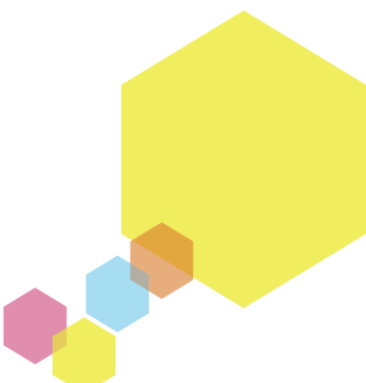


# THE RELATIONSHIP BETWEEN THE ENTREPRENEURIAL ACTIVITY AND THE ENTREPRENEURIAL PERFORMANCE INFLUENCING FACTORS IN THE EUROPEAN REGIONS


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## ABSTRACT

*Several studies showed that entrepreneurships are embedded in that socio-economic environment, where they continue their economic activity. The paper focuses on the relationship between the entrepreneurial activity and the entrepreneurial performance influencing factors. The entrepreneurial activity is measured by the number of newly born firms, and the entrepreneurial performance refers on the values of the influencing factors (pillars) which are grouped into three sub-categories according the methodology of Regional Entrepreneurship and Development Index (REDI Index). It can be assumed that in those regions where these pillars have high values, there will be higher entrepreneurial activity. The results were ambivalent. The entrepreneurial activity and performance are stronger related in the case of dominantly urban regions. However in the case of other regions the relationship between entrepreneurial activity and entrepreneurial performance indicated a weaker performance.*

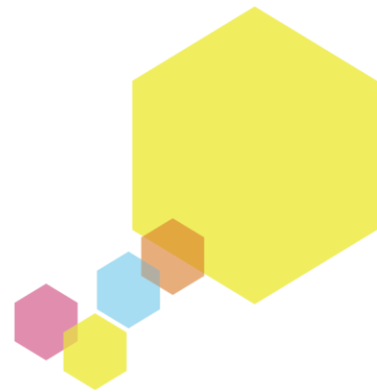


JEL: L26, O18



**KEYWORDS:** *entrepreneurship, entrepreneurial performance, regional economic development*

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## INTRODUCTION

The importance of regional entrepreneurial activity has increased in the last years and many scholars have been starting to investigate different parts of this topic. The regional level investigation of entrepreneurial performance and the effects of entrepreneurship on the regional development as research topics have emerged very fast since the last decade. The shifted economic environment, global competition, new results in sciences and new tools in communication have supported their gaining importance. It does not mean that the entrepreneurs were not important in the beginning of the last century. However the accelerated economic processes and competition among enterprises and countries require flexible business units which can respond on the negative and positive externalities faster than the large enterprises. Some relatively young industrial sectors have developed in the last decades. These industries base on new products and services and many new start-ups have come out in their frames. These new incomers may stimulate the competition, the division of labour and creating innovations (see for example Glaeser et al. 1992 and Acs–Armington 2004). Hence the greater variety may have an indirect influence on the regional development (Boschma 2004, Fritsch 2012). A new firm may inject diversity onto the market and “entrepreneurship is an important source of diversity by transforming knowledge into economic knowledge that otherwise would have been remained uncommercialized” (Audretsch–Keilbach 2004, 608.). Therefore new firms and enterprises may play a significant role in the regional economies due to their knowledge and novelties what they bring in the market. Audretsch and Thurik (2001) summarized the changes concerning the role of entrepreneurship in 14 trade-offs. These characterize the differences among the “managed economy” and “entrepreneurial economy”. The first approach marked the post-war decades after the Second World War. The source of its competitiveness was capital and labour. The production concentrated in relatively big and dominant enterprises. This period was characterized by the homogenous mass production and the economies of scale and the leading concept of firms was the stability and continuity. The relationship of cooperation and competition was complementary. Some changes on the job market as well as in consumption lead to the stepped shift of the economic systems. The emerging concept of the “entrepreneurial economy” has been characterized by the small and medium firms which strategy builds on diversity and flexibility. Its leading concept has become the change and different products. Instead of complementary relationship, there has been a substitute nexus among cooperation and competition in the entrepreneurial economy. The role of local policies and the focus on the

local and regional space became more significant than in the managed economy (Audretsch–Thurik 2001; Audretsch 2009).

We investigate the relationship between the regional entrepreneurial activities and regional entrepreneurial performance in this study. The measures of entrepreneurial activities focus mostly on the entrepreneurial attitudes and the quantity of new entrepreneurships (like the Total early-stage Entrepreneurial Activity which was developed by GEM research group). However the so-called qualitative aspects of entrepreneurs, like their abilities and aspirations are missing from these measures (Szerb et al. 2013a). In order to measure entrepreneurial attitudes, abilities and aspirations in a complex way, the Global Entrepreneurship and Development Index (GEDI)<sup>1</sup> has been developed. Recent studies and reports about this index (see for example Acs et al. 2013, Szerb et al. 2012, Szerb et al. 2013, Acs et al. 2014) have shown that the effect of quantity-based entrepreneurial activity rates and GEDI values on the economic growth is ambivalent. Therefore we study the relationship of entrepreneurial activities and performance on the regional level, and we compare the results to the economic growth. The next section reviews the theoretical background. Methods of the investigation are described in the third section and the results are represented in the fourth section. At the end we summarize the conclusions and further research orientations.

