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Spatial concentration of economic activity and competitiveness of Central European regions¹

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Abstract:

The paper tackles with a still somewhat underdeveloped aspect of regional competitiveness which regards to spillover effects stemming from spatial proximity of highly competitive neighbors. Although spillover effects are well recognized in the literature, we focus more on inter-regional concentration of business activity when enterprises are located in a particular district which is not far from the agglomeration center but not the center itself. We check for statistical significance of spatial autocorrelation measures (local Moran's I_i statistic) in order to identify spillovers between districts in Central European countries (Germany, Poland, Czech Republic and Slovakia). We use variables indicating Knowledge Intensive Services (KIS), in particular hi-tech KIS and information and communication services (including computer science). We compare 2009 with 2015 to notice agglomeration dynamics. We observe statistically significant spillover effects in Central European countries in urbanization-type clusters as well as strengthening of the effect over time. Taking into consideration more detailed data for Poland we conclude that while hi-tech KIS mostly spill over to neighboring districts, the reverse pattern may be observed for computer science (programming and consultancy). One explanation is that this subsector relies on highly demanded workforce and a prestigious localization (in the agglomeration centers) works as a bargaining chip to attract programmers. In order to measure the spillover effects more precisely it is recommended to define and measure the neighborhood of agglomeration centers using localization of firms based on GPS coordinates instead of centroids (geometric means) of districts – as shown in example of Poland.

Keywords: spatial agglomeration; spillover; regional competitiveness; KIS; Central European countries

JEL codes: R12, O31, O57

1. INTRODUCTION

The competitiveness of regions stems not only from their own resources and potential, but also from the positive effects generated by the strong (in terms of economic development) regions adjacent to them. It is related to the occurrence of spatial and

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functional interdependence of regions, as well as the external effects of spatial concentration of economic activity (agglomeration), including spillover effects (unintentional spatial interaction when the developmental processes, knowledge, productivity, innovations and so on spread between neighboring regions). In fact – according to Marshall (1920), Hoover (1936) and Jacobs (1969) – the basic premise of the spatial proximity and concentration of economic activity is that it can be beneficial due to agglomeration externalities to the overall economy as well as to sectors and firms clustered in a particular location (Prager & Thisse, 2012). This includes agglomeration externalities associated with the flow of knowledge, human resources (Ács 2002, 2005), or internationalization of services. It should be noted that spatial agglomeration (identified at low levels of data disaggregation eg. districts) as well as its externalities spread outside the boundaries of territorial units. This is why inter-regional effects of agglomeration (spillover effects) should be taken into consideration by analyzing the comprehensive regional competitiveness.

However, the strength and direction of the spatial correlation of the adjacent areas is different – in some regions strong spillover effects can be observed while in the others reverse processes – ie. diminishing spillovers – occur (centripetal effects of agglomeration centers). The challenge is therefore to measure the effects of spilling over of such development impulses including knowledge, entrepreneurship, foreign tourist flows and other effects of agglomeration of economic activity. In particular, the questions arise: how to measure inter-regional spillover effects with regard to knowledge and intellectual capital, what is the strength of those effects, and in which direction the phenomenon takes place in regions of Central Europe.

We employ the explorative spatial data analysis (ESDA) applying spatial statistics of autocorrelation (local Moran's I_i statistic) under the so-called Local Indicators of Spatial Association (Anselin 1995, 2010) in order to measure *geographic* spillovers along with PQStat software for spatial analysis.

We use the data collected by National Central Statistical Offices of Central European countries at district level (the number of enterprises registered in a given section and division of the NACE classification – the Statistical Classification of Economic Activities in the European Community), reflecting Hi-tech KIS (Knowledge Intensive Services), in particular ICT (Information and Communication Technologies) for the period of 2009-2015. Additionally we use the full database on individual firms registered in section I of Polish Classification of Activities (PCA, which is equivalent to NACE) within “food services activities” (division 56) in order to determine the “real” centers of agglomeration in each district – instead of using their centroids – in measuring the neighborhood and spatial autocorrelation. We use geostatistical information (GPS coordinates) of the enterprises (derived by geocoding their location on the basis of firms' addresses) in order to obtain the accuracy of the results in measuring the neighborhood.

The rest of the paper is organized as follows. Section 2 provides an overview of the literature on regional competitiveness as a result of agglomeration economies. In particular we discuss how spatial concentration of economic activity, spatial proximity, and spatial interdependency affect regional competitiveness of territorial

units. We give a special importance to agglomeration externalities and effects as drivers of inter-regional competitiveness. It is followed by Section 3 that shows the impact of Knowledge Intensive Services on regional competitiveness. Section 4 describes the research methods and data sources. Section 5 presents the research and results. It shows spillover effects of agglomeration phenomenon reflecting inter-regional competitiveness of Polish districts. The final section concludes and draws implications as well as shows limitations and further research directions.

