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Agglomeration economies, competitiveness and entrepreneurial performance

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Agglomeration economies, competitiveness and entrepreneurial performance[1]

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This paper aims to give a comprehensive account of the Jacobs-type agglomeration economies on countries' competitiveness and entrepreneurial performance. Our research goal is to improve our understanding of the relationship that exists between a country's urban system characterized by spatial agglomeration or deglomeration processes and its competitiveness and entrepreneurial performance, respectively.

In this paper the discussion centers on the true character of urbanization economies. Therefore, we selected 70 countries and calculated the so called ROXY Index measuring the degree of inter-city agglomeration or deglomeration processes. To exemplify country level competitiveness we applied the Global Competitiveness Index (GCI). While the Global Entrepreneurship and Development Index (GEDI) was used to demonstrate country level entrepreneurial performance. Using these indexes correlation and cluster analysis were designed to obtain understanding of the relationship among them.

We argue that urbanization economies using as explanatory variables for economic growth is often being treated with oversimplification, and that may explain the contradictory results of many prior studies. Our analysis indicates that as urban concentration increases competitiveness and entrepreneurial performance also increase, but at a decreasing rate. Both of them eventually reaches a maximum and then after a certain point decreases with further concentration. Therefore, the curve for apprehending this relationship is non-linear and folding back. This indicates that over- or under-concentration of the population within an urban system does not necessary result in a better outcome.

Keywords: urbanization economies, entrepreneurship, competitiveness, spatial cycles, ROXY Index.

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1. Introduction

As we know from the seminal work of Romer (1986, 1990), the stock of human capital and its rate of increase play a crucial role in country's economic performance. In endogenous growth theory, following Schumpeter's (1942) assumption, continuous technological change–improvements drive economic growth and provide the impetus for further human capital accumulation. Hence, technological changes are largely determined by the available quantity and quality of human capital. Human capital is considered being a collection of individually or collectively created and used resources such as knowledge, talents, skills, abilities, experiences, habits, creativity etc. gained through education and experience. As reported by Jones and Romer (2009), human capital has three important characteristics. First, it produces ideas which can be used due to learning process to produce new human capital. Second, higher levels of human capital per capita issue in higher level of new knowledge, and third, human capital is geographically bounded.

Endogenous growth models emphasizing the role of human capital led to a huge amount of works on innovation, viz. knowledge creation, spread and diffusion. In parallel with innovation papers, the new notion also gives rise to many papers dedicated to the geography of entrepreneurship. Innovation and entrepreneurship have the common characteristics that both phenomenon based on human capital, are geographically concentrated (mainly in large cities), and serve as explanatory variables for economic growth. Recently, several authors have proposed that innovation and entrepreneurship interlock with each other, and therefore, handling them separately is meaningless. As a result ardent theory building and empirical testing has begun in this research field. Audretsch and Lehmann (2005) introduced the *Knowledge Spillover Theory of Entrepreneurship* which builds a link between agglomeration economies, knowledge creation and entrepreneurship. According to this concept concentration of human capital facilitates the creation of new knowledge, physical proximity helps the easy flow among local agents, and finally knowledge spillovers generate entrepreneurial opportunities. In fact, in this concept entrepreneurship operates as a *'conduit'* for the spillover of knowledge (Acs et al. 2013). By proposing the *Absorptive Capacity Theory of Knowledge Spillover Entrepreneurship* Qian and Acs (2013) advanced the abovementioned concept. According to their theory, the extent to which economy able to grow depends not only on the speed of new knowledge production, but also on entrepreneurial absorptive capacity which they defined as *"the ability of an entrepreneur to understand new knowledge, recognize its value and commercialize it by creating a firm"* (Qian 2013, 564). In their model they

introduce five exogenous variables which may affect directly the location of human capital, create innovation and boost entrepreneurship for economic growth. These micro-foundations are agglomeration, industry specialization, the quality of life, the university and social diversity. The authors use population density (population per square mile) as a proxy for agglomeration, even though it has been considered in literature not an ideal measure. They suggest that high concentration of the population creates that beneficial physical proximity that implies more opportunities for face-to-face communications through which knowledge can spill over. Surprising in their model agglomeration triggers a negative effect on entrepreneurship.

From among these five factors the present paper focuses solely on agglomeration, especially on effects of urbanization economies. Agglomeration economies refer to considerable benefits generated by geographical concentration of people, firms or other complementary resources across similar (specialization), or even different (diversification) industries. Human capital attraction and accumulation is essentially prerequisite for knowledge based entrepreneurship. Nevertheless, agglomeration economies merely serve as an explanation for the existence of concentration processes itself. Moreover, in recent paper by Clarke Annez and Buckley (2009) it has been shown that the same sorts of agglomeration economies are at work in developing countries as those in developed countries cannot explain why some places start develop (while others do not), or it cannot give answer how big advantages would be generated due to concentration.

It has become an axiom that the better performance of global cities is mainly derived from agglomeration effects. This general assumption follows that the more concentrated an urban system of a country, the more competitive and better its entrepreneurial performance. Even though this notion has gained quick and ardent acceptance from practitioners, the related literature shows contradictory results and it has induced a heated debate in academic circles, because it has raised serious doubts about the *'bigger is better'* theory. Our goal with this paper is to contribute to this debate with our detailed analysis.

After all, our findings suggest that one reason behind these contradictory results is that, despite the assumption, relationship between agglomeration and economic growth is *not direct*, since it affects growth through innovation process and entrepreneurship. Another reason that might be the cause of reverse outcomes is the use of *oversimplified proxies* for measurement. On the other hand, inconsistent results are derived from the expectation that concentration can solely exert a positive effect on economic growth, while deconcentration indicates the opposite. We believe this is not inevitably true. Traffic congestion, pollution,

high rent and increasing land prices or other negative externalities, as consequences of prior excessive concentration of resources, may turn things around and lead to deconcentration. This means worsening economic performance of places characterized with population outflow, but it simultaneously signifies better performance of inflow to places elsewhere. This notion serves as an explanation to divergent economic growth which is complicated to measure because of its process-like character.

According to our view (1) positive agglomeration externalities derived from concentration result increasing return which has positive effect on economic growth, and give explanation on the difference in performance among cities (regions or countries), while (2) the quality of human capital determines the difference between developed and developing cities (regions or countries), and (3) negative externalities indicate, on the one hand, the melting-down of the increasing return of concentrated areas, on the other, explain the improvement of economic performance of less concentrated areas.

Considering the above-mentioned problems regarding measurement, we introduce, and use in an innovative way, the so-called ROXY Index, developed by Kawashima (1985), in order to measure the degree of inter-city agglomeration or deglomeration processes. Our research allows for a better understanding of the relationship that exists between a country's urban system, characterized by spatial agglomeration (concentration) or deglomeration (deconcentration) processes, and its competitiveness and entrepreneurial performance, respectively. In order to understand the true character of urban concentration, we selected 70 countries and calculated their ROXY Index. To exemplify country level competitiveness we applied the Global Competitiveness Index (GCI). While the Global Entrepreneurship and Development Index (GEDI) was used to demonstrate country level entrepreneurial performance. Using these indexes correlation and cluster analysis were designed to obtain understanding of the relationship among them.

The remainder of this paper is organized in the following fashion. The next section is devoted mainly to the literature related to agglomeration economies. In the second section, the descriptions of the employed indexes (GEDI, GCI and ROXY) are reviewed. We then describe the data and analysis methodology in the third section. The fourth section presents our empirical results. Finally, a concluding summary is provided in the last section.