## **1 THEORETICAL BACKGROUND**

The literature of entrepreneurial motivation, aspirations and the effects of new entrepreneurships on the economic development has broadened widely in the last years. We summarize in this section the most important theoretical concepts and empirical findings about the entrepreneurial activity and performance.

Several recent studies proved that the new entrepreneurships have a positive effect on economic growth in the developed countries (see among others Acs–Audretsch 1988; Acs–Varga 2005; van Stel et al. 2005; Acs–Szerb 2007). New firms have impact on the regional development in longer time period (Audretsch–Fritsch 2002, Fritsch–Müller 2004) and they may also influence the regional employment but this impact depends on the regional productivity level (Fritsch–Müller 2008). However, the relationship of entrepreneurial activity and economic growth is not unambiguously positive. Namely, a relatively high number of entrepreneurs (self-employers) can be observed in the underdeveloped countries that have started an

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<sup>1</sup> Its name has been changed into Global Entrepreneurship Index (GEI) in 2015.

entrepreneurship due to necessity. The probability of found necessity-motivated entrepreneurs increases in the low income economies (Fernandez-Serrano–Romero 2013). As the economic performance has developed the number of self-employer entrepreneurs decrease (because of the increasing number of jobs among others). As the economic develops the number of entrepreneurs starts to increase again, however these actors are rather “real entrepreneurs” (opportunity-driven entrepreneurs) who may have a positive effect on the economic development (Wennekers–Thurik, 1999). Similar trends have been observed by Bosma and Harding (2007), Acs et al. (2008) and Fernandez-Serrano–Romero (2013) among others.

Entrepreneurial activity can be derived from different motivations which influence entrepreneurial aspirations. According to Acs et al. (2008) three types of motivations can be distinguished: independence, increase-wealth and necessity. Among them independence plays the most important role primarily in richer countries. Increase-wealth motivated entrepreneurs correlate negatively to a country’s economic development. But these enterprises may have positive indirect influence on job growth and export aspirations in countries with higher rates of economic growth. Contrary to this, necessity-driven entrepreneurs do not have significant effect on job creation or economic growth (Acs et al. 2008). The entrepreneurial activity and the aspirations of individuals may be influenced by several factors (like economic performance among others). The attitudes and skills launch an entrepreneurial action on the individual level and from this action may come out start-ups, new entries and innovations on the firm level. Thus they can influence competition, variety and also the creation of more new enterprises (Wennekers–Thurik 1999). The entrepreneurial behaviour and attitudes have an important role in the new firms on regional level (Tamásy 2006). An adequate entrepreneurial climate influences positively the new firms’ foundation and regional policy-makers should focus on the indirect tools like improving regional entrepreneurial attitudes for developing regional entrepreneurship rates (Bosma–Schutjens 2011). The regional entrepreneurial culture has also a positive effect on the regional entrepreneurial attitudes (Beugelsdijk 2007, Fritsch–Wyrwich 2014).

However the individuals’ attitudes are influenced by the business environment as well. Namely, different economic conditions may constitute disparities in the business environment in which the local individuals and local entrepreneurs are embedded. The objective regional attributes influence the opportunity perception, thusly the entrepreneurial motivations and attitudes as well (Kibler 2013, Stützer et al. 2014). If we look at the economic performance, competitiveness and institutional set of European countries, we can observe many differences

among them and also within them. The institutional set may influence on the different (formal and informal) rules and it has a crucial role in determining entrepreneurial attitudes and aspirations through these rules (Minniti 2008). The regional circumstances (institutions, economic climate) and individuals' direct surroundings ("macro- and microsocial environment") influence the personal decision about starting new entrepreneurship (Feldman 2001, Wagner–Sternberg 2004). According to Stam (2010) "entrepreneurship is the result of the interaction between individual attributes and the surrounding environment" (Stam 2010, 141). Autio et al. (2014) notes that evidences show that quality matters in entrepreneurship. The mentioned diversity between the entrepreneurial motivation and activity of low-income and high-income countries also point out that the context around the individual have an important role (Autio et al. 2014). According the reviewed literature we have two research questions in this paper:

- How relates entrepreneurial activity and entrepreneurial performance to each other on the regional level?
- What kind of relationship can be observed among the entrepreneurial performance and growth of GDP?