2. REGIONAL COMPETITIVENESS AS A RESULT OF AGGLOMERATION ECONOMIES

The ability to compete, that is, to act and survive in a competitive environment, can be considered within many aspects. Territorial (spatial) aspect of competitiveness is of growing interest in the literature. The competitiveness of municipalities, cities and counties as spatially separate parts of the national economy (Gorynia & Łaźniewska, ed. 2009, p. 52; Enright & Newton, 2004; Crouch & Ritchie 2000; Hall 2007) is frequently discussed. The competitiveness of territorial units refers to many theoretical and methodological aspects. It has to do with the diversity of ways of defining and operationalizing the notion of competitiveness (the attribute and process understanding of competitiveness, recognition of its side effects from the perspective of its factors, the distinction of interdependent concepts of competitiveness in the strict sense, ability to compete and competitive position).

In today's regional competitive processes, simultaneous competing of businesses and environment in which they operate is noticeable (Markowski, 1999, p. 102). The competitiveness position of businesses depends not only on their own actions but also on the efficiency of the territorial socio-economic systems. Competitiveness of areas is therefore of an indirect nature (providing conditions to compete of various entities functioning in a given area) and direct (competing of territorial units in attracting investors or tourists along with income and other benefits for the region (Nawrot & Zmysłony, 2009, p. 65)).

The comprehensive analysis of the competitiveness of areas diversifies and verifies both comparative and competitive advantage of spatial units (Dwyer & Kim, 2003; Crouch & Ritchie, 2005; Vanhove, 2011), where the first refers to the available resources of the area (tourist attractiveness, location, intensity and diversity or specialization of spatially concentrated economic activity, etc.), and the latter to how they are used (land management). However, in contemporary regional studies, there is a growing need to take into account the neighborhood of territorial units (spatial interdependence) and its importance in creating conditions to compete. An example could be the last survey conducted by the Central Statistical Office for the tourist attractiveness of the Polish districts where measures of regional attractiveness were constructed taking into account the spatial proximity of districts. This had a significant impact on the results (GUS, 2015). Furthermore inter-regional agglomeration effects in tourism as spatial interactions between Polish districts were investigated within this context by Majewska (2015).

The externalities specific to the agglomeration (spatial concentration of economic activity) and drivers of the phenomenon were introduced to the economic literature by Marshall (1920), Ohlin (1933) and Hoover (1936). Since the 1920 study by Marshall, the variables traditionally considered as sources of the agglomeration economies are as follows (Prager & Thisse, 2012, p. 27): 1) the availability of business services (sharing), 2) the presence of specialized labor (matching), 3) the emergence and spread of new ideas (learning), and 4) the supply of modern infrastructure (sharing). According to the traditional localization theory, firms concentrate around low-cost and/or high-demand locations (Baum & Haveman, 1997). Lower transaction costs lead to competitive advantage and equally to other effects of agglomeration such as: diffusion of knowledge, formation of firms offering complementary services or formation of social and business networks (Krugman, 1991; Ottaviano, 2011). Apart from the cost factors, an important role in the localization decision is played by the demand (large and growing markets), and a circular causality can be noticed in the form of feedback relations between the firms' concentration and the growing markets. The increase in profitability due to localization decisions becomes a source of competitive advantage. The ability to communicate through informal channels which promotes physical proximity between companies and consumers also contributes to the competitive advantage. The result of the links between entities, interactions and knowledge transfer is a positive correlation between the agglomeration of economic activity and productivity (Duranton & Puga 2004). It is also argued that for example innovation improving the competitiveness in the hotel sector is derived not directly from mere spatial proximity of firms in the same industry, but from the formation of a special production environment (Rodríguez-Victoria, Puig, & González-Loureiro, 2016).

The positive agglomeration effects resulting from the concentration of economic activities are transmitted both within and between industries. Therefore, although the agglomeration economies may be grouped in various manners, in the contemporary literature two main different types of agglomeration economies are distinguished: specialisation (localisation) and diversity (urbanisation) externalities (Ács, 2005; Beaudry & Schiffauerova, 2009; Knoben, 2009). The localisation economies usually take the form of Marshall-Arrow-Romer (MAR) externalities, which operate mainly within a specific industry. The localisation economies are the advantages that firms in a single industry (or a set of closely related industries) gain from being placed in the same location. These promote positive externalities and thus economic growth within industries. The second type, the so-called Jacobs's externalities, work across sectors and stem from a local variety of producers (Jacobs, 1969); they refer to the so-called co-agglomeration, i.e., the tendency of different industries to locate near each other (Ellison, Glaeser & Kerr, 2007; Kolko 2010). In Jacobs's view, it is the industrial diversity (heterogeneity) rather than specialisation that is seen as the most important regional growth factor (Ács, 2002). Thus, the urbanisation economies are the advantages gained by firms, regardless of the sector, from being located together.

