121	121

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5% and 1%, respectively.

The interaction effect between the REDI and Schumpeterian entrepreneurship is negative and statistically significant for the high-quality EE when we look at GVA per worker and for low-quality EE when we use employment growth, thus pointing to a substitution effect between these variables. That is, in a less effective EE, innovative entrepreneurs contribute *more* to regional productivity of employment growth. A way to look at this result is that under tougher conditions for entrepreneurs, only the presence of innovative entrepreneurs matters, whereas in better environments their contribution is less pronounced due to more and better overall competitors. Schumpeterian (quality) entrepreneurship is often linked to highly skilled entrepreneurs who create businesses with superior innovative capacities that may potentially redirect consumer preferences by offering high value-added goods or services.

Table 4: Regression Results Employment Growth

Employment Growth			
	Model 1	Model 2	Model 3
REDI	0.0093 (0.0165)		
Low REDI		–0.0445* (0.0250)	0.0897 (0.0690)
High REDI		0.0572*** (0.0204)	0.0184 (0.0545)
Overall entrepreneurship	–0.0009 (0.0202)	–0.0024 (0.0189)	–0.0175 (0.0270)
Overall entrepreneurship X Low REDI			–0.1423 (0.2467)
Overall entrepreneurship X High REDI			0.1478 (0.1544)
Schumpeterian entrepreneurship	0.0070* (0.0036)	0.0069** (0.0032)	0.0014 (0.0040)
Schumpeterian entrepreneurship X Low REDI			–0.1058** (0.0429)
Schumpeterian entrepreneurship X High REDI			0.0124 (0.0260)
Capital city dummy	0.0066 (0.0044)	0.0058 (0.0045)	0.0061 (0.0047)
Population density	–0.0005 (0.0014)	–0.0011 (0.0013)	–0.0013 (0.0014)
Unemployment rate	–0.1276*** (0.0286)	–0.1377*** (0.0294)	–0.1341*** (0.0337)
Country dummies	Yes	Yes	Yes
Intercept	0.0007 (0.0081)	0.0027 (0.0067)	0.0120 (0.0093)
F-test	22.71***	27.78***	19.63***
Adjusted R2	0.4624	0.4994	0.4978
RMSE	0.0144	0.0139	0.0139

Average VIF	1.43	1.45	7.51
Observations	121	121	121

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5% and 1%, respectively.

The economic outcomes of regions with low-quality entrepreneurial ecosystems may be restrained by the lack of appropriate mechanisms to allocate entrepreneurial resources to the economy. In this context, innovative entrepreneurs whose businesses are of high quality constitute a substitute for the shortage of an adequate entrepreneurial ecosystem. Therefore, regions with low REDI scores may rely on Schumpeterian entrepreneurs—who channel new and more innovative resources to the economy—to compensate the absence of policies supporting entrepreneurship and increase their economic outcomes, in terms of GVA per worker and employment growth. This substitution effect may explain the negative result for the interaction term between the REDI score and the Schumpeterian entrepreneurship variable. We ran a series of robustness checks testing the individual effect of the independent variables (REDI, overall entrepreneurship, Schumpeterian entrepreneurship). Also, we added models using 42-month-borderline for the overall entrepreneurship and Schumpeterian entrepreneurship measures. Results can be found in Appendix 8. We now turn to the results of our second stage clustering analysis to investigate if regions cluster together and perhaps differ in the relationship between our variables of interest.

7.2 Clustering on performance, REDI and entrepreneurship types of European regions

This section complements the regression analysis above by introducing the results of the cluster analysis. Table 5 presents the results for the five different groups of regions that emerge from the cluster analysis. Additionally, Figure 2 graphically presents the distribution of the analysed regions according to the results of the cluster analysis.

The nine regions included in Group 1 are all in developed economies, namely Denmark (Hovedstaden), France (Île-de-France), Finland (Helsinki-Uusimaa), Germany (Hamburg), Ireland (Southern and Eastern), Sweden (Stockholm and South Sweden), and the UK (London and South-East). These high-performing regions show the greatest values in terms of the five analysed variables.