## **2 DATA AND METHODS**

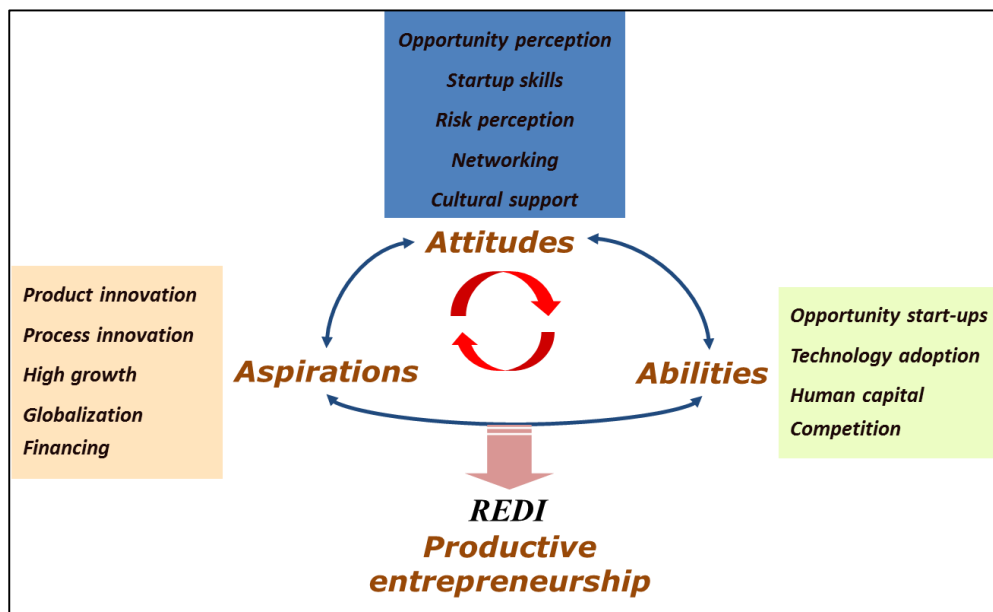
The methodology of the investigation is summarized in this section. We divided it into two parts. The Regional Entrepreneurship and Development Index (REDI Index), as a complex measure of the entrepreneurial performance, and its structure are introduced in the first part of the section. The used variables and methods will be described in the second part.

### **2.1 The structure of REDI Index**

The structure of REDI Index is based on the conception of the Global Entrepreneurship and Development Index (GEDI). It was developed by the Global Entrepreneurship Development Institute lead by Zoltan J. Acs and László Szerb. The GEDI approach of measuring entrepreneurial activity involves a composite index which measures productive entrepreneurship in a multidimensional way. It examines the connection between entrepreneurship and economic development, and provides policy recommendations regarding economic policies (Szerb et. al 2012). The basic idea of the GEDI Index is based on the theory of National System of Entrepreneurship that "(...) 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). On the one

hand, the index builds on individual data derived from the Global Entrepreneurship Monitor (GEM) Adult Population Survey. On the other hand, it focuses not only on the process of business creation, but it captures the qualitative aspects, the so called “contextual features” as well. The same systematic approach was used to capture the regional level entrepreneurship in the case of REDI Index. The Regional System of Entrepreneurship gives the theoretical background for this index (Figure 1). This theory is based on the idea of National System of Entrepreneurship (Szerb et al. 2014).

**Figure 1 – The dynamic of Regional System of Entrepreneurship**



Source: Szerb et al. 2014, 48.

This figure represents not only the systematic view of productive entrepreneurship but the structure of REDI Index as well. The REDI Index is a multi-level index, it has six levels: REDI Index, sub-indexes, pillars, variables, indicators, sub-indicators. The main index consists of three sub-indexes: attitudes (ATT), abilities (ABT) and aspirations (ASP)<sup>2</sup> (Szerb et al. 2014) (Table 1).

<sup>2</sup> The pillars are reviewed here shortly, a detailed description of them can be found in Appendix 2.

**Table 1: The pillars and variables of REDI Index**

Sub-index	Pillar	Individual variable	Institutional variable
Entrepreneurial attitudes (ATT)	Opportunity perception	Opportunity recognition	Market agglomeration
	Startup skills	Skill perception	Quality of education
	Risk perception	Business acceptance	Business risk
	Networking	Know entrepreneurs	Social capital
	Cultural support	Carrier status	Open society
Entrepreneurial abilities (ABT)	Opportunity startup	Opportunity motivation	Business environment
	Technology adoption	Technology level	Absorptive capacity
	Human capital	Education level	Education & training
	Competition	Competitors	Business strategy
Entrepreneurial aspirations (ASP)	Product innovation	New product	Technology transfer
	Process innovation	New technology	Technology development
	High growth	Gazelle	Clustering
	Globalization	Export	Connectivity
	Financing	Informal investment	Financial institutions