As the consequence of localised sources and the advantages of agglomeration, regional clusters, defined as the concentration of economic activity, emerge. They differ in regard to the scope and the scale of the spatial concentration of the economic activity as well as spatial interdependencies in neighborhood. The spatial concentration of economic agents itself does not necessarily involve strong linkages and interactions among them. Nonetheless, the probability of such ties increases with the growing number of agents and the decrease in the distance between them (Brodzicki & Kuczevska, 2012, p. 62).

Previously and recently researchers have explored and commented the importance of spatial concentration of firms and spatial proximity in enhancing innovation (including regional innovation systems), productivity, diffusion of knowledge, formation of social and business networks and other positive agglomeration effects (Ács, 2002; Duranton & Puga, 2004; Asheim, & Gertler, 2004; Sørensen, 2007; Weidenfeld, Williams & Butler, 2010; Prager & Thisse, 2012). However there is still room to analyse geographical/spatial and methodological context of agglomeration phenomenon which is accompanied by spillover effects and their impact on inter-regional competitiveness. The need to analyze the competitiveness in a wide inter-regional context stems from the presence of spatial externalities resulting in spillover effects between neighboring regions. It is conveyed through such channels as the flow of knowledge and human capital, technology transfer, or investments.

It is often argued that innovation is created and sustained through a highly localised process as exhibits strong geographical clustering in areas where specialized inputs, services and resources (including competition, interactive learning or institutional conditions) necessary for the innovation process are concentrated (Asheim & Gertler, 2005; Wolfe, 2009). Moreover in the rapidly changing knowledge-based economy innovation process is based on creative use of various forms of knowledge (Vinding, 2002; Alves, 2007). Innovation “remains fundamentally an application of knowledge” (Schaper & Volery, 2007, p. 64), which is best achieved through networks that serve as both repositories and generators of innovative ideas and information.

At the same time it should be mentioned that over the years the concept of innovation has changed towards more interactive, cumulative and cooperative phenomenon (Rothwell, 1992; Aralica, Račić, & Radić, 2005). Inter-organisational interaction and related external knowledge is believed to support innovativeness (Cohen, & Levinthal, 1990; Muller & Zenker, 2001). This is consistent with the concept of “open innovation” (Chesbrough & Garman, 2009) which – in contrast to the process of internal innovation – focuses on participation and collaboration of external firms (customers and suppliers) in generating innovative ideas. Suppliers’ knowledge can also be used to streamline decision-making processes through aligning customer requirements with supplier capabilities (Shu Mei Tseng, 2009). The innovation process is by its nature knowledge-intensive, therefore innovations rely to a large extent on the presence of knowledge-intensive services (KIS) (OECD 2003, p. 26). Thus with the rapid development of information and communication

technologies (ICT) and other knowledge-intensive services (KIS) a significant research direction emerged – as knowledge transfer in spatial concentrated areas is vital to innovation, and for competitiveness.

3. THE IMPACT OF KNOWLEDGE-INTENSIVE SERVICES ON REGIONAL COMPETITIVENESS

KIS is defined as services that involve economic activities which are intended to result in the creation, accumulation or dissemination of knowledge. Following Miles et al. (1995) and den Hertog (2000), ICTs are considered one of three major knowledge-intensive services (KIS) sectors.

The service sector is divided into: knowledge-intensive services and less knowledge-intensive services according to the approach defined as a method which classifies production and service activities in accordance with the intensity of R&D (expenditure on R&D / value added). This approach is based on The Statistical Classification of Economic Activities in the European Community - NACE.

The following sectors of NACE are included into KIS: Post and Telecommunications, Computer Science, Research and Development, Water Transport, Aviation, Real estate, Rental of machinery and equipment, Other business activities, Financial intermediation, Education, Health care and Social Assistance, Cultural activities, Recreation and Sport.

An important subgroup of knowledge-intensive services is called high-tech KIS. The group includes: Post and Telecommunications, Computer Science, Research and Development. Computer Science (division 62 of section J within NACE, ie. computer programming and consultancy) can be identified as ICT services. Other services are classified as less knowledge-intensive.