Regions from nine developed countries form Group 2: Austria (Eastern Austria), Belgium (Brussels-Capital Region), Denmark (Midtjylland, Nordjylland, and Southern Denmark), France (Centre-Est), Germany (Baden-Württemberg, Bayern, Berlin, Bremen, Hessen, Nordrhein-Westfalen, and Saarland), Ireland (Border, Midland and Western), Netherlands (Northern Netherlands, Eastern Netherlands, Western Netherlands, Southern Netherlands), Sweden (East Middle Sweden, Upper Norrland, and West Sweden), and UK (Yorkshire and The Humber, East Midlands, West Midlands, East of England, South West, Scotland, and Northern Ireland). These regions report high values for the REDI score (58.78), GVA per worker (73.91) as well as positive employment growth between 2012 and 2014 (0.99%); however, values for the REDI score (*t*-test: 10.66 and *p*-value < 0.001) and the GVA per worker (*t*-test: 4.92 and *p*-value < 0.001) are significantly lower than those reported for regions in Group 1.

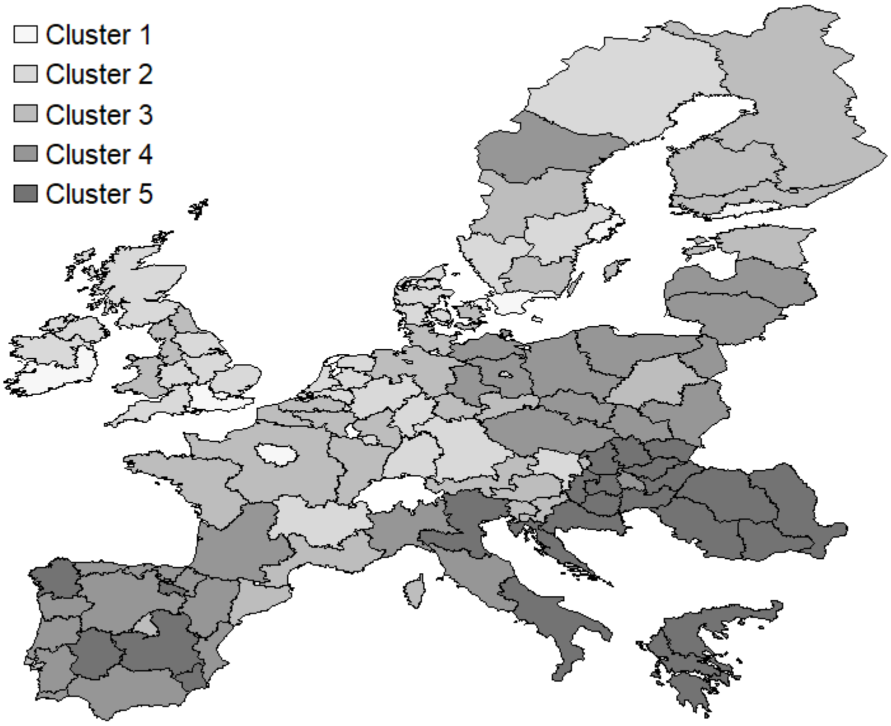
We note a drastic performance gap between regions in the first two high-performing groups (Groups 1 and 2) and regions positioned in the rest of groups. Group 3 includes regions from ten Western European countries and four economies mostly located in Central and Eastern Europe: Austria (Southern Austria, and Western Austria), Belgium (Flemish Region, and Walloon Region), Denmark (Sjælland), Estonia, Finland (West Finland, South Finland, North and East Finland), France (Bassin Parisien, Nord, Est, Ouest, Méditerranée), Germany (Niedersachsen, Rheinland-Pfalz, Sachsen, Schleswig-Holstein, Thüringen), Poland (Region Centralny), Portugal (Lisbon), Slovak Republic (Bratislava Region), Slovenia (Eastern Slovenia and Western Slovenia), Spain (Catalonia and Madrid), Sweden (Småland and the Islands and North Middle Sweden), and UK (North East, North West and Wales).

Although these regions show levels of quantity (overall) and quality (Schumpeterian) entrepreneurship comparable to those reported by regions in Group 1 and 2, the results for the entrepreneurial ecosystem (REDI: *t*-test: 14.78 and *p*-value < 0.001) and for the performance variables (GVA per worker: *t*-test: 3.14 and *p*-value < 0.01; Employment growth: *t*-test: 2.96 and *p*-value < 0.01) are significantly lower, relative to values observed for regions in high performing groups.