*Source: edited by the author based on Szerb et al. (2014)*

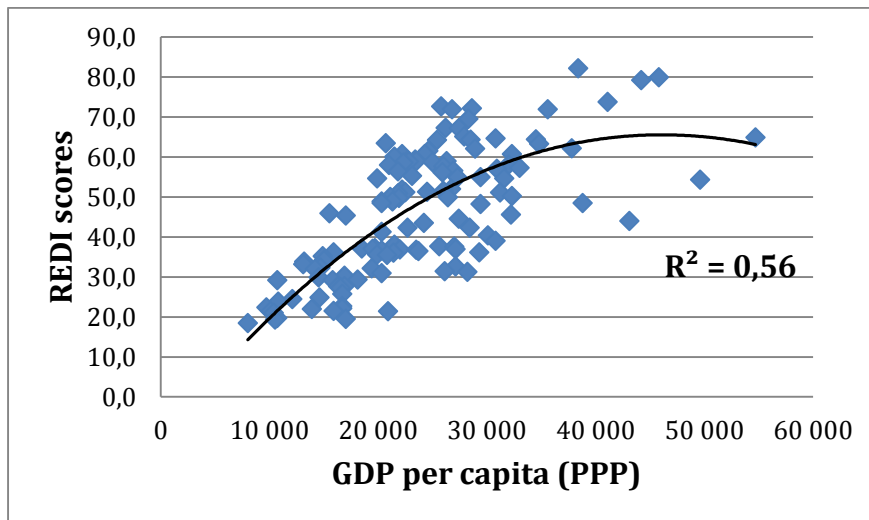
The data of REDI Index had many sources. There were two broad types of data: individual and institutional level data. Almost all of the individual data were based on the Adult Population Survey of Global Entrepreneurship Monitor (GEM) except two innovation based variables. The regional innovation performance variable was derived from the Poli-KIT database (Capello–Lenzi 2013). The NUTS level of individual data was various in the countries and it determined the number of regions from a country. Altogether 24 European countries and 125 regions were involved in the investigation. The institutional data were collected from different relevant databases and sources (Szerb et al. 2014).<sup>3</sup>Some of these data represent country level values. Most institutional variables have at least one regional level indicator (except Risk perception), and many of the variables consist country and regional level data as well.

Here we present only the main results of the REDI Index. The detailed description about calculation of REDI Index can be found in the Appendix.

<sup>3</sup> EUROSTAT Regional Database; United Nations, Department of Economic and Social Affairs, Population Division; EU Regional Competitiveness Index 2010; World Bank – World Development Index; Legatum Prosperity Index; World Economic Forum; EU QoG Corruption Index; 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 and OECD-PISA database



**Figure 2: The connection between GDP per capita and REDI Index scores**

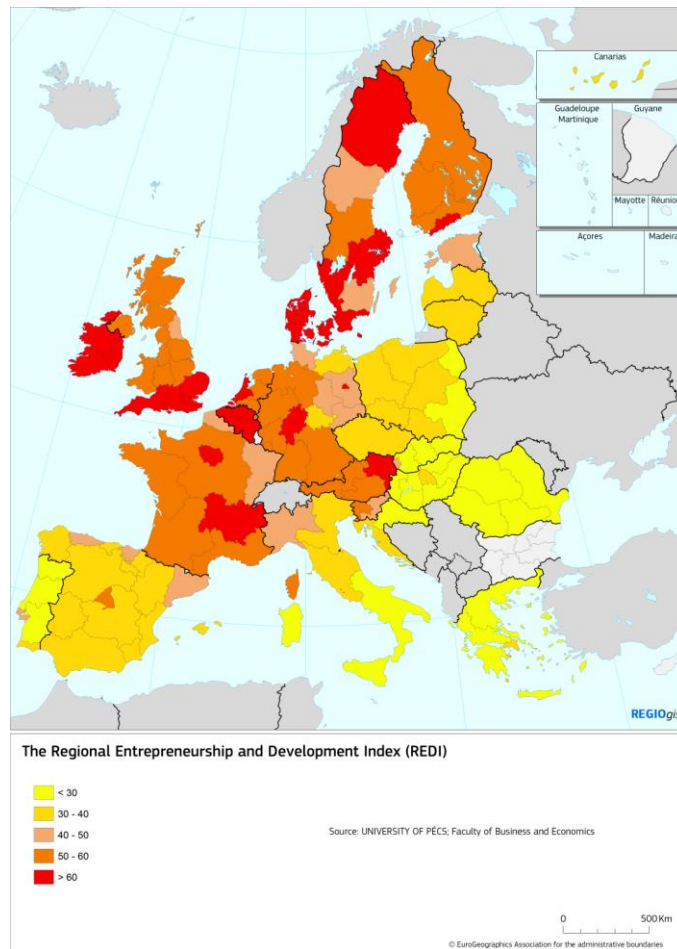


Notes: Third degree of polynomial adjustment. Number of observations = 125.

