ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 64 113 Number 3, 2016

http://dx.doi.org/10.11118/actaun201664030993

EFFECT OF THE CENTRIFUGAL AND CENTRIPETAL EFFECTS IN CORE VERSUS (SEMI)PERIPHERY IN CENTRAL EUROPE COUNTRIES

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Abstract

MARIŠ MARTIN. 2016. Effect of the Centrifugal and Centripetal Effects in Core Versus (Semi)Periphery in Central Europe Countries. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 64(3): 993–1000.

The paper focuses on examining regional disparities in Austria, Czech republic, Slovakia and Hungary (CE countries) in spatial perspective on NUTS III level. It took two crucial topics: spatial regional imbalances and polarization of the development. Spatial imbalances over the territory were examined via using the Moran's coefficient of spatial autocorrelation and the Geary's C statistics for mutual comparisons of achieving results. Both results showed a significant degree of the inequality. Polarization of the development was examined via measuring the possible centrifugal and centripetal effects, present in the proximity of the core regions of CE countries. Empirical examination showed "contradictory" results, indicating presence of both effects based on $G_i(d)$ statistics introduced by Getis and Ord (1992). Thus we can conclude the spatial imbalance over the territory of CE countries is significant, and we can't rule out acting of centrifugal and centripetal effects, however distinctly in some core regions.

Keywords: region, spatial imbalance, regional polarization, centrifugal and centripetal effects, spatial autocorrelation

INTRODUCTION

Evolution of the regional imbalances over the territory is closely linked with the development of commodity-cash relations and hence with the creation of the market economy. Since the establishment of the market economy in most countries over the world; rent, interest, yield and wage became the major market driver of the production factors in order to make its localization decisions. It led to spatial organization and deployment of the scarce resources over the territory. The specific feature of these scarce resources is, that they are distributed very unevenly. In the background affects centrifugal and centripetal effects which condition the concentration of the scarce resources in some areas and conversely its deconcentration in other areas. Above mentioned processes are leading to regional polarization. The concept of the polarized development is not unknown. It is a part of a broader set of the theories based on the polarized approach to the regional development.

Growth and development do not evolve everywhere at the same time, but it creates in the growth poles (Blažek, Uhlíř, 2002). According the Boudeville,the regional growth pole is set of expanding industries located in an urban area and including the further development of economic activity throughout its zone of influence. The place where these "expanding" or "propulsive" or "dominant" industries are located in the region becomes the pole of the region and agglomeration tendencies are promoted (Moseley, 1974). Development of the growth poles is tightly connected with the local settlement system. Newer theories of the urban systems considerably more take in mind central cities like as carriers of the development and growth.

The system of central cities creates spatial construction, where development processes are articulating. Innovations, development impulses don't occur at all places together, nor shall not extend uniformly, but outgrow across the urban hierarchy.The physical distance between the cities is not decisive, however hierarchical distance, namely the number of degrees in the hierarchy of the central cities, which separates two cities (Maier, Tödling, 1995).

Each region, at least theoretically has an own developed urban system, with own urban hierarchy. Urban systems are different, thus their economic performance is different, so naturally regional disparities between them persist, what finally might lead to regional polarization.

Bourne considers three tier system in European context: European urban system, national urban system and regional urban system (Bourne, 1975). Representatives of the theory of regional polarization underline mainly the differences between the regions and descript mechanisms, which are leading to regional polarization. Myrdal as Hirschman incorporate interactions between the regions in two counter effects. Myrdal recognizes "spread" and "backwash" effects, Hirschman denotes them as "trickling-down effects" and "polarization effects".

These effects include mechanisms, which are leading to spatial expansion of development impulses. On the opposite, backwash effects and polarization effects include effects which manifest on neighboring regions negatively – economic activity is concentrated into one center.Hirschman believes that in long time expansion effects will prevail, contrary, Myrdal is more pessimistic namely in case of developing countries. In free acting of the market forces is inherent tendency to regional inequality, which is stronger as the country is poorer (Maier, Tödling, 1995).