Table 5: Results Cluster Analysis

Cluster Analysis						
Variable / Group	1	2	3	4	5	Total
REDI score	73.29	58.88	47.28	35.43	25.10	44.57
GVA / worker	96.47	73.91	63.53	49.36	39.76	60.19
Employment growth	0.018	0.001	–0.002	–0.009	–0.009	–0.001
Quantity Entrepreneurship	0.20	0.18	0.18	0.15	0.18	0.17
Quality Entrepreneurship	2.89	2.07	2.07	1.98	1.68	2.04
Observations	9	28	31	28	25	121

Figure 2: Geographic distribution according to the results of the cluster analysis



Regions in groups 4 and 5 show the poorest results, except for the quantity entrepreneurship variable (overall entrepreneurship). Group 4 includes regions from six Western economies and five Central and Eastern European countries: Czech Republic, France (Sud-Ouest), Germany (Brandenburg, Mecklenburg-Vorpommern, Sachsen-Anhalt), Hungary (Central Hungary), Italy (Northwest Italy, Central Italy), Latvia, Lithuania, Poland (Region Południowy, Region Wschodni, Region Północno-Zachodni, Region Południowo-Zachodni, Region Północny), Portugal (Alentejo, Algarve, Centro, Norte), Spain (Andalusia, Aragón, Asturias, Basque Country, Cantabria, Castilla León, Navarra, Valencia), and Sweden (Middle Norrland). Compared to values reported by regions in Group 3, regions in Group 4 show significantly lower levels of the REDI score (*t*-test: 15.13 and *p*-value < 0.001) and performance: GVA per worker (*t*-test: 3.22 and *p*-value < 0.01), Employment growth (*t*-test: 1.69 and *p*-value < 0.10).

Finally, Group 5 comprises poor performing regions from mostly peripheral countries and regions (four out of the seven countries represented in this group are from Central and Eastern Europe): Croatia (Continental Croatia and Adriatic Croatia), Greece (Voreia Ellada, Kentriki Ellada, Attiki), Hungary (Central Transdanubia, Western Transdanubia, Southern Transdanubia, Northern Hungary, Northern Great Plain, Southern Great Plain), Italy (Northeast Italy, South Italy), Romania (Macroregion one, Macroregion two, Macroregion three, Macroregion four), Slovak Republic (Western Slovakia, Central Slovakia, Eastern Slovakia), and Spain (Castilla La Mancha, Extremadura, Galicia, La Rioja, Murcia). These regions show the lowest values for the REDI score, the GVA per worker, and the quality (Schumpeterian) entrepreneurship.

It seems very likely that policies to promote entrepreneurship would have to be different and also have different impacts across regions. The clustering analysis performed here, may give some indication what comparable regions in Europe any given region may look to, to identify best practises and benchmark performance on. It is important to strike a good balance between on the one hand imposing universal one-size-fit-all approaches to policy reform and on the other hand the completely fragmented and idiosyncratic approach where all must invent their own wheel. The balance may arguably be found when we can cluster regions on relevant indicator variables. Our results suggest that we can usefully cluster on our indicator for the quality of the entrepreneurial ecosystem. However, that is highly correlated with performance, almost by construction. Our analysis here suggests that we should also consider indicators of the quality and quantity of entrepreneurial outcomes.

8. Concluding remarks

In this study, we proposed that quantity- and quality-based entrepreneurship have a heterogeneous impact on regional economic performance, measured via GVA per worker and employment growth. Furthermore, we emphasised the relevance of the regional entrepreneurial ecosystem as a key factor moderating the role of different types of entrepreneurship on regional economic performance. In doing so, our approach offers a compelling argument to measure both the quantity and quality dimensions of entrepreneurship as well as the quality of the regional entrepreneurial ecosystem.