Source: Szerb et al. (2014)

There is a relatively strong relationship among REDI Index and GDP per capita (Figure 2). The highest REDI score has the Danish Hovedstaden (DK01) region (the capital city region) which obtained 82.2 REDI Index score. The lowest performance was measured in the case of Romanian Macroregiunea doi (RO2) region which showed only 18.4 REDI Index score. These were computed for the Western, Southern and Central and Eastern European regions. The average REDI Index value of the Western European regions is 58.5 which is significantly higher than the Southern European and CEE regions' performance. Their average REDI Index values are 34.7 and 30.1 REDI points. Hence there is a significant difference among the Western and Eastern European regions (Figure 3).

**Figure 3: The REDI Index scores in Europe**



Source: Szerb et al. (2014)

## 2.2 Methods of this analysis

In our investigation, we have assumed that the higher entrepreneurial activity, the higher is its entrepreneurial performance (REDI Index score). Beside this assumption, we checked the relationship of GDP growth and REDI Index scores. We used for measuring entrepreneurial activity the number of local units<sup>4</sup>. In order to making a regional comparison, we used the area and population (total number of local units per 1000 populations). The REDI Index data have been collected between 2007 and 2011. Therefore we have collected the density data from this time period. 125 regions were involved in REDI Index originally. However we had to exclude 10 regions due to lack of data. Therefore we conducted the investigation for 115 regions. Eurostat measures the number of local units within a region in the frame of structural business statistics

<sup>4</sup> "The local unit is an enterprise or part there of (e.g. a workshop, factory, warehouse, office, mine or depot) situated in a geographically identified place. At or from this place economic activity is carried out for which - save for certain exceptions - one or more persons work (even if only part-time) for one and the same enterprise." (Eurostat)

(SBS). However it has been divided into two parts due to the changes in NACE codes. In order to cover the time period, we had to harmonize two different tables, because NACE 1 codes were valid till 2007. The NACE 2 codes have been used since 2008. After harmonizing, we computed the total number and the density of local units using two different denominators (area and population). We checked its descriptive statistics and it showed high skewness in the case of units per square kilometer. It may mean that these data may disfigure the results. Therefore these data have been transformed by using capping method. We computed the 95% percentile of the data and we used this value as maximum value. This method decreased the skewness value. After computing and transforming the variables, we checked the correlation values among the two variables and REDI Index values and the sub-index (ATT, ABT and ASP) scores (Table 2). We have also measured the correlation between REDI Index scores and logarithmic GDP growth (2007–2011).

**Table 2: Correlation values**

	REDI	ATT	ABT	ASP
ModDens0711	0.29**	0.179	0.272**	0.361**
EP_1kPOP	-0.177	-0.132	-0.193*	-0.16
GDPgrowth0711 (log)	-0.134	-0.137	-0.303**	0.125

Note: ModDens 0711: modified number of local units per square kilometers  
 EP\_1kPOP: number of local units per 1000 populations  
 \*\*: Correlation is significant at the 0.01 level (2-tailed).  
 \*: Correlation is significant at the 0.05 level (2-tailed).

*Source: author's calculation and edition*

The link between the units per 1000 populations and REDI Index is negative, but insignificant. The sub-indexes have also negative relationship with units per 1000 populations and only ABT sub-index has some significance. Contrarily, the relationship between REDI Index and local units per square kilometers seemed to be significant. However it is a relatively weak link among them. The sub-indexes represent more or less similar values. The relationship of density and entrepreneurial attitudes is not significant and the entrepreneurial aspirations sub-index has the strongest relationship with density among the sub-indexes (0.361). According to the results of correlation analysis, we will use the units per square kilometer for creating different groups. Although it may show that the urban and metropolitan regions have higher density of local units, but we assume it can make an adequate alignment for regional entrepreneurial activity.

For grouping the regions according their REDI scores and density of local units, we have used cluster analysis. Firstly, we have conducted hierarchical cluster analysis and using Ward-method for determining the number of groups. 8 groups were suggested by this method.

**Table 3: ANOVA for 7 and 8 groups**

		Cluster		Error		F	Sign.
		Mean Square	df	Mean Square	df		
ANOVA for 8 groups	REDI	3496.835	7	26.021	107	134.386	0.000
	ModDens0711	2497.267	7	17.080	107	146.209	0.000
ANOVA for 7 groups	REDI	4066.196	6	26.527	108	153.286	0.000
	ModDens0711	2878.550	6	18.862	108	152.608	0.000