2. Agglomeration economies

It was the classical economist, Alfred Marshall (1920) who first identified the main characteristics and sources of location-specific economies of scales labelled in economic

literature as *agglomeration* or *external economies*. Since that time other researchers have actively been contributing to the further development of his theory. Today it is widely accepted that agglomeration economies refer to an increasing return of scale derived from the clustering of different or, on the contrary, similar and specific economic activities. Co-locating in close proximity to other firms, organizations and people can result in higher benefit from higher diversity and/or specialization. Some often-mentioned reasons of these advantages are the followings: (1) market size effect (demand side), (2) local skilled labor pool effect (supply side), (3) local non-traded inputs (e.g. special business services), as well as (4) tacit knowledge and spillover effects. Clustering of firms together at a location implies frequent personal contacts, social ties among local actors that facilitate the circulation of information among them. Hence, intense knowledge spillovers are fostered by the proximity of firms, thereby promoting their innovation activity, and ultimately resulting in higher profit. Local non-traded inputs refer to peculiar products or services whose provision can be very expensive. However, if there are many firms located together, the cost of such special products or services can be dispersed among them. Co-locating of many firms also goes hand in hand with the accumulation of skilled workforce. In many sectors, the cost of searching and (re)training people can be extremely high and time-consuming, particularly in a rapidly changing environment. Therefore, easy access to a pool of skilled labor is also benefits to firms (Duranton – Puga 2004; Rosenthal – Strange 2004; Puga 2010; McCann 2013). Even though agglomeration economies can be classified in several ways, typically three major categories are distinguished: (1) benefits of *localization economies (Marshall – Arrow – Romer externalities)* are derived from the agglomeration of specialized firms across the same industrial sector, (2) *urbanization economies* (*Jacobs' externalities*) refer to cost savings generated through the locating together of people and firms across different industries, and (3) *internal economies of scale* results in a significant return because of the size of the firms (Parr 2002; McCann 2013).

Nowadays, there is a widely and strongly held view that global cities and large urban areas perform better and grow faster than the others. First of all the appearance of globalization, new information and communication technologies have given rise to the recognition that metropolis are the '*space of flows*' as they are important nodes of innovation and creativity (Castells 1996), and that give birth to the notion of *'global city'* theory (Sassen 2001). According to a large extent of literature the better performance of big cities can be explained by agglomeration economies. According to an array of empirical studies, agglomeration economies can be identified unambiguously as the pure '*benefits of cities*' (see summary by

Rosenthal – Strange 2003), or saying differently, agglomeration economies simply "*justify the existence of cities*" (Duranton – Puga 2004, 1)

According to several empirical analyses much evidence affirms that competitiveness (regarded as growth in productivity) associated with large and dense cities where agglomeration economies account for the accumulation of resources (e.g., Chinitz 1961; Glaeser et al. 1992; Ellison and Glaeser 1997; Ciccone and Hall 1996; Ciccone 2002; Henderson 2003a; Rosenthal and Strange 2003; Brülhart and Mathys 2008; Gardiner et al. 2010). The empirical evidence on the presence of agglomeration economies in developed countries is strong. Studies dealing with urbanization economies ascertain that a doubling of city size results in a productivity gain between 2 and 8 per cent (see overview from Vreeker 2009).

This general assumption follows that the more concentrated an urban system of a country, the more competitive and better its entrepreneurial performance. In his well-known theoretical general equilibrium model Paul Krugman explained the initial spatial concentration processes of economic activities by identifying the main reasons, and introduced a new stream in spatial economic science, the New Economic Geography (NEG). NEG interprets agglomeration economies as the outcome of three reasons: (1) increasing returns, (2) trade costs and (3) the demand of manufacturing products. Krugman's theory implies that production is prone to concentrate in a few regions, which will become populous and competitive (Krugman 1991, 2009). Despite the remarkable novelty of Krugman's theory, it does not give any satisfying answer about divergent regional growth (Acs and Varga 2002). Also Dijkstra et al. (2013) reviews those often-mentioned four tenets which serve as explanation for the ever-increasing concentration of people and economic growth in the largest cities, these are (1) density-competition effects, (2) Zipf's law type of distribution, (3) global cities are nurseries for new sectors as they are recipient of new knowledge and (4) free mobility of factors. Quigley (1998) also provides at least four possible reasons why a metropolitan area may provide greater economic efficiency. He ascertain that without the effect of (1) scale economies within the firm, (2) shared inputs in production and consumption, (3) reductions in transaction costs and (4) law of large numbers to the fact of fluctuation, there would be no role for the city at all.

The 'bigger is better' notion has gained quick and ardent acceptance from practitioners, particularly from policymakers. Consequently, many EU territorial strategic concepts support the same view, viz. metropolitan areas are the most important drivers of European competitiveness. Nevertheless, there are two new kinds of notions that keep urban

geographers, economist and also policymakers in suspense. First, over the last decade became an obvious trend that the overgrown increase of the largest cities has slowed down or even reversed in many developed (mainly European) countries. Second, despite the continuously reinforced relevance of agglomeration forces in explaining the better performance of big cities, less competitive metropolis regions, as well as demanding small- and medium cities still exist. This supports the view that the elaborated theory in present form cannot present a satisfying explanation to the phenomenon. So far there are only a few studies which pointed out that the relationship between productivity and city size is not that clear-cut as it was assumed in former studies (McCann and Acs 2011). Summarizing recent findings Dijkstra et al. (2013) point out that *"Although the academic literature tends to focus on the agglomeration advantages of large cities as linear and monotonic, the European data presented in this paper points to a much more mixed picture*." (Dijkstra et al. 2013, 347)

On the one hand, new explanations emphasize the often neglected and separated role of negative externalities as obstacles to further large city urbanization and as amenities to smaller and medium ones. Other hand, new explanations highlight that may other forces are at play, and these positive changes may increase the role of small cities and rural regions such as access to special services, including broadband etc. (Dijkstra et al. 2013). These new findings shed very different light on the role played by agglomeration economies in cites and urban areas' performance: "*there is something of an inverted U-shaped cross-sectional relationship between per capita productivity and urban scale*" (Dijkstra et al. 2013, 337). Duranton and Puga (2003) draw similar conclusion by assuming that the utility as a function of the city size shows an inverted U-shaped curve, and conclude that there is a trade-off between urban agglomeration economies and diseconomies which determine the efficient size of a city.

Burgeoning literature emphasizing that only indirect relationship exists between agglomeration effects and economic performance of cities, because agglomeration economies affects through innovation and entrepreneurship, therefore they must be handled in conjunction with each other (Acs et al. 2004; Acs and Varga 2005; Mueller 2006; Agarwal et al. 2010). During the last decades an almost uncountable number of papers were published in order to explain the relationship between agglomeration effects and innovation. Much empirical research has confirmed that enhanced flow of ideas and new knowledge attributable to agglomeration effect. Due to agglomeration economies primarily large cities provide easy sharing of knowledge. By attracting large numbers of skilled workforce, large cities are stronger and more competitive than smaller ones, because facilitate proximity necessary for face to face interactions which needed to generate, diffuse, and accumulate knowledge

(Feldman 1999; Keilbach 2000; Audretsch – Feldman 2004; Varga – Schalk 2004; Koo 2007; Carlino and Kerr 2014). Duranton and Puga (2001) introduced the notion of *'nursery'* cities, pointing out that large urban areas can be good at providing the incubation function. Also using data of 248 manufacturing firms during 8 years (1975–1982) *Batista and Swann* (1998) showed that if employment within the same sector in home region is strong a firm is considerably more likely to innovate, than firms outside the region. Also findings of empirical studies indicate positive effect of urban concentration on entrepreneurial performance mainly measured by new firm formation rates. New firms prefer highly urbanized areas which offer more opportunity for entrepreneurial success, because they can provide firms with large consumer base, relatively cheap physical infrastructure, tacit knowledge, special services or skilled workforce etc. (Reynolds et al. 1994; Acs and Armington 2004; Van Stel and Suddle 2008; Knoben et al. 2011). Quite recently, considerable attention has been paid the so called *Knowledge Spillover Theory of Entrepreneurship* which analyzes the relationship between agglomeration economies, knowledge creation and entrepreneurship. A higher level of accumulated knowledge stock may leads to a higher level of entrepreneurship. Human capital accumulation fostered by agglomeration forces is necessary for the facilitation of knowledge flow among local actors. New knowledge can be regarded as entrepreneurial opportunities, while absorptive capacity of entrepreneurs is critical for success of knowledge-based entrepreneurial actions (Audretsch et al. 2005; Audretsch – Keilbach 2007, 2008; Acs – Audretsch 2010; Acs et al. 2013; Qian – Acs 2013; Qian et al. 2013; Audretsch – Belitsky 2013). In their study, Plummer and Acs (2014) find a positive relationship between new knowledge and entrepreneurial activity, and according to their results agglomeration counteracts the moderating effect localized competition.