The analysis provides some preliminary evidence that helps us understand how the entrepreneurial ecosystem helps to capitalise on regions' entrepreneurial outcomes. The main effects of Schumpeterian entrepreneurship (measured here as the average innovativeness of new firm technologies over incumbent firm technologies) are as we would expect, positive. Interestingly, however, we also report negative interaction effects between Schumpeterian entrepreneurship and high and low quality REDI-scores. We interpreted this result as innovative entrepreneurship being the only type that still contributes to regional economic performance especially in regions that score low on REDI in the above and below median REDI-groups. Improving the REDI-score in such regions will thus improve the overall quality of new firm formation to the point that the less innovative will contribute more to regional performance.

The results on overall entrepreneurship (measured here as the number of new to incumbent firms) is negative on productivity and insignificant on employment growth. This would suggest that it is quality, not quantity that in general contributes to regional economic performance. The interaction effects are also largely insignificant. This suggests that improving the quality of the entrepreneurial ecosystem has a quantity and quality effect that tend to offset each other. When the ecosystem promotes more business formation, that may also suck in more marginal start-ups, reducing or at best obscuring the contribution of firm formation on regional economic performance.

Our clustering of European regions on the identified indicators of entrepreneurial activity and ecosystem quality then shows these regions fall into five distinct groups. Performance and ecosystem quality seem highly correlated throughout, but innovative entrepreneurship can remain high for some medium quality regions. In the lowest performing regions entrepreneurship is predominantly of the overall type and as our results have shown, may even affect the performance negatively. We should be careful, however, to make strong causal claims based on our cross-regional regression. The contribution of this paper is not in establishing the causal link between entrepreneurship and growth.

Despite these limitations, the present report has important implications for both scholars and policy makers. From an academic perspective, the results of the study further clarify the relationship between entrepreneurial activity and regional economic performance reported in previous studies (see e.g. Acs et al., 2017a; Acs and Varga, 2005). We found that quantity entrepreneurship is negatively associated with regional outcomes when we control for the quality of the entrepreneurial ecosystem. However, we also find that this type of entrepreneurship may prove efficient in regions that benefit from a superior entrepreneurial ecosystem. A high-quality ecosystem helps attract and channel entrepreneurial resources into the regional economy, thus contributing to leverage the impact of new entrepreneurial ventures. We therefore suggest that policy makers turn their attention to improving the entrepreneurial ecosystem when considering the adoption of entrepreneurship support measures. The naive prioritization of policies oriented to increase the business start-up rate may yield sterile (or even negative) outcomes if the region does not enjoy a healthy entrepreneurial ecosystem.

Schumpeterian entrepreneurship—which we link to the creation of highly innovative businesses with disruptive potential—is associated with superior regional performance on employment growth. However, the outcomes of this type of entrepreneurship may be restrained by the lack of appropriate mechanisms that allocate entrepreneurial resources to the economy (low-quality entrepreneurial ecosystem). Our results suggest that high quality entrepreneurship can act as a substitute for the shortage of an appropriate entrepreneurial ecosystem. Therefore, regions lacking the appropriate mechanisms to allocate entrepreneurial resources to the economy must rely on scarce Schumpeterian entrepreneurial activity to channel new innovative resources to the economy to compensate for the absence of entrepreneurship policy-support instruments. This aspect is of crucial importance as it suggests that, in regions with a poor entrepreneurial ecosystem, policy makers can foster regional performance by re-directing resources to promote the entrepreneurial ecosystem. In other reports and contributions, the authors have already shown in publications in and outside the FIRES-project (Acs et al., 2015; Szerb et al., 2013; Szerb et al., 2017) how REDI can be a useful tool to help policy makers identify and implement such policies.

Some important limitations to the paper remain. First, we have examined only two entrepreneurship activity measures; others could be developed. Second, the output measures—GDP, GVA, employment—all have limitations (e.g. Aghion, 2017; Audretsch et al., 2015). Third, we examine only short run influences, whereas long run effects could also be important (Fritsch, 2008; Müller, 2016). Fourth, we cannot exclude the possibility that the causality between entrepreneurship and GVA/worker or employment growth is reverse and/or important feedback effects exist. To analyse this issue and bring the full potential of modern econometric tools to bear, however, we need a panel with a much longer time dimension. This simply takes time. The cross-sectional regional data underlying the REDI-index (and available in GEM) is still limited in the time dimension. The available data could also be used to develop a richer taxonomy of alternative measures for both entrepreneurial outcomes and institutional framework conditions. Although this could help to unravel the complex interactions between institutional environment, individual agency and aggregate economic outcomes, such an exercise is beyond the scope of this report and the FIRES-project. This report certainly puts these issues high on the agenda for future research. Our analysis has not produced a smoking gun yet. But we have been successful in at least lifting the curtains a little bit, so we have a clearer view of the stage upon which Hamlet may appear.