KIS-providers play a special role in innovation systems, and therefore in enhancing regional competitiveness. They serve as sources of innovations (initiating and developing innovation activities in client organizations), facilitators of innovations (supporting the innovation process of an organization) and as carriers of innovations (aiding in transferring existing knowledge so that it can be applied in a new context) (Miles et al., 1995). Thus, using KIS enables firms to conduct their own innovative activities. In particular, ICT-use constitutes not only an innovation in itself but also enhances the innovation process by shortening distances and saving on costs and time, as well as facilitating information transfer and the promotion of a higher quality of decision-making (Vilaseca-Requena et al., 2007; Czarnitzki & Spielkamp, 2003; Amit & Zott, 2001). There is a general, strong preference for locally provided KIS (OECD, 2006). The evidence of local sourcing (location of KIS-related providers) may support the importance of geographical proximity and the generation of clusters and networks in strengthening the innovative system in which the firms operate (Ács, 2002).

Innovation policy focuses on stimulating innovativeness or enhancing the ability to adopt innovations developed abroad. Both paths rely heavily on possibilities to broaden the intellectual capital in a country or region. Developed countries

or regions are in clear comparative advantage as the higher level of intellectual capital enables faster rate of both technology creation and adoption (as endogenous source of growth according to P. Romer, P. Aghion and P. Howitt). Less developed countries (LDCs) need first to develop intellectual capital to be able to take the benefit of existence of innovative production factors. Despite the comparative disadvantage in innovation many LDCs implement policies aimed at development of highly technologically advanced products (eg. biotech or nanotech projects) what results in insular type of development in regions where hi-tech “isles” neighbor traditional production of low-tech goods (Kubielas, 2009, p. 277).

In Poland, for example, which in the context of innovation should be classified as a LDC, innovation policy is also conducted towards supporting the development of high-tech products. However, it is worth noting that the requirements of EU programs, which constitute a significant source of funds for innovation policy, require that the support is not provided directly to innovators, but is channeled to support the development of innovative business environment – such as technology parks, incubators, clusters, etc. Despite low evaluation of effectiveness of the funds, the development of the business environment secures that the aid goes to the companies which existence is due to market forces – the demand for advanced products and services and supply of innovative ideas (intellectual capital) – and not due to government support. In the Polish case, this means primarily the development of services based on ICT.

4. MEASURING SPATIAL CONCENTRATION AND SPILLOVER EFFECTS AS INTER-REGIONAL AGGLOMERATION

The occurrence of inter-regional spatial concentration, ie. agglomeration phenomenon including spillover effects as well as patterns of local spatial relationship between the territorial units (regions) can be identified using spatial statistics (Anselin, 1995, 2010; Kopczevska, 2011; Páez & Scott, 2004; Schabenberger & Gotway, 2005), in particular Local Indicators of Spatial Association (LISA) within exploratory spatial data analysis (ESDA).

In a general approach to modeling spatial association there are two exploratory techniques for the local analysis of spatial association, namely Getis and Ord’s distance-based statistics (Getis & Ord, 1992; Ord & Getis, 1995) and Anselin’s (1995) local decomposition of a global statistic of spatial association (Páez & Scott, 2004, p. 55). The local Moran’s I_i statistic belongs to the most common (within LISA) measures of spatial interdependence (autocorrelation) of spatial variables in neighboring regions, and thus allows the identification of spatial autocorrelation processes (Anselin, 1995; Schabenberger & Gotway, 2005).

It has been successfully used in the research on spatial distribution of tourist flows, formation of clusters in tourism and spatial spillover effects in regional tourism growth as well as the issues of spatial interactions between tourism destinations (Yang, & Wong, 2013; Yang & Fik, 2014; Yang, Fik, & Zhang, 2016). In particular, Majewska (2015) identifies and empirically measures interregional

effects of spatial agglomeration in tourism considering the occurrence and strength of geographic spillover effects in Poland.

Local Moran's I_i statistic is weighted correlation coefficient used for detection in the random distribution of the variable \mathbf{X} of deviations with spatial characteristics. It allows to determine whether neighbouring areas are more similar to each other (in terms of variable \mathbf{X}), than would result from the stochastic nature of the phenomenon studied (Mora and Moreno 2010). Moran's I_i statistic is expressed by the following formula (Anselin, 1995; Schabenberger & Gotway, 2005, p. 24):

$$I_i = \frac{(x_i - \bar{x}) \sum_{j=1}^n w_{ij}(x_j - \bar{x})}{\sum_{j=1}^n (x_j - \bar{x})^2 / n} \quad (1)$$

where:

$x_i(x_j)$ - value of the variable \mathbf{X} in the region $i(j)$,

n - number of regions,

\bar{x} - the arithmetic mean of the variable \mathbf{X} ,

w_{ij} - elements of the spatial weights matrix \mathbf{W} (line standardization) between units i and j .