*Source: own computation*

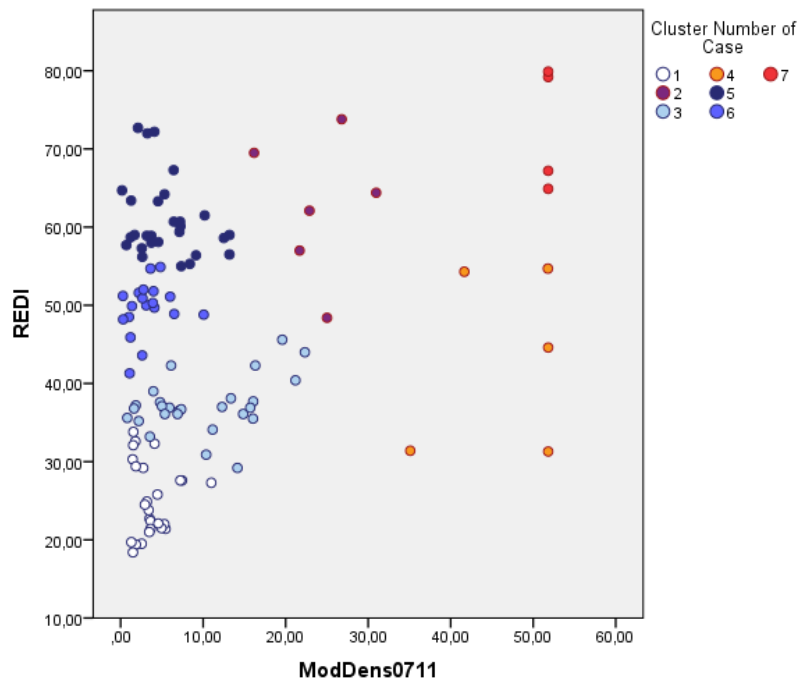
We checked the results by using k-means cluster method. ANOVA indicated relatively high F values in the case of 8 groups. It seemed to be a good solution. In order to verify our decision about the number of groups, we checked F values with less number of groups. After testing different versions (7, 6, 5 and 4 groups), we decided to create 7 groups. The F values strengthen this decision, because this version had the highest F values considering both variables (Table 3).

### 3 RESULTS

As we have written in the previous section, seven groups have been created. We can divide the clusters into two main groups: clusters in which metropolitan and highly urbanized regions are dominant (2, 4 and 7) and clusters of the other regions<sup>5</sup> (Figure 4). This break-up can be explained by their high density of local unit values. Therefore we present our results divided: for the urban regions and separately for the other regions.

<sup>5</sup> It does not mean that the „other regions” groups have not got any highly urbanized regions. However these are not as dominant as in Cluster 2, 4 and 7.

**Figure 4: The created clusters**



*Source: own edition*

The three urbanized clusters can be differentiated by their REDI scores. Cluster 7 has only four members: London, Ile de France (Paris), Berlin and Brussels. They seem to be the most important centers in terms of entrepreneurial activity and performance. The density of local units is also high in Cluster 4, but their REDI scores are significantly lower. The group includes three South European capital regions (Madrid, Athens and Lisbon), an Eastern European metropolitan region (Budapest and its agglomeration) and Hamburg. It has to be noticed that there is a relatively high deviation among REDI scores in Cluster 4. Cluster 2 contains not only metropolitan regions, but also highly urbanized territories as the Belgian Vlaams Gewest or the Dutch West- and Zuid-Nederland. They have the second highest average REDI score among the clusters.

Cluster 1, 3, 5 and 6 contains not only highly urbanized and metropolitan regions. Cluster 5 has the most members and highest REDI Index score among them. It contains many Western European and Scandinavian regions. The regions of Cluster 6 have weaker REDI Index scores compared to the other Northern and Western European regions (Cluster 5) and its density value is the smallest among the clusters. Cluster 3 includes the better performing Southern and Eastern European regions. Their REDI Index scores are lower than the values of Northern and Western European regions, but the average density is higher. Primarily the South European regions have

higher density of local units. Cluster 1 regions have the lowest entrepreneurial performance and its density values indicate relatively low activity.

We compared separately the two main groups, thus the dominantly urban clusters to each other and the other regions (Table 4). This comparison shows that entrepreneurial activity is high in urban regions but their performance is not also high in every case. Those territories had lower level in entrepreneurial performance which economic performance is also weak compared to the Western European urban regions. The density of local units was obviously lower in the not dominantly metropolitan clusters. As the comparison shows the entrepreneurial activity and performance do not correlate strongly to each other. Relatively high entrepreneurial activity can be observed in Cluster 3 which contains many the developed Southern and Eastern European regions. However this result may be explained better by the entrepreneurial culture of the Southern European regions. The more developed and in terms of entrepreneurial performance better performing Western European regions have represented average level in entrepreneurial activity. Low activity and performance values have been measured in the underdeveloped Southern and Eastern European regions.