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Appendices

Appendix 1: The Regional Entrepreneurship and Development Index (REDI) calculation methodology

In the constructing the index we followed eight points:

1 ***The selection of variables:*** We start with the variables that come directly from the original sources for each region involved in the analysis. The variables can be at the individual level (personal or business) that are coming from the GEM Adult Population Survey or the institutional/environmental level that are coming from various other sources. Altogether we use 14 individual and 14 institutional variables. Individual data are calculated from the 2007-2011 pooled dataset. In the case of the institutional variables we used the most recent available data on 31. December 2013. Altogether, we have data for a mix of 121 NUTS1 and NUTS2 regions.

2 ***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. This results pillar values for all the 121 regions.

$$z_{i,j} = IND_{i,j} * INS_{i,j} \qquad \text{(F1)}$$

for all j= 1 ... k, the number of individual and institutional variables
$IND_{i,j}$ is the original score value for region i and variable j individual variable
$INS_{i,j}$ is the original score value for region i and variable j institutional variable
$z_{i,j}$ is the original pillar value for region i and pillar j

3 ***Normalization:*** pillars values were first normalized to a range from 0 to 1:

$$x_{i,j} = \frac{z_{i,j}}{\max z_{i,j}} \qquad \text{(F2)}$$

for all j= 1 ... k, the number of pillars
where $x_{i,j}$ is the normalized score value for region i and pillar j
$z_{i,j}$ is the pillar value for region i and pillar j
$max\ z_{i,j}$ is the maximum value for pillar j

4 ***Capping:*** 95 All index building is based on a benchmarking principle. In our case we selected the 95 percentile score adjustment meaning that any observed values higher than the 95 percentile is lowered to the 95 percentile.

5 ***Average pillar adjustment:*** The different averages of the normalized values of the pillars imply that reaching the same pillar values require different effort and resources. Since we want to apply REDI for public policy purposes, the additional resources for the marginal improvement of the pillar values should be the same for all pillars. Therefore, we need a transformation to equate the average values of the components. Equation F2 shows the calculation of the average value of pillar *j*:

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{i,j}}{n} \qquad \text{(F3)}$$

We want to transform the $x_{i,j}$ values such that the potential minimum value is 0 and the maximum value is 1:

$$y_{i,j} = x_{i,j}^{k} \qquad \text{(F4)}$$

where k is the "strength of adjustment", the k-th moment of X_j is exactly the needed average, $\overline{y}_j$.

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

$$\sum_{i=1}^{n} x_{i,j}^{k} - n\overline{y}_j = 0 \quad \text{(F5)}$$

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

$$\overline{x}_j < \overline{y}_j \quad k < 1$$
$$\overline{x}_j = \overline{y}_j \quad k = 1$$
$$\overline{x}_j > \overline{y}_j \quad k > 1$$

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

6 ***Penalizing:*** After these transformations, the PFB methodology was used to create indicator-adjusted PFB values. We define our penalty function following as:

$$h_{(i),j} = min\, y_{(i),j} + (1 - e^{-(y_{(i)j} - min\, y_{(i),j})}) \quad \text{(F6)}$$

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

7. 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 region is the weighted average of its average equalized 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 region in a particular sub-index.

$$ATT_i = 100 \sum_{j=1}^{5} h_{i,j} \quad \text{(F7a)}$$

$$ABT_i = 100 \sum_{j=6}^{9} h_{i,j} \quad \text{(F7b)}$$

$$ASP_i = 100 \sum_{j=10}^{14} h_{i,j} \quad \text{(F7c)}$$

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

8. The super-index, the Global Entrepreneurship Index, is simply the average of the three sub-indices. Since 100 represents the theoretically available limit the GEDI points can also be interpreted as a measure of efficiency of the entrepreneurship resources

$$REDI_i = \frac{1}{3}(ATT_i + ABT_i + ASP_i) \quad \text{(F8)}$$

where $REDI_i$ is the regional entrepreneurship and development index score of region i.
i = 1, 2,……n = the number of regions