Local Moran's I_i statistic is based on a neighborhood matrix (the spatial lag operators \mathbf{W}). A spatial weights matrix \mathbf{W} is simply a matrix ($n \times n$) containing weights w_{ij} that describe the degree of spatial relatedness (i.e. contiguity, proximity and/or connectivity) between units of analysis i and j (Páez & Scott, 2004). There are different ways of defining the neighborhood and building spatial weights matrices (Griffith, 1996; Páez & Scott, 2004) which, on one hand, is its limitation/weakness due to the sensitivity of the statistic on the type of spatial weights matrix (neighborhood matrix). On the other hand, it allows to modify and improve the measurement results due to the possibility to correct the neighborhood matrix using GIS (GPS coordinates) as proposed previously (Majewska, 2016).

The rules of neighbourhood used in the local Moran statistics (and other indicators of spatial association) often operate on the distance between the centroids of adjacent territorial units (Anselin, 1995; Schabenberger & Gotway, 2005; Lloyd, 2010). Then the neighbours are regions where the distance between the centroids of districts, that is, their geometric centres, regional capitals, centres designated on the basis of location data of entities (GPS coordinates), etc. does not exceed a specified number d of km.

In this study we use both: 1) centroids (for the whole group of districts of Central European countries) and 2) central tendencies of the localization of enterprises (for Polish districts) as centres of agglomerations – the data in the latter case were only available for Poland. It should be noted that GPS coordinates of individual enterprises allow to determine the centres of districts more precisely comparing to centroids – as they are closer to the actual agglomeration processes in the regions.

5. INTER-REGIONAL COMPETITIVENESS – AGGLOMERATION AND SPILLOVER EFFECTS ON THE EXAMPLE OF CENTRAL EUROPEAN DISTRICTS

The research was performed with respect to the districts of four Central European countries, ie. Germany, Poland, Czech Republic and Slovakia (N = 960 of territorial entities) and based on the data collected by Central Statistical Office of each country for the period 2009-2015, describing the competitiveness of regions from the perspective of spatial agglomeration effects. In the study, we used three variables as: 1) the share of information and communication (NACE section J) in total number of firms registered in a given district of Central European countries as well as 2) the share of Hi-tech KIS and 3) the share of ICT in total number of firms registered in Polish districts – as a special case within the Central European countries. It should be mentioned that two of the six subsectors (at the division level) dominated the information and communication services sector in the EU-28, namely computer programming and consultancy (Division 62) and telecommunications (Division 61). These two subsectors generated close to three quarters (71.1%) of sectorial value added (Eurostat Statistics Explained, 2016).

In measuring the neighborhood and spatial autocorrelation we use two approaches. First, for the whole group of districts in Central European countries we used geometric centers of districts (centroids). Then, considering Poland as a special case study we use GPS coordinates of enterprises (generated with a dedicated tool to geocode their addresses). The central tendencies of the localization of firms were designated by calculating mean latitude and longitude coordinates to represent centers of agglomeration in each of 380 Polish district. In this article GPS coordinates of entities registered in Section I of PKD as “food services activities” (division 56, N = 96 775 firms) were used as an approximation of spatial concentration of economic activity. On this basis, new spatial weights matrices were built allowing to determine local Moran I_i statistics and investigate the occurrence of spatial dependencies of neighboring districts in relation to KIS (high-tech KIS and ICT). Those variables reflects the existence of positive agglomeration externalities which can spilling over the neighborhood and enhancing inter-regional competitiveness of territorial units.

The neighborhood matrices were defined by the radius of the distance d between the centers of districts ($d = 25$ km). They were set, on the one hand, as geometric means (for the whole group of districts within Central European countries) and, on the other hand, as central tendencies, ie. the average value of GPS coordinates of enterprises of section I and division 56 located in each district in Poland.

Maps below (figures 1-2) present the results of spatial autocorrelation statistics – Moran's local I_i – obtained using PQStat software with regards to districts of Central European countries. Statistically significant values of the statistic are presented for 2009 and for 2015 in respect to the share of information and communication (NACE section J) companies in total number of firms registered in a given district.