Even if only a few studies could *unambiguously* prove a positive contribution of agglomeration effects on economic growth. In fact the majority of studies have highlighted contradictory results. *De facto*; there are some papers that support the view that urbanization economies tend to increase with the size of the city and they have a positive impact on economic growth; on the other hand, other studies have found no clear evidence that urbanization economies would generate growth (David et al. 2013). Then, there are some other studies which may explain these contradictory results. Findings of these papers refer to the negative effects of urban concentration, such as higher costs of skilled labor or higher rent for land, environmental contamination and severe congestion. Recent studies suggest that spatial competition (for qualified labor and other inputs) as a centrifugal force can restrain the above-mentioned positive effect of urban concentration, possibly leading to a decrease in

start-up rates and productivity growth (Rizov et al. 2012). Henderson (2003b) has estimated the impact of urbanization and urban concentration on productivity growth at the country level for the period between 1960 and 1990. According to his results, productivity growth is not strongly affected by urbanization, because *"urbanization is not a growth stimulus per se, is it a by-product"*, but there is a "*best degree of urban concentration in terms of maximizing productivity growth which varies with the level of development and country size*" (Henderson 2003b, 50). Consequently, both over- and under-concentration have negative effects on growth: "*City size affects positively the degree of local information spillovers, which interactively affects local knowledge accumulation, promoting productivity growth. However, cities of extensive size draw resources away from investment and innovation in productive activity to try to maintain quality of life in a congested local environment.*" (Henderson 2003b, 67). According to Duranton and Puga (2001, 1454) cities can be conceived as areas "*facilitating search and experimentation in innovation"*. They also found evidence that under-sized cities have too little experimentation affecting productivity nationally, while over-sized cities waste excessive amounts of resources on other activities which drawing resources away from experimental activities, accordingly also inhibiting growth (Henderson 2003b). David et al. (2013) have systematically tested the relationship between city size (urban concentration) and the economic performance of cities in the European context. Their analysis also confirmed that the comparative advantage of cities also depends on the country in which they are located: *"In highly developed and densely urbanized areas, congestion effects might counteract the advantages of agglomeration. (...) Hence, it may be that, in the dense Western part of Europe more than in the rest of Europe, the performances of the cities are more linked to their economic structures, their heritage, and the quality of their governance than to their size and centrality.*" (David et al. 2013, 249). Castells-Quintana and Royuela (2014) in their study explain that agglomeration (as urban concentration) fosters growth particularly in low-income developing countries, while urbanization has positive effect on high-income developed countries. Since the large cities in Europe are highly urbanized areas, the positive link between urbanization and economic growth has already vanished. At the same time, dis-economies as congestion, pollution or high housing prices may have a negative effect. Consequently, economic growth in developed countries has been observed in small- and medium-sized cities, because of their intense urbanization: *"among the rich countries, twelve out of fifteen most entrepreneurial cities are small to medium-sized cities…"* (McCann – Acs 2012, p. 23).

We assume that the reasons behind these contradictory results that the most of the studies

focus solely on positive agglomeration economies. City size or population density are poor proxies for simultaneous handling the interrelatedness of the positive and negative externalities. We believe that the negative externalities are the natural consequences of positive agglomeration effect, and therefore, we need a variable which can express this dynamic interrelationship of negative and positive effect. For this purpose the best solution is using a variable which is calculated for *urban system* instead of individual cities. ROXY Index used in this study is that kind of variable, it helps to understand the complex relationship between a country's urban system characterized by spatial agglomeration (concentration) or deglomeration (deconcentration) processes and its competitiveness, as well as entrepreneurial performance, respectively. The innovative component of our paper is that we demonstrate the impact of urbanization economies classified by the four stages of spatial-cycle path on economic performance using a large sample of developed and developing countries, a long time span and a method which has never been used for such purpose. Our results consistent with other studies' findings related to the emerging literature on the limits of agglomeration economies.

3. Data and methodology

In this section we summarize the applied indexes and methodology. We employed three indexes for the analyses: (1) the *Global Competitiveness Index* (GCI) as a comprehensive tool to characterize country level competitiveness, (2) the *Global Entrepreneurship and Development Index* (GEDI) as a composite indicator of entrepreneurship performance, and (3) as a third index the *ROXY Index* which indicates the direction and size of population changes (concentration or deconcentration processes) within an urban system. We conducted correlation and cluster analysis to understand the relationship between urban concentration/deconcentration trends and economic performance.

3.1. Measuring country level competitiveness and entrepreneurship

Since 2004 the yearly published Global Competitiveness Report – developed by the World Economic Forum (WEF) – ranks countries according to their competitiveness based on a composite indicator, the so called *Global Competitiveness Index* (GCI). According to the WEF, competitiveness can be defined *"as the set of institutions, policies, and factors that determine the level of productivity of a country"* (Schwab 2013, p. 4). Therefore, GCI builds up from many different indicators which characterize the institutions, productivity or policies of countries. Altogether 12 pillars are created from the identified set of indicators, which can

be divided into three sub-indexes[2]: "basic requirements" (4 pillars), "efficiency enhancers" (6 pillars) and "innovation and sophistication factors" (2 pillars). The three sub-indexes are calculated by using weights which express the development level of a country's economy. Three development categories are used by WEF: factor-driven, efficiency-driven and innovation-driven economies. The involved countries are grouped into five groups which are determined by the three development levels and two transition stages. Finally, the GCI Index is composed by the weighted average of the three sub-indexes. In our research, we used data derived from several GCI reports over the period 2006–2014.

The Global Entrepreneurship Development Institute lead by Zoltan J. Acs and Laszlo Szerb developed the *Global Entrepreneurship Index* (GEDI). The GEDI Index is 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). 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 "institutional context" of the country as well. The index consists of three sub-indexes (attitudes, abilities, aspirations) and each sub-index has four or five pillars. The GEDI pillars are determined by a complex way and they indicate a combined effect of individual and institutional data[3].

To express urbanization economies, we calculated the so called ROXY Index[4] which is *"an indicative instrument to quantitatively identify the major stages of the spatial cycles. This index can be used in conducting both of the intra- and inter-city analysis to study the spatial agglomeration and deglomeration processes"* (Fukatsu – Kawashima et al. 1999, p. 395). The ROXY Index captures the effect of migration through the periodical change of population. On the one hand, it measures the change of population by a weighted average growth ratio, and on the other hand, by a simple average growth ratio (see the formula below).

[2] The whole descriptions of GCI sub-indexes and pillars are available in the 2013-14 edition of the Global Competitiveness Report: http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf
[3] The whole description of GEDI sub-indexes and pillars are available in the latest GEDI book: Zoltan J. Acs et al. (2013): *Global Entrepreneurship and Development Index*. Edward Elgar Publishing.
[4] ROXY means "**R**atio **o**f *Weighted Average Growth Ratio* (abbreviated as **X**) to *Simple Average Growth Ratio* (abbreviated as **Y**)" (*Kawashima* 1985)

$$ROXY\ Index = \frac{WAGR_{t,t+1}}{SAGR_{t,t+1}} - 1{,}0 \ \ * 10^4 = \frac{\sum_{i+1}^{n} x_i^t * r_i^{t,t+1}}{\sum_{i=1}^{n} x_i^t} * \frac{n}{\sum_{i=1}^{n} r_i^{t,t+1}} - 1{,}0 \ \ * 10^4 \qquad (1)$$

where:

x_i^t = population of city "i" in year "t"

$r^{t,\,t+1}_i$ = annual growth ratio of population in city "i" for the period between years "t" and "t+1", which is defined as the "k"th root of x_i^{t+k}/x_i^t

n = number of cities

$WAGR_{t,\,t+1}$ = weighted average of annual growth ratios of population "n" cities for the period between years "t" and "t+1", which is equal, in the case where population level of each city is used as a weighting factor, to

$(x_i^t * r_i^{t,t+1}) / \ x_i^t$

$SAGR_{t,\,t+1}$ = simple average of annual growth ratios of population in "n" cities for the period between years "t" and "t+1", which is equal to

$r_i^{t,t+1}/n$

Marginal value of the ROXY Index (ΔROXY)

$$\Delta ROXY = \frac{ROXY\ Index_{(t+1,t)} - ROXY\ Index_{(t,t-1)}}{Cf} \qquad (2)$$

$ROXY\ Index_{(t+1,t)}$ = the value of ROXY Index for period "t"

$ROXY\ Index_{(t,\,t-1)}$ = the value of ROXY Index for period "t-1"

Cf = the difference between the mid-point time for "t" period and the mid-point time for "t-1" period

Source: Kawashima et al. (1997, 221.) and Fukastu – Kawashima (1999, 407.)