Central Europe countries for a long time had been exhibiting with the relatively egalitarian society under the socialist rule, in despite of, the differences between the capital regions and the rest of the country were apparent. Our paper is focusing on acting the centripetal and peripetal effects on regional level in the four countries of Central Europe: Austria, Hungary, Slovakia and Czech republic. It is assumed that these effects will be most observable around the capital regions of these states, namely: Wien, Budapest, Bratislava and Prague. However we can't rule out its effect in greater physical distance.

MATERIALS AND METHODS

The Main object of the paper was to analyze and evaluate the effects of centrifugal and centripetal forces on regional economies of the CE countries and recognize some common spatial patterns of the development. In our empirical research, we were focusing on the CE countries, namely the Czech Republic, Austria, Slovakia and Hungary.

The sample consists regions of these countries on NUTS III level. For analysis of spatial imbalance within the territory of CE countries we used state variable – regional GDP/capita. In terms of examining causal relations of regional disparities in CE countries is appropriate to rely on tools of spatial statistical analysis. From this point we were concerned with measuring the spatial relations within the regional structure of CE countries.

Preliminary we supposed that strongest influence of the centrifugal and centripetal forces is present around the core regions of CE countries, namely: Praha, Bratislava, Wien and Budapest. The object of our paper was measuring the intensity of these forces. Primarily, we examined the spatial imbalance within regions of the CE countries via using the *Moran's autocorrelation statistics, I (1950)* and for the purpose of mutual comparisons, we used *Geary's C statistics (1954)*. We supposed that the spatial differentiation within the regions of CE countries acquire more or less regular pattern, so it, indicates that regional imbalance is conditioned also spatially.

Secondary, in more details we focused on local patterns in spatial-temporal data on the wealth, centering on our core regions: Praha, Bratislava, Wien and Budapest. For these purpose we used the statistics $G_i(d)$ introduced by *Getis and Ord (1992)*. Our research is based on secondary data sources collected in statistical databases by CE countries (*www.statistics.sk, www.ksh.hu, www.statik.at, www.czso.cz)*. As a basis for measurement we took indicator of regional GDP / capita converted to dollars at PPP.

The first research task was concerned with the spatial conditionality causes of the regional disparities. As a basis for the measurement we took indicator of GDP/capita for last available data 2011 for all countries. As a key method of spatial statistical analysis we opt for the Moran coefficient for assessing the spatial autocorrelation rate. Coefficient takes the real values within the range of –1 *to* +1. The first value within our sample is GDP/capita in regions of CE countries above the median and the second value is GDP/capita below the median. If a given character has a value which converges to +1, talking about the strong positive autocorrelation, if the value converges to –1, talking about negative autocorrelation. For values converging to $-1/(n-1)$ studied phenomenon is randomly distributed in space (Stehlíková, 2001).

Moran coefficient can be formally specified as follows:

$$I = \frac{N}{\sum_{i=1}^{i=n}\sum_{j=1}^{j=n} W_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1;j\neq i}^{n} W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{i=n}(x_i - \bar{x})^2}, \qquad (1.1)$$

where N means number of spatial units indexed by i and j; W_{ij} is the binary weight matrix of the general cross-product statistics, such that $W_{ij} = 1$ if locations i and j are adjacent and zero for all cells, points or regions which are not andjacent and by convention $W_{ii} = 0$ (a cell or region is not adjacent to itself x_i (i = 1, 2,…, n) value of examined character *i.*

In case of positive autocorrelation, regions with similar intrinsic value tend to be clustered next to each other, negative autocorrelation indicates their spatial distribution in a "checkerboard" shape and the last case (where values close to 0) tend to be randomly distributed.

Mentioned hypothesis we will statistically verify by means of two-sided test at significance level = 0.05 α significance of the spatial distribution of GDP/capita. The basic procedure for the adoption or rejection of the null hypothesis and rejection, or adoption of an alternative hypothesis, according to Moran (1950), can be formally specified as follows:

The expected value of the Moran coefficient under the null hypothesis of no spatial autocorrelation is

$$\mathrm{E(I)} = \frac{-1}{N-1}. \tag{1.2}$$

Its variability equals to

$$\mathrm{Var(I)} = \frac{NS_4 - S_3S_5}{(N-1)(N-2)(N-3)\left(\sum_i^n w_{ij}\right)^2}, \tag{1.3}$$

where

$$S_1 = \frac{1}{2}\sum_i \sum_j (w_{ij} + w_{ji})^2, \tag{1.4}$$

$$S_2 = \sum_i \left(\sum_j w_{ij} + \sum_j w_{ji}\right)^2, \tag{1.5}$$

$$S_3 = \frac{N^{-1}\sum_i (x_i - \bar{x})^4}{\left(N^{-1}\sum_i (x_i - \bar{x})^2\right)^2}, \tag{1.6}$$

$$S_4 = (N^2 - 3N + 3)S_1 - NS_2 + 3\left(\sum_i \sum_j w_{ij}\right)^2, \tag{1.7}$$

$$S_5 = (N^2 - N)S_1 - 2NS_2 + 6\left(\sum_i \sum_j W_{ij}\right)^2. \tag{1.8}$$

Resulting value of Moran coefficient we transform on statistics with normal distribution for testing the hypothesis of spatial autocorrelation at significance level α = 0.05.

$$U = \frac{I - E(I)}{\sqrt{Var(I)}} \sim N(0, 1).$$

Alternatively we can use other approach based on Geary's C index, which is a measure of spatial autocorrelation. Geary's C is inversely related to Moran's I, but it is not identical. Moran's I is a measure of global spatial autocorrelation, while Geary's C is more sensitive to local spatial autocorrelation.

$$\mathrm{C} = \frac{(N-1)\sum_i \sum_j w_{ij}(X_i - X_j)^2}{2W\sum_i (X_i - \bar{X})^2}, \tag{1.9}$$

where N is the number of spatial units indexed by i and j; X is the variable of interest; $\bar{X}$ is the mean of X; w_{ij} is a matrix of spatial weights; and W is the sum of all w_{ij}.

The value of Geary's C lies between 0 and 2, respectively. Number 1 means no spatial autocorrelation. Values lower than 1 demonstrate increasing positive autocorrelation, whereas values higher than 1 demonstrate increasing negative autocorrelation.

The second research task was concerned with measuring the possible effects of centrifugal and centripetal effects acting around the core regions of CE countries. The focus of this task is a pair of tests for the detection of clusters, introduced by Getis and Ord (1992). These statistics are especially useful in cases where global statistics may fail to alert the researcher to significant pockets of clustering (Getis, Ord, 1995). Local coefficients G_i indicates the area in which is locality encircled by the cluster of high or low values of studied statistical character. Positive values indicate clustering of high values and negative values indicate clustering of low values. Statistics has standardized normal distribution.

So, consider an area of CE countries subdivided into n regions on NUTS III level, i = 1, 2, …, n, where each region is identified with a point whose Cartesian coordinates are known. Each i has associated with a value x_i that represents an observation upon the random variable X_i. If spatial autocorrelation exists, it will be exhibited by similarities between contiguous regions, altough negative patterns of dependence are also possible. Furthermore, we focus upon physical distances, which maybe interpreted as travel time, conceptual distance or any other measure that enables the n points to be located in a space of one or more dimensions (Getis, Ord, 1995). In our case, we mean by the unit of "distance" area of the region. So, we decide to select increment of "regional unit" from core regions of CE countries individually up to distance d = 3. We define the distance between core region and the specific region as the smallest number of regions laying between the core and the specific region plus one.

In Getis and Ord (1992), the statistics $G_i(d)$ is defined as

$$\mathrm{G}_i(d) = \frac{\sum_j w_{ij}(d)x_j}{\sum_j x_j}, j \neq i, \tag{2.0}$$

where $\{w_{ij}(d)\}$ is symmetric one/zero spatial weight matrix with ones for all links defined as being within distance d of a given i; all other links are zero including the link of point i to itslef. The sum of weights is written as

$$W_i = \sum_{j \neq i} w_{ij}(d). \qquad (2.1)$$

The numerator of (1.9) is the sum of all x_j within d of i but not including x_i. The denominator is the sum of all x_j not including x_i. Whe we set

$$\bar{x}(i) = \frac{\sum_j x_j}{(n-1)} \text{ and } s^2(i) = \frac{\sum_j x_j^2}{(n-1)} - [\bar{x}(i)]^2 \qquad (2.2)$$

it may be shown that

$$Var(G_i) = \frac{W_i(n-1-W_i)}{(n-1)^2(n-2)} \times \left[\frac{s(i)}{\bar{x}i}\right]^2. \qquad (2.3)$$