Appendix 2: List of sampled regions

Regions		
Country	NUTS level	Regions
Austria	NUTS 1	Eastern Austria, Southern Austria, Western Austria
Belgium	NUTS 1	Brussels-Capital Region, Flemish Region, Walloon Region
Croatia	NUTS 2	Continental Croatia, Adriatic Croatia
Czech Republic	NUTS 1	Czech Republic
Denmark	NUTS 2	Hovedstaden, Sjælland, Southern Denmark, Midtjylland, Nordjylland
Estonia	NUTS 1	Estonia
France	NUTS 1	Île-de-France, Bassin parisien, Nord, Est, Ouest, Sud-Ouest, Centre-Est, Méditerranée
Finland	NUTS 2	West Finland, Helsinki-Uusimaa, South Finland, North and East Finland
Germany	NUTS 1	Baden-Württemberg, Bayern, Berlin, Brandenburg, Bremen, Hamburg, Hessen, Mecklenburg-Vorpommern, Niedersachsen, Nordrhein-Westfalen, Rheinland-Pfalz, Saarland, Sachsen, Sachsen-Anhalt
Greece	NUTS 1	Voreia Ellada, Kentriki Ellada, Attiki
Hungary	NUTS 2	Central Hungary, Central Transdanubia, Western Transdanubia, Southern Transdanubia, Northern Hungary, Northern Great Plain, Southern Great Plain
Ireland	NUTS 2	Border, Midland and Western NUTS-II Region, Southern and Eastern NUTS-II Region
Italy	NUTS 1	Northwest Italy, Northeast Italy, Central Italy, South Italy
Latvia	NUTS 1	Latvia
Lithuania	NUTS 1	Lithuania
Netherlands	NUTS 1	Northern Netherlands, Eastern Netherlands, Western Netherlands, Southern Netherlands
Poland	NUTS 1	Region Centralny, Region Południowy, Region Wschodni, Region Północno-Zachodni, Region Południowo-Zachodni, Region Północny
Portugal	NUTS 2	Norte Region, Algarve, Centro Region, Lisboa Region, Alentejo Region
Romania	NUTS 1	Macroregion one, Macroregion two, Macroregion three, Macroregion four
Slovak Republic	NUTS 2	Bratislava Region, Western Slovakia, Central Slovakia, Eastern Slovakia
Slovenia	NUTS 2	Eastern Slovenia, Western Slovenia
Spain	NUTS 2	Galicia, Asturias, Cantabria, Basque Community, Navarre, La Rioja, Aragon, Madrid, Castile-Leon, Castile-La Mancha, Extremadura, Catalonia, Valencian Community, Andalusia, Region of Murcia
Sweden	NUTS 2	Stockholm, East Middle Sweden, Småland and the islands, South Sweden, West Sweden, North Middle Sweden, Middle Norrland, Upper Norrland
United Kingdom	NUTS 1	North East, North West, Yorkshire and the Humber, East Midlands, West Midlands, East of England, London, South East, South West, Wales, Scotland, Northern Ireland

Appendix 3: Regression results for GDP growth

Gross Domestic Product (GDP) growth			
	Model 1	Model 2	Model 3
REDI	–0.1358*** (0.0399)		
Low REDI		–0.2129*** (0.0618)	–0.1777 (0.2102)
High REDI		–0.0670 (0.0458)	–0.1484 (0.1016)
Overall entrepreneurship	0.0310 (0.0316)	0.0289 (0.0298)	0.0662* (0.0372)
Overall entrepreneurship X Low REDI			0.6278* (0.3810)
Overall entrepreneurship X High REDI			–0.1262 (0.3351)
Schumpeterian entrepreneurship	0.0031 (0.0082)	0.0030 (0.0075)	–0.0113 (0.0081)
Schumpeterian entrepreneurship X Low REDI			–0.1636 (0.1562)
Schumpeterian entrepreneurship X High REDI			0.1011** (0.0494)
Capital city dummy	0.0147 (0.0091)	0.0136 (0.0090)	0.0146 (0.0099)
Population density	0.0063* (0.0035)	0.0055 (0.0035)	0.0049 (0.0036)
Unemployment rate	–0.1918*** (0.0533)	–0.2063*** (0.0567)	–0.2408*** (0.0636)
Country dummies	Yes	Yes	Yes
Intercept	0.0773*** (0.0244)	0.0135 (0.0198)	0.0274 (0.0233)
F-test	13.94***	13.75***	12.04***
Adjusted R2	0.3330	0.3559	0.3589
RMSE	0.0277	0.0272	0.0271
Average VIF	1.43	1.45	7.51
Observations	121	121	121