The index based on the spatial-cycle hypothesis originally conceptualized by Klaassen (1979, 1981). Klaassen differentiated four stages of the spatial-cycle path: Stage 1 – Accelerating concentration, Stage 2 – Decelerating concentration, Stage 3 – Accelerating deconcentration and Stage 4 – Decelerating deconcentration (Kawashima et al. 1997). First version of the ROXY Index was published in an empirical study written by Kawashima (1978). Since then the index has been developed further and used in numerous empirical studies to identify the spatial agglomeration – deglomeration phenomena associated with the changes in population or other social and economic variables (see Kawashima 1982, 1985, 1986; Hirvonen et al. 1997; Fukatsu–Kawashima 1999).

According to the size and direction of the ROXY Index four hypothetical stages of the spatial-cycle process can be distinguished. The positive value of the ROXY Index means concentration, while the negative value shows deconcentration. The direction of change depends on the value of ΔROXY: if it is positive, there is an accelerating concentration or decelerating deconcentration; if it is negative, it indicates an accelerating deconcentration or decelerating concentration (Table 1).

Table 1: The characteristics of different stages of urbanization

Stages of urbanization	The size and direction of change

AC (accelerating concentration)	positive ROXY value , ΔROXY positive
DC (decelerating concentration)	positive or negative ROXY value, ΔROXY negative
DD (decelerating deconcentration)	negative or positive ROXY value, ΔROXY positive
AD (accelerating deconcentration)	negative ROXY value, ΔROXY negative

Source: own compilation based on Kawashima et al. (1997).

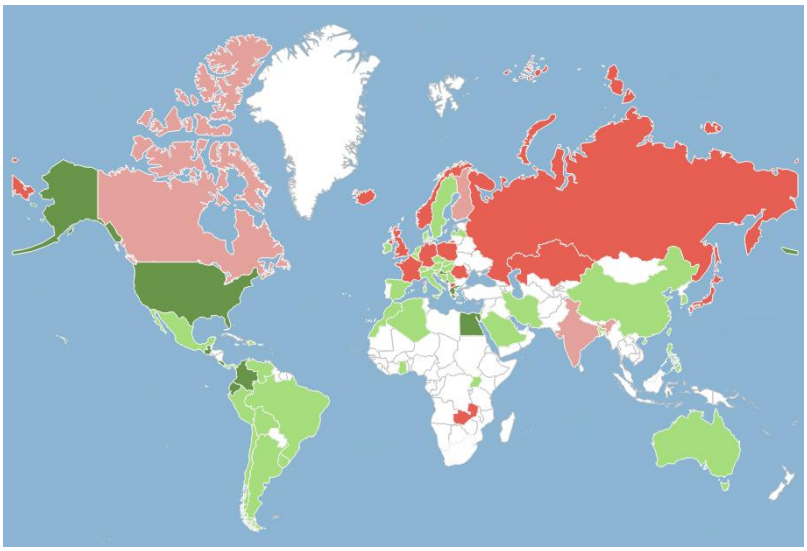
There are two crucial points in the computation of the ROXY Index: (1) the length of the examined period and (2) the number of cities which are involved in the examination. Therefore, we tried to find a rule or concept which could help us identify the most important cities of each examined country. However, data like GDP which could represent the most important cities in a country are available only for few countries at the city level. After reviewing some of the relevant literature (see Gabaix 1999; Eeckhout 2004; Tabuchi et al. 2005; Czaller 2012), we realized that although the problem of determining the adequate number of cities is known, but there is no clear solution exists. Therefore, we decided to analyze three cases and conducted the analysis for the first 20, 30 and 40 most populated cities of the 70 countries. We had to consider that our sample contains very different countries with regard to their size. Thus, examining an urban system with less than 20 cities was considered too small; on the other hand, in the case of some countries, it was not possible to examine their urban systems with more than 40 cities, because data were not available. The three mentioned cases may serve as a robustness check of the results as well.

The other important factor to calculate the ROXY Index is the time period in which the index indicates the agglomeration or deglomeration trends. Therefore, we used the three latest available data of city populations. Thus, we created two periods ($ROXY_t$ and $ROXY_{t-1}$) and calculated the ΔROXY that shows the direction and the scale of change. Our original idea was that the time periods used by the GEDI/GCI Index would be considered by the calculation of the $ROXY_t$ and $ROXY_{t-1}$ indexes. However, because of data availability, the first or last years, and also the lengths of the periods were not the same for the different countries (see Appendix Table A1).

Originally, we planned to carry out analyses for all the countries involved in the GEDI research during the examined time period. It was altogether 76 countries, but we excluded some of them due to the lack of city population data. Thus, we could involve 70 countries (Figure 1). Our country set contains developed and developing nations as well. Because of the lack of former city population data, it was not possible to calculate $ROXY_{t-1}$ for some countries (Jordan, Malaysia, Portugal and South Africa), hence we had to exclude them from

the later examinations. In the case of the United Arab Emirates city population data are available only for its 9 biggest cities, therefore only the ROXY20 was calculated for the available cities of United Arab Emirates (UAE).

Figure 1: The involved countries and their characteristics of different stages of urbanization



Note: green color refers to countries where deconcentration is accelerating, light green color refers to countries where deconcentration is decelerating, while red and pink colors represent counties where concentration is accelerating or decelerating, respectively.
Source: own edition.

3.2. Method

In order to examine the intensity and direction of the relationships among the indexes we conducted correlation analysis. We carried out the correlation analyses separately for the two indexes – GCI and GEDI – using the three versions of the ROXY Index (ROXY20, ROXY30 and ROXY40). The analyses were not limited to the main indexes alone. We analyzed the relationships between the ROXY Index and the different sub-indexes of GCI and GEDI as well. Furthermore, those sub-indexes of GCI and GEDI which showed the highest correlation with the ROXY Index were also examined.

As a first step, we checked the characteristics of our descriptive statistics. GCI and GEDI did not require any data transformations, but a relatively high skewness was discovered considering the ROXY Index. We managed this problem with a transformation process. Many data transformation processes were checked that may solve the problem of skewness. The results of the correlation analysis with different transformation processes did not show significant differences. Hence, we decided to apply the Box-Cox transformation method, in the same way as Annoni–Kozovska (2010). Finally, the transformed ROXY Index data were rescaled to a scale from 0 to 10.

We endeavor to use not only the annual values of GEDI and GCI, but representing the changes in their values during a given time period as well. Therefore, we calculated the average value of both indexes for the whole period (GCI_AVE and GEDI_AVE). To catch the changes within the examined period, the changes from year to year were calculated and averaged for each country as well (GCI_CH and GEDI_CH). Finally, we multiplied the "average values" with the "change values" in the case of both indexes (GCI_AVG_CH and GEDI_AVG_CH). Then we rescaled both modified indexes to a scale from 0 to 10.

As a next step, K-means cluster analysis was conducted. First, the observed outliers were excluded from the analysis. The examination started with 66 countries in the case of ROXY20 (no available [t-1] data for Jordan, Malaysia, Portugal and South Africa) and 65 countries in the case of ROXY30 and ROXY40 (no available [t-1] data for Jordan, Malaysia, Portugal and South Africa and UAE). We used the original and transformed ROXY indexes in the cluster analysis as well. We tested different numbers of clusters (2, 3, 4, 5 and 6 groups). However, the results of the ANOVA test (the optimal F- and significance-values) have indicated to create 3 clusters in the case of GCI with original ROXY Index and 4 clusters with transformed ROXY values. While countries were classified in 4 groups in the case of GEDI Index using transformed ROXY values. The tests proved that the groups are significantly different from each other at every significance level.

4. Results

4.1. Results of the examination: ROXY and GCI indexes

In this sub-section, we examine the intensity and direction of the relation between the GCI Index and the three version of ROXY Index. Table 2 contains both the original ROXY indexes for different pools of cities (ROXY20, ROXY30 and ROXY40) and the three Box-Cox transformed and rescaled ROXY indexes (ROXY_BOXCOX_10) as well.