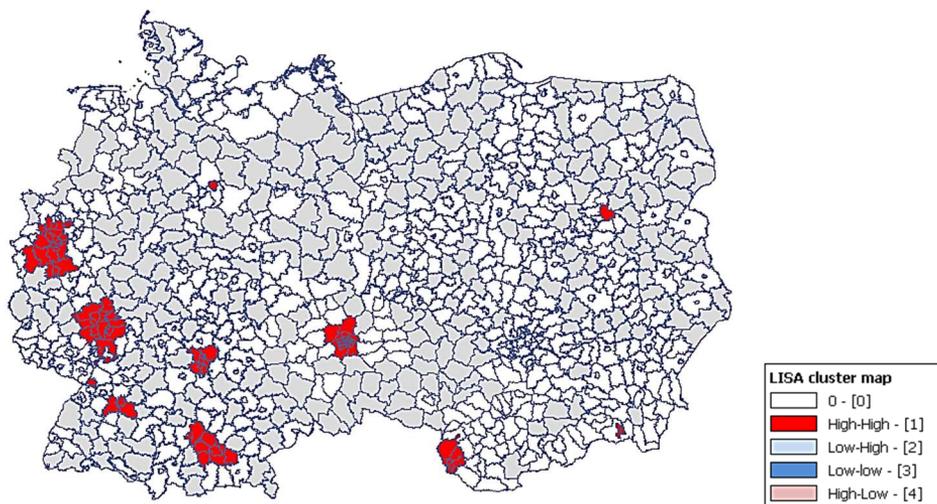


Figure 1. Significant local Moran's I_i statistics in relation to the share of section J (information and communication) in total number of economic activities registered in districts of Central European countries in 2009 ($p < 0.01$).

Source: own work based on data collected by Central Statistical Offices of Central European countries with the use of PQStat software.

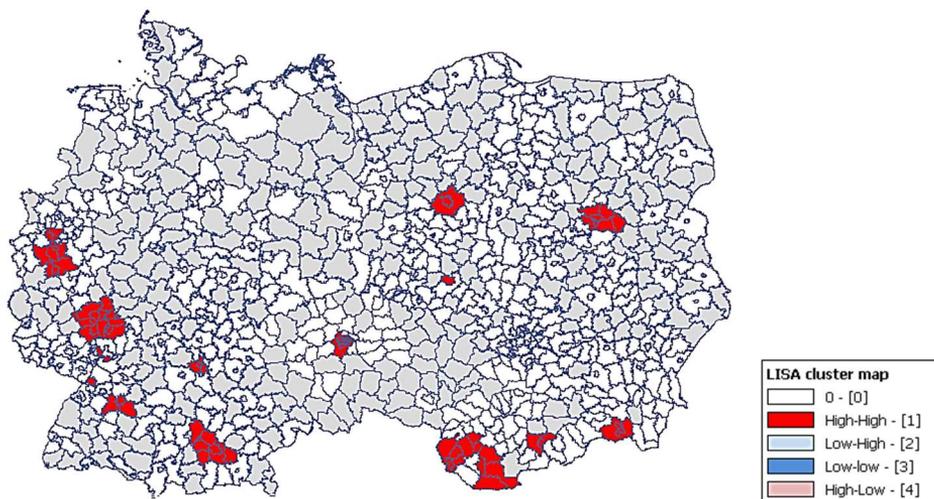


Figure 2. Significant local Moran's I_i statistics in relation to the share of section J (information and communication) in total number of economic activities registered in districts of Central European countries in 2015 ($p < 0.01$).

Source: own work based on data collected by Central Statistical Offices of Central European countries with the use of PQStat software.

A comparable number of statistically significant districts in 2009 and 2015 years may be noticed (93 and 92, respectively), but in the initial period of the study they occurred mainly in the south-western part of the analyzed group of countries (Germany) – Ruhr agglomeration with Essen and Cologne, or agglomerations of: Stuttgart, Frankfurt, Nuremberg and Munich. Especially worth attention is that almost no clusters of districts with similar high values of shares of Section J enterprises in the economic structure occurred in Poland (spillover effects in this period related only the capital city of Warsaw). In 2015 eastern and southern regions, ie. in Poland (Warsaw, Poznań and Wrocław) and Slovakia (Bratislava agglomeration, region of Nitra, Trnava, Banská Bystrica and Košice) gained in importance at the expense of Germany.

A small number of clusters of districts characterized by a high share of information and communication services sector in the economic structure of districts in Poland and the Czech Republic is due to the low average value of these shares compared with Germany and Slovakia (see. table 1), ie. lower importance of Knowledge Intensive Services in the economy.

Table 1. The average value of shares of Section J enterprises in the economic structure of districts based on the number of entities registered in these districts by section in 2009 and 2015

Country	Average share of section J (information and communication) in total number of firms in districts	
	2009	2015
Germany	2.89%	2.80%
Poland	1.42%	1.87%
Czech Republic	2.07%	1.35%
Slovakia	2.97%	3.98%

Source: own work based on data collected by Central Statistical Offices of Central European countries.

In the next step, values of Moran's I_i statistics were calculated using only data on Polish districts to check for the occurrence of spillover effects of knowledge-intensive activities in these regions exclusively. The results are shown below on a map (figure 3).