**Table 4: Main results of the cluster analysis**

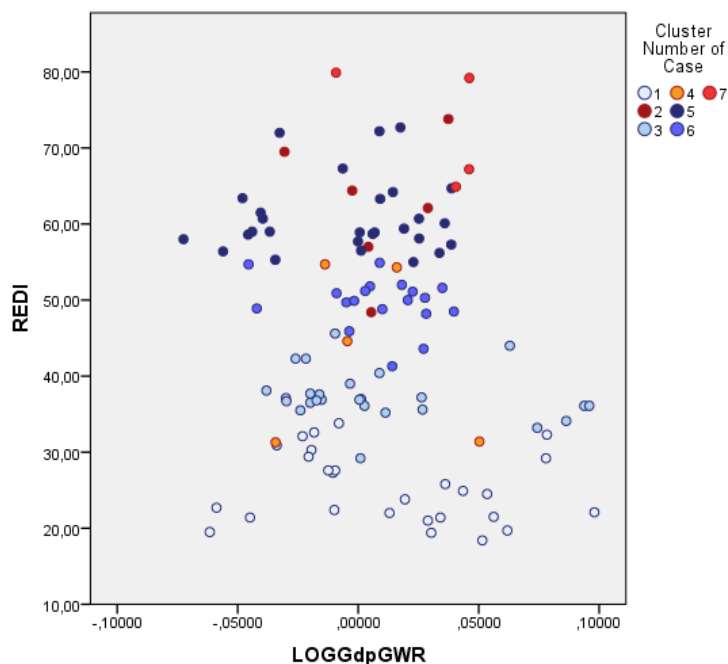
Cluster number	Cluster name	Entrepreneurial activity	Entrepreneurial performance
2	Northern and Western European centers	average	high
4	Southern and Eastern European centers	high	average/low
7	International hubs	high	high
1	Underdeveloped Southern and Eastern European regions	low	low
3	Developed Southern and Eastern European regions	high	below European average
5	More developed Western Europeans	average	above the European average
6	Average Western Europeans	low	average

*Source: own calculation and edition*

As it has been showed in the correlation analysis there is a negative but insignificant relationship among the four year GDP growth and entrepreneurial performance. Most of the regions disperse around zero (Figure 5). It means that despite the high entrepreneurial performance, the GDP has not grown during this short-term period. However two things have to be taken into consideration: the impact of economic crisis on the one hand and the development

level of the regions on the other hand. The economic crisis in 2008 and 2009 had a serious negative impact on GDP and it may be also represented in the values. The other thing: regions with lower level of economic development may develop faster than the economic stronger regions. The strongest growth in GDP had the Eastern European regions. However their entrepreneurial performance is weaker than the developed Western European regions. The entrepreneurial performance is shaped by many factors. Some of them develop relatively slow (like institutions or culture). Therefore it is not sure that the short-term growth of GDP goes hand in hand with the development of these factors.

**Figure 5: The relationship of entrepreneurial performance and growth of GDP**



*Source: own edition*

## CONCLUSION

The aim of the paper was the investigation of relationship between the entrepreneurial activity and performance. We used the recently developed REDI Index for measuring the entrepreneurial performance. In order to measure the entrepreneurial activity, two density indicators have been created from the number of local units. One of them had significant relationship with REDI Index, therefore we used this. It showed a weak correlation values with the REDI Index scores. The results of the investigation were ambivalent. The entrepreneurial activity and performance are stronger related in the case of dominantly urban regions (see Cluster 2, 4 and 7). However in the case of other regions the relationship between entrepreneurial activity and entrepreneurial

performance indicated a weaker performance. The weakest performing other regions had relatively low activity rates in entrepreneurship, but the best other regions had only average rates in entrepreneurial activity (see Cluster 1, 3, 5 and 6). The highest activity rate among the other regions has been indicated by the more developed Southern and Eastern European regions. But it may be influenced strongly by the cultural aspects as well (primarily in the Mediterranean countries). Therefore, the relatively high entrepreneurial activity does not mean relatively high entrepreneurial performance. From this result we may also conclude that the entrepreneurial activity does not always couple with high level of economic development (see for example Figure 2). We analysed also the relationship between the growth of GDP and the entrepreneurial performance. It showed that there is only a weak correlation among them. Therefore we may conclude that the high entrepreneurial performance does not mean high growth of GDP. The highest growth had relatively underdeveloped (Southern and Eastern European) regions. The entrepreneurial performance has relatively strong relationship with the level of regional economic development, but only weak with the growth of regional economy. The business environment among entrepreneurs is a complex formation (especially the institutional environment) and it is not easy to influence by the region itself. Therefore these regions may focus rather on the improvement of the individual factors. The investigations about REDI Index provide chance to determine the bottlenecks of the entrepreneurial performance for each region and it may help to form the adequate policy for regional entrepreneurial processes. The level of entrepreneurial performance depends on the motivations, aspirations and abilities of entrepreneurs who launch a new venture. Therefore it is not enough to support the foundation of new entrepreneurships, but the entrepreneurs or future entrepreneurs should recognize the opportunities and they have to possess entrepreneurial skills.