According to the correlation analysis, there is a positive relationship between the ROXY and the GCI Index, but the intensity of this relationship is quite moderate and it is significant only with the Box-Cox transformed ROXY indexes. The ROXY40_BOXCOC_10 variable and the GCI Index show the strongest correlation coefficient (r = 0.321). If we analyze the relationship between the ROXY Index and the three sub-indexes of GCI (BASIC – GCI Basic sub-index, EFF – Efficiency sub-index, INN – Innovation sub-index), the strongest correlation can be observed between the ROXY Index and the GCI Efficiency sub-index, but only a loose connection can be confirmed among them (r = 0.350). We can assume that

concentration or deconcentration of the population within an urban system has a moderate effect on efficiency (Table 2). In order to investigate this presumption, we detach the relationship between the transformed ROXY Index and the different pillars of the GCI Efficiency sub-index (Table 3).

Beside the intensity of the connection, the direction is also very important. A positive correlation coefficient between the ROXY Index and the GCI Index and its sub-indexes means that *the higher concentrated the population within a country's urban system, the higher the value of the GCI Index. Higher GCI value refers to the higher competitiveness of the country.*

Table 2: The correlation coefficients between the GCI Index, its sub-indexes and ROXY Index

ROXY INDEX *(original and transformed)*	**GCI_(AVG_CH)**	**BASIC_(AVG_CH)**	**EFF_(AVG_CH)**	**INN_(AVG_CH)**
ROXY20	0.187	0.186	0.220	0.139
ROXY30	0.216	0.210	0.242*	0.154
ROXY40	0.218	0.209	0.241*	0.153
ROXY20_BOXCOX_10	0.221	0.223	0.267*	0.182
ROXY30_BOXCOX_10	0.295*	0.279*	0.348**	0.260*
ROXY40_BOXCOX_10	0.321**	0.305*	*0.351***	0.292*

Note: BASIC = GCI „Basic" sub-index, EFF = GCI „Efficiency" sub-index, INN = GCI „Innovation" sub-index
* – Correlation is significant at the 0,05 level (2-tailed), ** – Correlation is significant at the 0,01 level (2-tailed)
Source: own calculations.

Table 3: The correlation coefficients between the pillars of GCI Efficiency sub-index and ROXY Index

Pillars of GCI Efficiency sub-index	**ROXY20_BOXCOX_10**	**ROXY30_BOXCOX_10**	**ROXY40_BOXCOX_10**
HT_(AVG_CH)	0.283*	*0.361***	*0.362***
MEFF_(AVG_CH)	0.149	0.255*	0.283*
LEFF_(AVG_CH)	0.297*	*0.403***	*0.382***
FIN_(AVG_CH)	0.112	0.192	0.206
TECH_(AVG_CH)	0.295*	*0.385***	*0.396***
MSIZE_(AVG_CH)	0.143	0.108	0.095

Note: HT = Human capital pillar, MEFF = Market efficiency pillar, LEFF = Labor efficiency pillar, FIN = Financing pillar, TECH = Technological readiness pillar, MSIZE = Market size pillar, AVG = average, CH = change.
Source: own calculations.

Efficiency sub-index group's pillars related to human capital, market efficiency, labor productivity, financing, technology readiness and market size. Three of the pillars – Human capital, Labor efficiency and Technology readiness – show positive medium-strength correlation coefficients with the transformed and rescaled ROXY Index (Table 3). The strongest connection is shown between GCI Labor efficiency pillar and transformed ROXY30 (r = 0.404). The positive coefficient means that *the higher the concentration in a country's urban system in a given period, the higher the labor efficiency, the technological readiness and the quantity of skilled human capital of the country.*

As a next step, we conducted cluster analysis for each county's urban system consisting of the first most populous 20, 30 and 40 cities, respectively. Determining the direction of change we calculated the ROXY values for the previous period (t-1) in order to receive the ΔROXY. We carried out the cluster analysis with different cluster number (2, 3, 4, 5 and 6 groups). Using original ROXY values, the ANOVA analysis showed the best F-test values with 3 clusters (the interpretation of the clusters below or over 3 clusters was problematic). However, using the Box-Cox transformed ROXY values, the interpretation of 4 clusters seem to be more appropriate (ANOVA analysis showed appropriate F-test values for both 3 and 4 clusters). Consequently, we present here the results of the cluster analysis for three and four clusters. According to the ANOVA test, the significance was lower than 0.05, proving that the clusters in terms of the variables differ from each other. Here, we only show the results of the cluster analysis conducted between the ROXY30 and GCI index (cluster analyses with ROXY20 and ROXY40 are available in the Appendix and serve as robustness checks).

As mentioned above, using the original ROXY Index, we could distinguish three clusters (Table 4). *Cluster 1* contains those countries whose urban system is characterized by a strong concentration trend represented with a high ROXY value (final cluster center = 5.21). The results show that the competitiveness of those countries in which the urban system is highly concentrated is high (GCI final cluster center = 5.33). It contains 11 countries characterized by the acceleration of concentration (AC) and 29 countries characterized by the deceleration of deconcentration (DD). *Cluster 2* consists of 12 countries, among them 9 characterized by deceleration of deconcentration, but they are still in deconcentration stage. This cluster generally contains countries in which the urban system is heading to concentration from the deconcentration stage. This cluster is a transitional category. *Cluster 3* contains those countries in which the deconcentration of the urban system is accelerating (AD, ROXY final cluster center = -168.86). According to the results of the analysis, *if deconcentration is strengthening, competitiveness will drop* (GCI final cluster center = 2.63).

On the other hand, using the Box-Cox transformed ROXY Index, we could identify 4 clusters of countries (Table 4 and Figure 2). An important difference compared to the 3 cluster case is that here, if a country's urban system is characterized *either by a strong concentration trend* (Cluster 1) *or by a strong deconcentration trend* (Cluster 4), *competitiveness will fall* (Cluster 1 – GCI final cluster center = 2.77, Cluster 4 – GCI final cluster center = 2.82). While if the county's urban system is in a transition stage – meaning it is not so concentrated, or not so deconcentrated – competitiveness will be more outstanding (Cluster 2 – GCI final cluster center = 8.33, Cluster 3 – GCI final cluster center = 4.57).

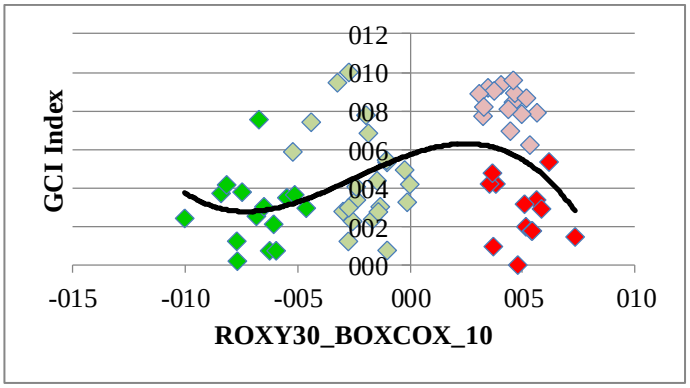
Table 4: Results of the cluster analysis: ROXY30 – GCI index

Final Cluster Centers	Cluster 1 *Concentration with generally high GCI values*	Cluster 2 *Deceleration of deconcentration with GCI values higher than the average*	Cluster 3 *Deconcentration with generally low GCI values*
Number of cases	45	12	5
ROXY 30	5.21	-55.51	-168.86
GCI	5.33	3.49	2.63
AC	***11***	-	-
DC	2 *(conc)*	-	1 *(deconc)*
DD	***29*** *(16 deconc, 13 conc)*	***9*** *(deconc)*	1 *(deconc)*
AD	3	3	***3***

Final Cluster Centers	Cluster 1 *Concentration with generally low GCI value*	Cluster 2 *Acceleration of concentration with high GCI value*	Cluster 3 *Deceleration of deconcentration with high GCI value*	Cluster 4 *Deconcentration with generally low GCI value*
Number of cases	13	15	22	15
ROXY 30_BOXCOX	5.04	4.30	-2.02	-6.85
GCI	2.77	8.33	4.57	2.82
AC	***5***	***6***	-	-
DC	-	*2 (conc)*	-	1 *(deconc)*
DD	***7****(conc)*	***7*** *(conc)*	***18*** *(deconc)*	***8*** *(deconc)*
AD	1	-	4	***6***

Notes: same as in Table 3.
Source: own calculation.