In addition to previously designated clusters in agglomerations of Warsaw, Poznań and Wrocław, clusters of high values of the shares of Section J enterprises in the economic structure of the districts also revealed in agglomerations of Kraków, Gdańsk, Rzeszów and Silesian conurbation. These are areas that create positive neighborhood externalities increasing the competitiveness of the whole regions they are located in (innovative activities associated with knowledge-intensive services spill over to the neighborhood). These centrifugal effects strengthened over the six analyzed years in agglomerations of Kraków and Wrocław, decreased in case of Bydgoszcz and the surrounding districts.

Moreover we take into consideration others variables for Polish districts, namely: 1) the share of Hi-tech KIS and 2) the share of ICT in total number of firms registered in Polish districts. Maps below (figures 4-5) present the results of spatial autocorrelation statistics (Moran's local I_i).

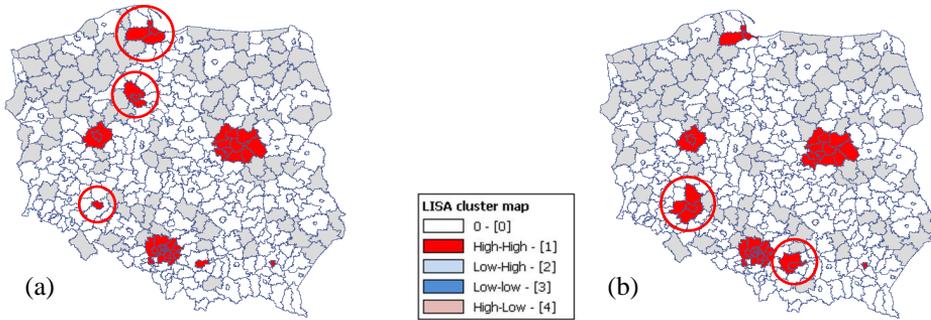


Figure 3. Significant local Moran's Ii statistics for two different points in time (2009 (a) and 2015 (b)) – in relation to the share of section J (information and communication) in total number of firms in Polish districts ($p < 0.01$)
Source: own work based on Central Statistical Office data with the use of PQStat software.

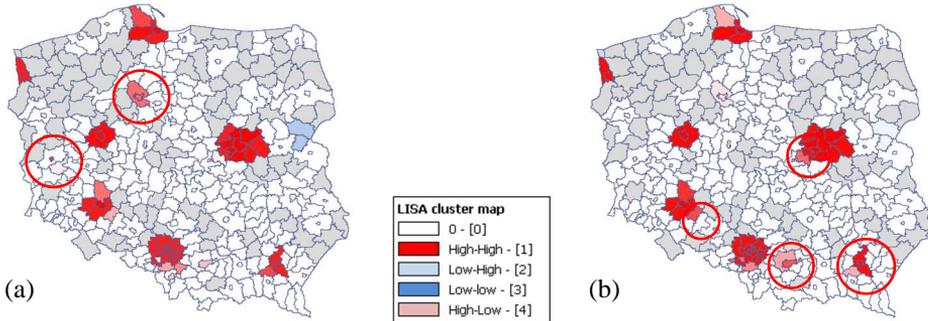


Figure 4. Significant local Moran's Ii statistics for two different points in time (2009 (a) and 2015 (b)) – in relation to the share of Hi-tech KIS in total number of economic activities registered in Polish districts ($p < 0.01$)
Source: own work based on Central Statistical Office data with the use of PQStat software.

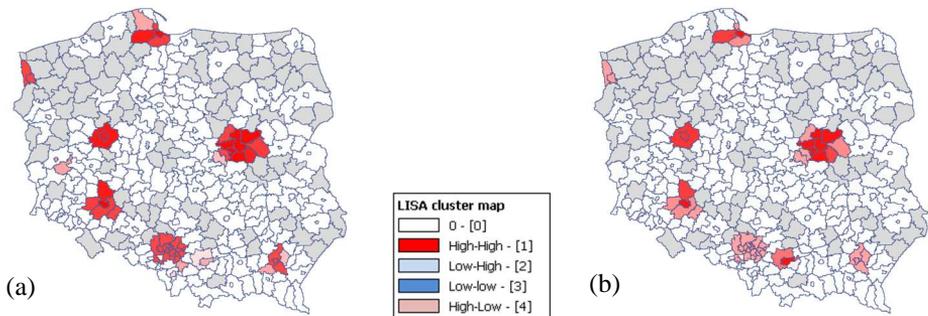


Figure 5. Significant local Moran's Ii statistics for two different points in time (2009 (a) and 2015 (b)) – in relation to the share of ICT in total number of economic activities registered in Polish districts ($p < 0.01$)
Source: own work based on Central Statistical Office data with the use of PQStat software.