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5% and 1%, respectively.

Appendix 4: Regression results for GVA per worker (cut-off: 42 months)

Gross Value Added/Worker			
	Model 1	Model 2	Model 3
REDI	2.9409*** (0.1986)		
Low REDI		3.6010*** (0.3933)	–0.0455 (0.1137)
High REDI		2.4043*** (0.2620)	0.0311 (0.1007)
Overall entrepreneurship	–0.5655*** (0.1387)	–0.5188*** (0.1363)	–0.0074 (0.0130)
Overall entrepreneurship X Low REDI			–0.0292 (0.1180)
Overall entrepreneurship X High REDI			0.0167 (0.0971)
Schumpeterian entrepreneurship	–0.0170 (0.0661)	–0.0186 (0.0594)	0.0015 (0.0056)
Schumpeterian entrepreneurship X Low REDI			0.0142 (0.0662)
Schumpeterian entrepreneurship X High REDI			0.0184 (0.0565)
Capital city dummy	–0.1915*** (0.0563)	–0.1887*** (0.0581)	0.0056 (0.0046)
Population density	–0.0128 (0.0227)	–0.0079 (0.0224)	–0.0011 (0.0013)
Unemployment rate	2.2884*** (0.3765)	2.4514*** (0.3860)	–0.1403*** (0.0352)
Country dummies	Yes	Yes	Yes
Intercept	2.7604*** (0.1649)	4.0911*** (0.1468)	0.0114 (0.0114)
F-test	47.71***	56.14***	19.83***
Adjusted R2	0.7800	0.7888	0.4718
RMSE	0.2119	0.2076	0.0143
Average VIF	1.47	1.50	14.14
Observations	121	121	121

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5% and 1%, respectively.

Appendix 5: Regression results for employment growth (cut-off: 42 months)

Employment Growth			
	Model 1	Model 2	Model 3
REDI	0.0124 (0.0169)		
Low REDI		–0.0457* (0.0268)	–0.0455 (0.1137)
High REDI		0.0596*** (0.0205)	0.0311 (0.1007)
Overall entrepreneurship	–0.0004 (0.0080)	–0.0045 (0.0084)	–0.0074 (0.0130)
Overall entrepreneurship X Low REDI			–0.0292 (0.118)
Overall entrepreneurship X High REDI			0.0167 (0.0971)
Schumpeterian entrepreneurship	0.0019 (0.0045)	0.0021 (0.0044)	0.0015 (0.0056)
Schumpeterian entrepreneurship X Low REDI			0.0142 (0.0662)
Schumpeterian entrepreneurship X High REDI			0.0184 (0.0565)
Capital city dummy	0.0056 (0.0044)	0.0053 (0.0044)	0.0056 (0.0046)
Population density	–0.0007 (0.0013)	–0.0011 (0.0013)	–0.0011 (0.0013)
Unemployment rate	–0.1295*** (0.0295)	–0.1438*** (0.0302)	–0.1403*** (0.0352)
Country dummies	Yes	Yes	Yes
Intercept	0.0058 (0.0103)	0.0099 (0.0088)	0.0114 (0.0114)
F-test	20.35***	23.54***	19.83***
Adjusted R2	0.4511	0.4900	0.4718
RMSE	0.0146	0.0141	0.0143
Average VIF	1.47	1.50	14.14
Observations	121	121	121

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5% and 1%, respectively.