Figure 2: Connection between GCI scores and ROXY30_BOXCOX



Note: green color refers to countries where deconcentration is accelerating, light green color refers to countries where deconcentration is decelerating, while red and pink colors represent counties where concentration is accelerating or decelerating, respectively.
Source: own calculation.

4.2. The results of ROXY and GEDI examination

For the analysis we used both the original index values (ROXY) and the Box-Cox transformed values (ROXY_BOXCOX_10). The original values represented a relatively high level of skewness, hence the results of their examination should take into account carefully. The analysis show that there are positive relationships between the GEDI Index and the

different ROXY indexes, but the intensity is moderate. We examined the relationships for the three sub-indexes of GEDI as well (ATT – Entrepreneurial Attitudes, ABT – Entrepreneurial Abilities, ASP – Entrepreneurial Aspirations). The Attitudes sub-index has the weakest, while the Aspiration has the strongest relationship with ROXY indexes among the sub-indexes (Table 5).

Table 5: The correlation coefficients between the GEDI Index, its sub-indexes and ROXY Index

ROXY INDEX *(original and transformed)*	**GEDI (AVGCH)**	**ATT (AVGCH)**	**ABT (AVGCH)**	**ASP (AVGCH)**
ROXY20	0.309**	0.252*	0.278*	0.334**
ROXY20_BOXCOX_10	0.277*	0.198	0.264*	0.305*
ROXY30	0.328**	0.279*	0.297*	0.343**
ROXY30_BOXCOX_10	*0.355***	*0.281**	*0.353***	0.358**
ROXY40	0.310**	0.246*	0.284*	0.335**
ROXY40_BOXCOX_10	0.335**	0.254*	0.316**	*0.360***

Notes: ATT = "attitudes", ABT = "abilities, ASP = "aspirations", AVG = average, CH = change
* – Correlation is significant at the 0,05 level (2-tailed), ** – Correlation is significant at the 0,01 level (2-tailed)
Source: own calculation.

The analysis indicates the strongest correlation between the ROXY Index and GEDI in the case of ROXY30_BOXCOX_10 (r = 0.355). The lowest results were measured in the case of ROXY20, while the other two ROXY cases have almost the same scores. We can see almost the same results at the sub-indexes. The positive correlation coefficient between the ROXY indexes and GEDI means that *the higher concentrated the population in a given country's urban system, the better the entrepreneurial performance there*. To discover more about the attributes of entrepreneurial aspirations, we analyzed the pillars of this sub-index as well (Table 6).

Table 6: The correlation coefficients between the pillars of GEDI Aspiration sub-index and ROXY Index

Pillars of GEDI Aspirations sub-index	**ROXY20_BOXCOX_10**	**ROXY30_BOXCOX_10**	**ROXY40_BOXCOX_10**
ProdInnov_AVG_CH	0.191	0.230*	0.271*
ProcInnov_AVG_CH	0.257*	0.270*	0.317**
HGrowth_AVG_CH	**0.307****	**0.382****	**0.346****
Internation_AVG_CH	0.268*	0.345**	0.326**
RiskCap_AVG_CH	0.246*	0.261*	0.261*

Notes: ProdInnov = "product innovation", ProcInnov = "process innovation", HGrowth = "high growth", Internation = "internationalization", RiskCap = "risk capital", AVG = average, CH = change
* – Correlation is significant at the 0,05 level (2-tailed), ** – Correlation is significant at the 0,01 level (2-tailed)
Source: own calculation.

Almost all of the pillars of Aspiration sub-index have significant relationship with the different ROXY indexes, but two pillars are outstanding among them: High growth and Internationalization have the strongest correlation coefficients with the ROXY Index. It

means that *the high growth (of firm size) and internationalization of firms are relatively dependent on the concentration or deconcentration of a country's population*.

The cluster analysis was carried out for each ROXY Index case (cluster analyses with ROXY20 and ROXY40 see in the Appendix) with the GEDI Index. We applied the original ROXY Index for this examination. The ROXY30 cases showed the best correlation values with the GEDI Index and its sub-indexes. In this case, we used the data of 65 countries, because it was not possible to involve the United Arab Emirates. The first results of cluster analysis helped us to filter the extreme values. There were altogether 7 countries which had extreme positive or negative values (Costa Rica, Dominican Republic, Ecuador, Guatemala, India, Panama and Zambia). Thus, 58 countries have been involved in this cluster analysis (Table 7).

Table 7: Results of cluster analysis: ROXY30 and GEDI Index

Final Cluster Centers	**Cluster 1** *Concentration with generally lower GEDI value*	**Cluster 2** *Acceleration of concentration with high GEDI value*	**Cluster 3** *Deceleration of deconcentration with high GEDI value*	**Cluster 4** *Deconcentration with generally low GEDI value*
Number of cases	10	18	21	9
ROXY 30_BOXCOX	27.76	4.24	-10.31	-62.66
GEDI	39.35	69.4	41.07	31.78
AC	***5***	***5***	2	-
DC	-	2 *(conc)*	-	-
DD	***5*** *(conc)*	***6*** *(conc)* ***3*** *(deconc)*	***16*** *(deconc), 2 (conc)*	**6** *(deconc)*
AD	-	2	1	***3***

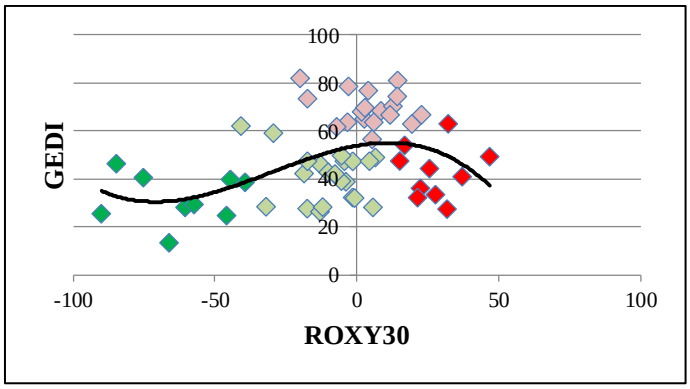
Source: own calculation.

Cluster 4 contains those countries whose urban system is characterized by the acceleration of deconcentration or deceleration of deconcentration (but the cases typically still remain in the deconcentration stage) represented with a relatively low ROXY30 and GEDI values (GEDI final cluster center = 31.78). *Cluster 3* contains those countries where deconcentration is decelerating, but these countries are mostly still in deconcentration stage. In this cluster the GEDI Index is a bit higher than in Cluster 4 (GEDI final cluster center = 41.07). Those countries have the highest GEDI values which belong to *Cluster 2* (GEDI final cluster center = 69.4). This cluster can be characterized by the acceleration of concentration trends. This cluster generally contains countries in which the urban system is heading to concentration from deconcentration stage. This cluster is a transitional category: it shows deceleration of

deconcentration in countries those already changed into concentration stage (DD) or are still in deconcentration stage (DC). The countries in *Cluster 1* have the highest ROXY30 values (final cluster center = 27.76), but their GEDI values (final cluster center = 39.35) lower than of countries in Cluster 2.

These results refer that those countries which show deconcentration trends have lower GEDI values than other countries characterized by concentration. However, this does not mean an obvious nexus between concentration and high entrepreneurial performance. It seems that concentration of the population has a positive effect on entrepreneurship, but on the other hand, *there is a threshold and after that further concentration of the population may not improve the entrepreneurial performance, but it has a negative effect on it* (Figure 3).

Figure 3: The connection between the GEDI scores and ROXY30



Note: green color refers to countries where deconcentration is accelerating, light green color refers to countries where deconcentration is decelerating, while red and pink colors refer to counties where concentration is accelerating or decelerating, respectively.
Source: own calculation.

In order to gain a deeper understanding, we provide descriptions of each identified cluster in a detailed manner regarding the countries stage of economic development, entrepreneurship (GEDI Index score) and competitiveness (GCI score).