This investigation has some limitations. The analyzed regions are on different NUTS levels (NUTS 1 and NUTS 2). It may cause inconvenience because some of these regions are too large and heterogeneous to explain their entrepreneurial activity and performance by only few measures. In further investigations we try to fit the territorial level for the better comparison and we plan to focus on smaller areas (for example only on the Central and Eastern European regions). We applied the local units per square kilometers for clustering the regions. However it is obvious that this measure have been high in metropolitan regions, because they are the centers of entrepreneurial activity. Furthermore, it has indicated a relatively low entrepreneurial activity in some regions of Northern Europe (primarily in Scandinavian regions). Therefore, we have to test our assumption by using other indicators as well. We try also to create new measures for entrepreneurial activity. In order to focus on the productive and innovative entrepreneurships



we will conduct the analysis for industry branches (B-F according to the NACE Codes). Clustering may provide an adequate starting point, but we have to use also more sophisticated methods for recognition of the effects between entrepreneurial activity and performance. This paper may serve as a starting point for further researches concerning the entrepreneurial characters of different regions. The analysis individual and institutional aspects may show us some crucial strengths or weaknesses which influence significantly the regional entrepreneurial performance. Furthermore, it may give assistance for us to answer how this regional performance influences the foundation of new enterprises.

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## APPENDIX

### Calculation of REDI Index

#### 1. Creation of variables and pillars

The pillars were built up from an individual and an institutional variable. We paid an extraordinary attention on the skewness values, because the lack of normal distribution might disfigure the final values and cause false benchmarking value application. Pillars were transformed if skewness values fall out the  $[-1;1]$  range.

#### 2. Handling of extreme values.

We used the *capping* method. It means that the 95 percentile score was determined in the case of each pillars and it served as a benchmark in each case. Hence the extreme positive values were cut down to the 95 percentile of the original values.

#### 3. Normalization of the pillars.

The min-max normalization technique was applied in the REDI Index (Szerb *et al.* 2014) (2).

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

for all  $j= 1, \dots, m$ ;  $m=14$  is the number of pillars

$x_{i,j}$  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  $j$

#### 4. Average adjustment

To apply REDI Index for determining public policy recommendations the average values should be the same for all of the 14 pillars. Therefore we needed a transformation to equate the average values of the 14 pillars.  $X_i$  is the normalized score for region  $i$  for pillar  $j$ . The arithmetic average of pillar  $j$  for  $n$  regions is:

$$\bar{x}_j = \frac{\sum_{i=1}^n x_{i,j}}{n} \quad \text{for all pillars} \quad (4)$$

We wanted to transform the  $x_{i,j}$  values, that the potential values to rescale in the  $[0,1]$  range.

$$y_{i,j} = x_{i,j}^k \quad (5)$$

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

$$\sum_{i=1}^n x_{i,j}^k - n\bar{y}_j = 0 \quad (6)$$

This 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 getting  $k$ , the computations are straightforward. If

$$\bar{x}_j < \bar{y}_j \text{ then } k < 1$$

$$\bar{x}_j = \bar{y}_j \text{ then } k = 1$$

$$\bar{x}_j > \bar{y}_j \text{ then } k > 1$$

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

#### 5. Penalty for the Bottleneck (PfB) method (Szerb–Rappai 2011)

The method compares the bottleneck pillar to the other pillars of a given territory and it makes a penalization in the measure of differences between the best and worst pillars. The bigger differences are among the pillars, the higher penalization will be realized on the values of a give region. The model of the Penalty for Bottleneck was developed by alteration the original function of Tarabusi and Palazzi (2012).

(7)

$$h_{(i),j} = \min y_{(i),j} + (1 - e^{-(y_{(i),j} - \min y_{(i),j})}) \quad (7)$$

$h_{(i),j}$  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

$\min y_{(i),j}$  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

## 6. Aggregation of pillar values

We have already determined which pillars belong to the adequate sub-indexes. To obtain the sub-index values we computed the arithmetical average of the penalized pillar values. These were on a scale from 0 to 1. To get a range from 0 to 100 points the values were multiplied by 100 after averaging the pillars.

### Detailed values of clusters

Cluster number	Members	Density (A)	REDI (A)	ATT (A)	ABT (A)	ASP (A)
1	26	3.78	24.44	23.67	21.16	28.51
2	6	23.92	62.53	63.38	67.03	57.23
3	27	9.3	36.90	37.29	34.10	39.32
4	5	46.43	43.26	39.94	45.74	44.02
5	28	5.46	60.92	62.43	63.19	57.12
6	19	3.24	49.65	50.68	51.89	46.37
7	4	51.84	72.8	66.73	74.93	76.72

Source: own edition

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