Appendix 6: Correlation matrix

		1	2	3	4	5	6	7	8	9
1	GVA per worker (ln)	1								
2	Employment growth	0.0212	1							
3	GDP growth	–0.5024***	0.2782***	1						
4	REDI score	0.7051***	0.4589***	–0.1375	1					
5	Overall entrepreneurship	–0.2689***	0.1888**	0.3153***	0.0582	1				
6	Schumpeterian entrepreneurship	0.1209	0.1876	–0.0153	0.1340	–0.0790	1			
7	Capital city dummy	0.0143	0.0800	0.0929	0.2572***	0.2639***	–0.1881**	1		
8	Population density (ln)	0.2348***	0.2027**	0.1553*	0.4308***	0.2321**	–0.0226	0.3602***	1	
9	Unemployment rate	–0.0998	–0.5551***	–0.1598*	–0.4982***	–0.1665*	–0.1342	–0.0090	–0.1349	1
10	GDP per head (ln)	0.5122***	0.1241	–0.2868***	0.7919***	–0.0766	0.1138	0.3287***	0.4620***	–0.3281***

*, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

Appendix 7: Results of the discriminant analysis

Classification according to the discriminant analysis						
True groups: Cluster analysis	1	2	3	4	5	Total
Group 1	9 (100.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	9
Group 2	0 (0.00%)	27 (96.43%)	1 (3.57%)	0 (0.00%)	0 (0.00%)	28
Group 3	0 (0.00%)	0 (0.00%)	30 (96.77%)	1 (3.23%)	0 (0.00%)	31
Group 4	0 (0.00%)	0 (0.00%)	0 (0.00%)	27 (96.43%)	1 (3.57%)	28
Group 5	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (4.00%)	24 (96.00%)	25

Appendix 8: Robustness check

	Gross Value Added/Worker					Employment growth				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
REDI	3.2912*** (0.1879)					0.0140 (0.0149)				
Overall entrepreneurship (18 months)		–2.0831*** (0.4445)					–0.0062 (0.0187)			
Schumpeterian entrepreneurship (18 months)			0.2286** (0.1086)					0.0077** (0.0035)		
Overall entrepreneurship (42 months)				–1.2915*** (0.2012)					–0.0042 (0.0072)	
Schumpeterian entrepreneurship (42 months)					0.3894** (0.1551)					0.0033 (0.0042)
Capital city dummy	–0.2726*** (0.0579)	0.0483 (0.1027)	–0.0432 (0.1108)	0.0654 (0.0965)	–0.0423 (0.1047)	0.0053 (0.0042)	0.0065* (0.0039)	0.0072* (0.0039)	0.0066* (0.0039)	0.0064 (0.004)
Population density	–0.0313 (0.0247)	0.1101*** (0.0389)	0.0981** (0.0415)	0.1087*** (0.0344)	0.1018*** (0.0384)	–0.0007 (0.0013)	–0.0002 (0.0012)	–0.0002 (0.0011)	–0.0002 (0.0012)	–0.0002 (0.0011)
Unemployment rate	2.8892*** (0.4016)	–0.0742 (0.4695)	0.3582 (0.5309)	–0.5109 (0.4191)	0.4034 (0.4962)	–0.1291*** (0.0287)	–0.1413*** (0.0238)	–0.1346*** (0.0240)	–0.1429*** (0.0236)	–0.1387*** (0.0243)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	2.4013*** (0.1369)	3.7138*** (0.2492)	3.1556*** (0.2925)	3.9508*** (0.2239)	2.9463*** (0.2850)	0.0075 (0.0079)	0.0127** (0.0057)	0.0027 (0.0069)	0.0136** (0.0060)	0.0078 (0.0085)
F-test	47.84***	11.48***	11.39***	14.51***	11.27***	26.08***	23.93***	27.67***	22.31***	22.37***
Adjusted R2	0.7463	0.3057	0.1715	0.3839	0.2017	0.4603	0.4554	0.4696	0.4560	0.4568
RMSE	0.2276	0.3764	0.4112	0.3546	0.4037	0.0145	0.0145	0.0143	0.0145	0.0145
Average VIF	1.34	1.17	1.14	1.17	1.14	1.34	1.17	1.14	1.17	1.14
Observations	121	121	121	121	121	121	121	121	121	121

Robust standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5% and 1%, respectively.