Cluster 1 represents a trend of over-concentration. On the one hand, this cluster includes countries that are in the stage of strong concentration, on the other, countries with weakening deconcentration. The group includes developed (like Austria or Japan) and less developed countries (like FYRO Macedonia or Uganda) also. The concentration may cause difficulties (like pollution, crime or higher real estate prices) in agglomeration areas due to overconcentration of the population. The lack of medium-size cities within city-network may also explain the over-concentration of the most populated agglomeration area.

Cluster 2 contains the most developed countries (like Switzerland, USA or Germany) in our examination. They have the highest scores in competitiveness and entrepreneurial performance. Their ROXY30 scores are around zero, it means that there are not any

unambiguously trend in concentration or deconcentration which could characterize this group. It may refer on the relatively high competitiveness of these economies. The medium-sized cities have also an important role because they may serve as attractive destinations for entrepreneurial activity and investments. The concentration level of city-network seems to be optimal.

Cluster 3 involves emerging economies from all over the world mostly. It is the most mixed group from the aspect of stage of economic development among the four clusters. They are characterized by average entrepreneurial performance and medium-level of competitiveness. Their main trend is decelerating deconcentration according to the ROXY30 values. It refers on the continuously growth of population in the most important cities of the countries. It means that the population move to those one or two agglomeration areas which may attract the investments and human capital in this way. The over-concentration of these areas has not caused serious difficulties (like high real estate prices or higher level of crime) yet.

Cluster 4 (trend of under-concentration) is characterized by the lowest level of competitiveness and the weakest entrepreneurial performance. Its main trend is the deconcentration of population. These countries (city-networks) cannot attract investment (both of domestic and foreign) which may help to stimulate the entrepreneurships and the whole economy. It seems to be unsure which cities can provide an adequate environment for example for FDI or other investments that can stimulate the creation of an agglomeration.

5. Conclusions

The correlation analyses confirmed that *the higher concentrated the population within a country's urban system, the higher its competitiveness and entrepreneurial performance*. This result seemingly supports the "bigger is better" concept. The correlation analysis has shown that the concentration or deconcentration of the population is *only one important factor* in explanation of countries' entrepreneurial performance and competitiveness. This has been proven by the moderate correlation coefficients between the GCI/GEDI and ROXY indexes (both original and transferred). Consequently, we should consider that other effects may exist (e.g. differences in institutional settings, creativity and openness, culture, connectivity).

However, in depth analysis (conducing cluster analyses) confirmed that *relatively high-level of concentration or deconcentration within an urban system is coupled with lower GCI/GEDI values*. Those countries have the highest GCI/GEDI values which have ROXY Index value close to zero. It means that they have a moderate level of concentration (positive

ROXY values) or moderate level of deconcentration (negative ROXY values). Our analysis indicates that initially as concentration increases (or deconcentration decreases) competitiveness and entrepreneurial performance also increase, but at a decreasing rate. Both of them eventually reaches a maximum and then after a certain point decreases with further concentration.

Although the academic literature tends to consider the agglomeration advantages of large cities as linear and monotonic, we could prove on a large sample of developed and developing countries' urban system the curve apprehends this relationship is non-linear and folding back.

As follows, our results support the view that concentration is useful till a certain threshold, but excessive concentration could not help to improve competitiveness or entrepreneurial performance. In other words, this indicates that *under- or over-concentration of the population within an urban system is not a useful phenomenon considering competitiveness or entrepreneurial performance*.

Our findings suggest there is an optimal city size for each city in a country's urban system simultaneously influenced by agglomeration economies and diseconomies. The ROXY Index using it for analyzing the inter-city population trends helps us to roll up the position of each element of a country's urban system in spatial-cycle process. As a result, our findings suggest that place-based and tailor-made development policy recommendations should not focus on individual (large) cities, but should take a holistic view and considering the whole urban system of the country.

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Appendix

Table A1: The length of examined periods

Country	*Period (t)*	*Period (t-1)*		*Period (t)*	*Period (t-1)*
Algeria	2008/1998	1998/1987	Jordan	2004/1994	no results
Argentina	2010/2001	2001/1991	Kazakhstan	2012/1999	1999/1989
Australia	2011/2006	2006/2001	Korea	2012/2002	2002/1997
Austria	2013/2001	2001/1991	Latvia	2013/2000	2000/1989
Bangladesh	2011/2001	2001/1991	Macedonia	2010/2002	2002/1994
Belgium	2013/2000	2000/1990	Malaysia	2000/1991	no results
Bolivia	2010/2001	2001/1992	Mexico	2010/2005	2005/2000
Bosnia Herzegovina	2013/1991	1991/1981	Montenegro	2011/2003	2003/1991
Brazil	2010/2000	2000/1991	Morocco	2004/1994	1994/1982
Canada	2011/2006	2001/1996	The Netherlands	2013/2000	2000/1990
Chile	2012/2002	2002/1992	Norway	2013/2000	2000/1990
China	2010/2000	2000/1990	Panama	2010/2000	2000/1990
Colombia	2010/2005	2005/1993	Peru	2007/1993	1993/1981
Costa Rica	2011/2000	2000/1984	Philippines	2010/2000	2000/1990
Croatia	2011/2001	2001/1991	Poland	2012/2002	2002/1992
Czech Rep	2011/2001	2001/1991	Portugal	2011/2001	no results
Denmark	2013/2000	2000/1990	Puerto Rico	2010/2000	2000/1990
Dominican Rep	2010/2002	2002/1993	Romania	2011/2002	2002/1992
Ecuador	2010/2001	2001/1990	Russia	2013/2002	2002/1989
Egypt	2006/1996	1996/1986	Saudi Arabia	2010/2004	2004/1992
Finland	2012/2000	2000/1990	Serbia	2011/2002	2002/1991
France	2011/2006	2006/1999	Slovakia	2012/2001	2001/1991
Germany	2012/2001	2001/1995	Slovenia	2013/2002	2002/1991
Ghana	2010/2000	2000/1996	South Africa	2011/2001	no results
Greece	2011/2001	2001/1991	Spain	2013/2001	2001/1991
Guatemala	2008/2002	2002/1994	Sweden	2012/2005	2005/2000
Hungary	2013/2001	2001/1990	Switzerland	2012/2000	2000/1990
Iceland	2013/2005	2005/2000	Taiwan	2012/2006	2006/2001
India	2011/2001	2001/1991	Uganda	2011/2002	2002/1991
Iran	2011/2006	2006/1996	UAE	2005/1995	1995/1985
Ireland	2011/2006	2006/2002	United Kingdom	2011/2001	2001/1991
Israel	2012/2008	2008/1995	United States	2012/2000	2000/1990
Italy	2012/2001	2001/1991	Uruguay	2011/2004	2004/1996
Jamaica	2011/2001	2001/1991	Venezuela	2011/2001	2001/1990
Japan	2010/2005	2005/2000	Zambia	2010/2000	2000/1990

Source: edited by the authors.

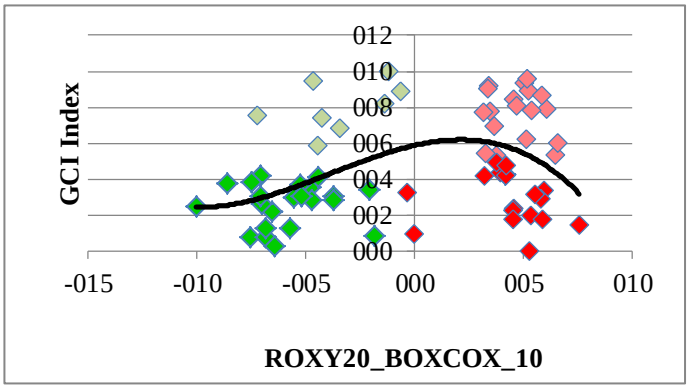
Table A2: Results of the cluster analysis: ROXY20 – GCI index

Final Cluster Centers	Cluster 1 *Concentration with generally high GCI value*	Cluster 2 *Deceleration of deconcentration, with GCI values higher than the average*	Cluster 3 *Deconcentration, with generally low GCI values*
Number of cases	33	20	10
ROXY 20	15.10	-17.43	-82.13
GCI	5.58	4.60	2.61
AC	***9***	-	-
DC	2 *(conc / deconc)*	1 *(deconc)*	2 *(deconc)*
DD	***22*** *(conc)*	***18*** *(deconc)*	3
AD	-	1	***5****(deconc)*

Final Cluster Centers	Cluster 1 *Concentration with generally low GCI value*	Cluster 2 *Acceleration of concentration with high GCI*	Cluster 3 *Deceleration of deconcentration with high GCI value*	Cluster 4 *Deconcentration with generally low GCI value*
Number of cases	18	18	8	22
ROXY 20_BOXCOX	4.35	4.69	4.35	-5.81
GCI	2.78	7.62	7.94	2.49
AC	***6***	***4***	-	-
DC	1 *(deconc)*	*2 (conc)*	-	2 *(deconc)*
DD	***11*** *(conc)*	***12*** *(conc)*	***7*** *(deconc)*	***13*** *(deconc)*
AD	-	-	1	***7***

Notes: **AC** = Acceleration of concentration. **DC (deconc)** = Deceleration of concentration and it has already changed to deconcentration stage. **DC (conc)** = Deceleration of concentration, but it is still in concentration stage. **DD (deconc)** = Deceleration of deconcentration, but it is still in deconcentration stage. **DD (conc)** = Deceleration of deconcentration and it has already changed to concentration stage. **AD** = Acceleration of deconcentration.
Source: own calculation.