We observed a statistically significant tendency to cluster by neighboring districts similar to each other by the high values of these two variables (share of Hi-tech KIS providers and share of ICTs providers in the total number of enterprises registered and localized in a given district). It means that there are spatial interrelations between some districts and in some cases we can observe inter-regional effects of agglomeration phenomenon that reflect spillovers with regard to KIS-based measures.

Taking into consideration Hi-tech KIS variable it should be noted that there are 8 main centers of inter-regional competitiveness where agglomeration and spillover effects can be observed, such as agglomerations: Warsaw, Poznań, Wrocław, Tricity, Szczecin, Kraków, Silesian conurbation and Rzeszów – on the south-east part of Poland. Comparing the results of local Moran's I_i statistics between 2009 and 2015 it can also be seen that spillover effects grew broader and stronger for the district of Kraków (Kraków itself in 2009), Żyrardów (south-western part of Warsaw agglomeration) and Oława (Wrocław agglomeration). Conversely, the disappearance or weakening of the spillover effect was observed in the case of Bydgoszcz and the district of Bydgoszcz, and Zielona Góra, and Nowa Sól. The effect of a “sucking in” in the case of Rzeszów and Rzeszów district in relation to the surrounding districts (strzyżowski) is also worth noting.

The disappearance or weakening of the spillover effects is even clearer in relation to the share of ICT providers in the economic structure of districts (Silesian conurbation, agglomerations of Rzeszów and Szczecin). Increasing spatial interdependence is apparent (but in the narrower number of territorial units) in eg. of stronger Wrocław and trzebnicki districts with weaker remaining districts of Wrocław agglomeration, or in Warsaw agglomeration where the situation is similar). The opposite tendency was recorded in Kraków agglomeration – the strengthening interdependence in an inter-regional cluster composed of Kraków and the Kraków district. Inter-regional effects of Kraków agglomeration and spillover improve the competitiveness of the whole area, including districts located within further radius from the center of the agglomeration.

6. CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

In the study we tested spatial autocorrelation of neighboring regions with regards to variables on KIS-oriented measures using the example of four Central European countries (Germany, Poland, Czech Republic and Slovakia). The methodology based on local statistics of spatial association and GPS coordinates (used only in case of Poland) allowed us modelling agglomeration processes. As the main implication of the study within methodological context we identified spillover effects in neighboring regions as indicators of highly competitive districts in Central European countries. However it should be noted that we do not observe any cross-border agglomeration, ie. the phenomenon of spatial agglomeration in the international context.

Under the cognitive effects of our study we observed three types of spatial association effects taking into consideration changes in time (2009 vs. 2015): 1)

strengthening spillover effects with regards to information and communication sectors (eg. Warsaw and Wrocław agglomerations as well as Bratislava or Kosice), 2) diminishing spillovers (centripetal effects of agglomeration centers – eg. in Nuremberg, Prague or Rzeszów in the south-east part of Poland), and 3) dispersion effects e.g. in Wolfsburg in Germany or in Polish Bydgoszcz.

The results of the study indicate inter-regional competitiveness of territorial units in Central European countries, which are gaining momentum due to the phenomenon of positive spillover effects of spatial agglomeration. This applies mainly to clusters of urbanization – cities – that create the functional relationship of varying strength and range with the surrounding districts. This reflects a trend of hi-tech KIS companies to locate in the vicinity of large cities. However, it is different with regard to the ICT sector where spillover effects mostly disappear over the years 2009-2015. This demonstrates the high bargaining power of IT employees who are not necessarily interested in commuting outside the city of residence.

The results may optimize localization decisions and geomarketing of enterprises as well as planning and management of districts (administrative units). Regions where *geographic* spillovers are the main driver of the development should combine marketing activities with the regions that generate spillovers. Such collaborative marketing is necessary to enhance competitiveness of regions without important resources or development potential but localized in the vicinity of strong regions generating spillover *effects*.

The main limitations of the research are applied to LISA measures (local Moran I_i statistics) which are sensitive to the localization, size and shape of the analyzed territorial units (determining neighborhood). Thus, in order to measure the spillover effects more precisely it is recommended to define and measure the neighborhood of agglomeration centers using localization of firms based on GPS coordinates instead of centroids of districts – as shown in example of Poland. It seems to be of special importance in case of districts in East Germany which are much bigger in size compared to those located in west part of the country. Thus, potential spillover effects (of eg. Berlin) could not be captured as many centroids of neighboring regions were farther to each other than the range determined to delimit the neighborhood.

Additionally, the spatial interrelation of neighboring regions seems to be dependent on various regional features. Thus, in-depth assessment of the existence, strength and direction of spillover effects using case-study analyses of different agglomerations may be required to compliment the picture.

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