Figure A1: The connection between GCI scores and ROXY20_BOXCOX



Note: green color refers to countries where deconcentration is accelerating, light green color refers to countries where deconcentration is decelerating, while red and pink colors refer to counties where concentration is accelerating or decelerating, respectively.
Source: own calculation.

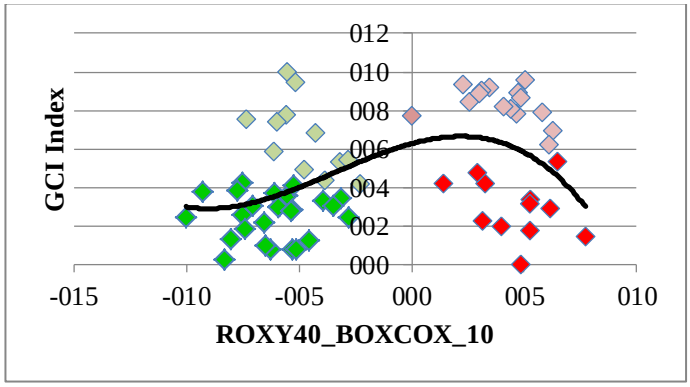
Table A3: Results of the cluster analysis: ROXY40 – GCI index

Final Cluster Centers	**Cluster 1** *Concentration with generally high GCI values*	**Cluster 2** *Deceleration of deconcentration, with GCI values higher than the average*	**Cluster 3** *Deconcentration, with generally low GCI values*
Number of cases	26	28	8
ROXY 40	16.38	-21.28	-96.10
GCI	6.12	4.03	3.03
AC	***10***	-	-
DC	4 *(conc)*	-	1 *(deconc)*
DD	***12*** *(conc)*	***24*** *(deconc)*	1 *(deconc)*
AD	-	4	***6***

Final Cluster Centers	**Cluster 1** *Concentration with generally low GCI value*	**Cluster 2** *Acceleration of concentration with high GCI value*	**Cluster 3** *Deceleration of deconcentration, with high GCI value*	**Cluster 4** *Deconcentration, with generally low GCI value*
Number of cases	12	15	12	26
ROXY 40_BOXCOX	4.64	4.02	-4.74	-6.11
GCI	2.96	8.33	6.60	2.47
AC	***5***	***5***	-	-
DC	1 (conc)	*3 (conc)*	1 *(deconc)*	-
DD	***6*** *(conc)*	***7*** *(conc)*	***8*** *(deconc)*	***17*** *(deconc)*
AD	-	-	3	***9***

Notes: same as in Table 3 and Table 4.
Source: own calculation.

Figure A2: The connection between GCI scores and ROXY40_BOXCOX



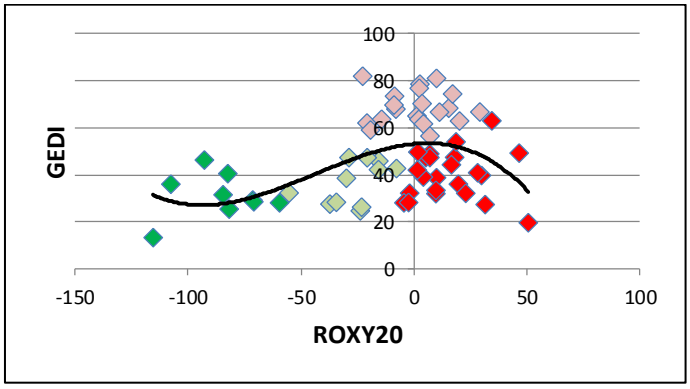
Note: green color refers to countries where deconcentration is accelerating, light green color refers to countries where deconcentration is decelerating, while red and pink colors refer to counties where concentration is accelerating or decelerating, respectively.
Source: own calculation.

Table A4: Results of cluster analysis: ROXY20 – GEDI Index

Final Cluster Centers	Cluster 1 *Concentration with generally lower GCI value*	Cluster 2 *Acceleration of concentration with high GCI value*	Cluster 3 *Deceleration of deconcentration, with high GCI value*	Cluster 4 *Deconcentration, with generally low GCI value*
Number of cases	23	20	11	9
ROXY 40_BOXCOX	15.8	1.16	-26.58	-85.12
GEDI	40.04	68.52	36.66	31.01
AC	***6***	***3***	-	-
DC	-	*2 (conc)*	1 *(deconc)*	2 *(deconc)*
DD	***14 (conc),*** 3 *(deconc)*	***8 (conc), 7 (deconc)***	***8*** *(deconc)*	3 *(deconc)*
AD		-	2	***4***

Notes: **AC** = Acceleration of concentration. **DC (deconc)** = Deceleration of concentration and it has already changed to deconcentration stage. **DC (conc)** = Deceleration of concentration, but it is still in concentration stage. **DD (deconc)** = Deceleration of deconcentration, but it is still in deconcentration stage. **DD (conc)** = Deceleration of deconcentration and it has already changed to concentration stage. **AD** = Acceleration of deconcentration.
Source: own calculation.

Figure A3: The connection between the GEDI scores and ROXY20



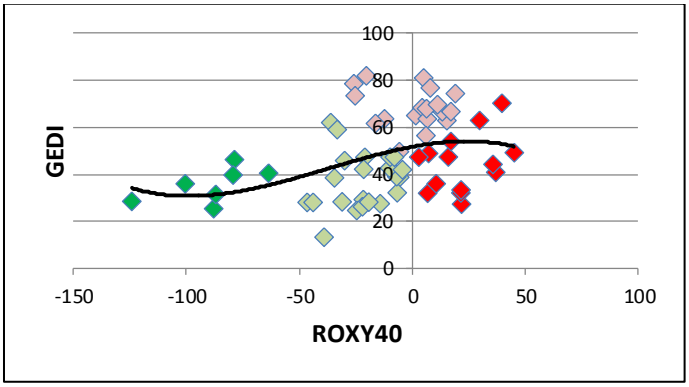
Note: green color refers to countries where deconcentration is accelerating, light green color refers to countries where deconcentration is decelerating, while red and pink colors refer to counties where concentration is accelerating or decelerating, respectively.
Source: own calculation.

Table A5: Results of cluster analysis: ROXY40 and GEDI Index

Final Cluster Centers	**Cluster 1** *Concentration with generally lower GCI value*	**Cluster 2** *Acceleration of concentration with high GCI value*	**Cluster 3** *Deceleration of deconcentration, with high GCI value*	**Cluster 4** *Deconcentration, with generally low GCI value*
Number of cases	14	18	22	7
ROXY 40_BOXCOX	22.31	0.43	-22.27	-88.71
GEDI	42.29	68.26	37.21	35.45
AC	**6**	***4***	-	-
DC	2 *(deconc)*	2 *(conc)*	-	1 *(conc)*
DD	**6** *(conc)*	***6*** *(conc)*, 3 *(deconc)*	***21*** *(deconc)*	1 *(conc)*
AD	-	3	-	***5***

Source: own calculation.

Figure A4: The connection between the GEDI scores and ROXY40



Source: own computation