The resulting measures are

$$G_i(d) = \frac{\sum_j w_{ij}(d)x_j - W_i\bar{x}(i)}{s(i)\left\{\left[(n-1)S_{1i}) - W_i^2\right]/(n-2)\right\}^{\frac{1}{2}}}, \; j \neq i, \qquad (2.4)$$

where $\bar{x}$ and s^2 denote usual sample mean and variance.

RESULTS

In first research task we developed matrices of neighbourhood area, which includes all regions of CE countries on NUTS III level. In our case, we consider a symmetric matrix:

[77 × 77].

Median of GDP/capita for all regions was set at 27 951€ for 2013. The Moran's I, was computed as

$I = 0.5358$.

Thus, in the case of CE countries we can speak about positive spatial autocorrelation. Moran coefficient reached 0.514, which indicates a strong degree of positive spatial autocorrelation.

On significance level $\alpha = 0.05$, we tested the hypothesis of spatial autocorrelation based on the median of GDP/capita in regions of CE countries. In the computations we proceed as follows:

$$S_1 = \frac{1}{2}\sum_i \sum_j (w_{ij} + w_{ji})^2 = 706,$$

$$S_2 = \sum_i \left(\sum_j w_{ij} + \sum_j w_{ji}\right)^2 = 9444,$$

$$S_3 = \frac{N^{-1}\sum_i (x_i - \bar{x})^4}{\left(N^{-1}\sum_i (x_i - \bar{x})^2\right)^2} = 0.04212,$$

$$S_4 = (N^2 - 3N + 3)S_1 - NS_2 + 3\left(\sum_i \sum_j w_{ij}\right)^2 = 3.67 \times 10^6,$$

$$S_5 = (N^2 - N)S_1 - 2NS_2 + 6\left(\sum_i \sum_j W_{ij}\right)^2 = 6.39 \times 10^5,$$

$$\mathrm{Var(I)} = \frac{NS_4 - S_3S_5}{(N-1)(N-2)(N-3)\left(\sum_i^n w_{ij}\right)^2} = 0.0055.$$

Moran index for regions of CE countries transform on the normal distribution statistics for testing the hypothesis of spatial autocorrelation at significance level $\alpha = 0.05$.

$$U = \frac{I - E(I)}{\sqrt{Var(I)}} \sim N(0, 1),$$

$$u_0 = \frac{0.5358 - (-0.01316)}{\sqrt{0.0055}} = 7.402.$$

To determine the confidence interval on significance level $\alpha = 0.05$ we find in tables of normal distribution quantile $u_{0.975}$ = 1.96. Confidence interval for the alternative hypothesis is $\langle -\infty; -1.96 \rangle \cup \langle 1.96; \infty \rangle$. Our calculated value is realized in the given interval, and therefore we should accept the alternative hypothesis about the significance of spatial autocorrelation of regions of CE countries at NUTS III level with at least a 95% probability.

Alternatively, for the purposes of comparisons we also computed Geary's C statistics, which was set at:

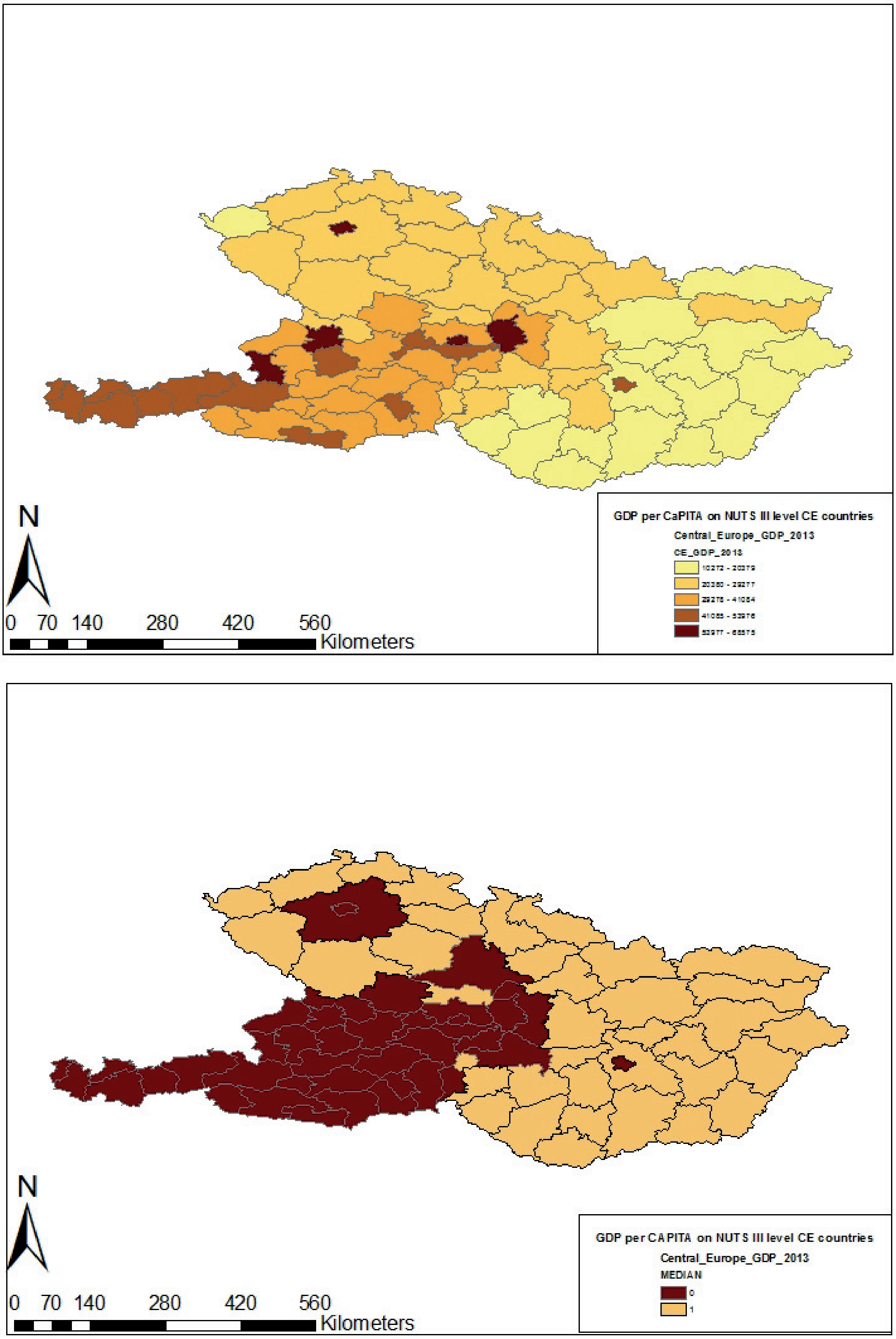
C = 0.321 what suggests also strong degree of spatial autocorrelation, thus our hypothesis is being confirmed by both indicators.

Fig. 1a represents a spatial deployment of GDP/capita in interval distribution, based on Natural breaks classes (Jenks) (Law, Collins, 2013). Picture shows relatively great differences in levels of GDP/capita across the regional structure of CE countries. Regional GDP varies greatly between 68575–10272 € level, respectively. The regions with the lowest level of regional GDP/capita are located mostly in southern and eastern part of the Slovakia and Hungary. Moderate level of regional GDP/capita is located in Czech republic. The regions with the highest level of regional GDP/capita are located in Austria, except of several outliers. Capital regions of all countries belong also to regions with the highest level of GDP/capita.

Fig. 1b) represents a deployment of GDP/capita in spatial perspective. The empirical analysis confirmed relatively strong degree of spatial autocorrelation in the case of GDP/capita in regional structure of CE countries. The regions above and below the median are forming clear clusters.

In the second research task we have measured possible centrifugal and centripetal effects, centered around the core capital regions of the CE countries. Based on own calculations we get results for a given distance d_i (Tab. I).

Tab. I shows computed values for clusters around the core regions of CE countries. On first look we

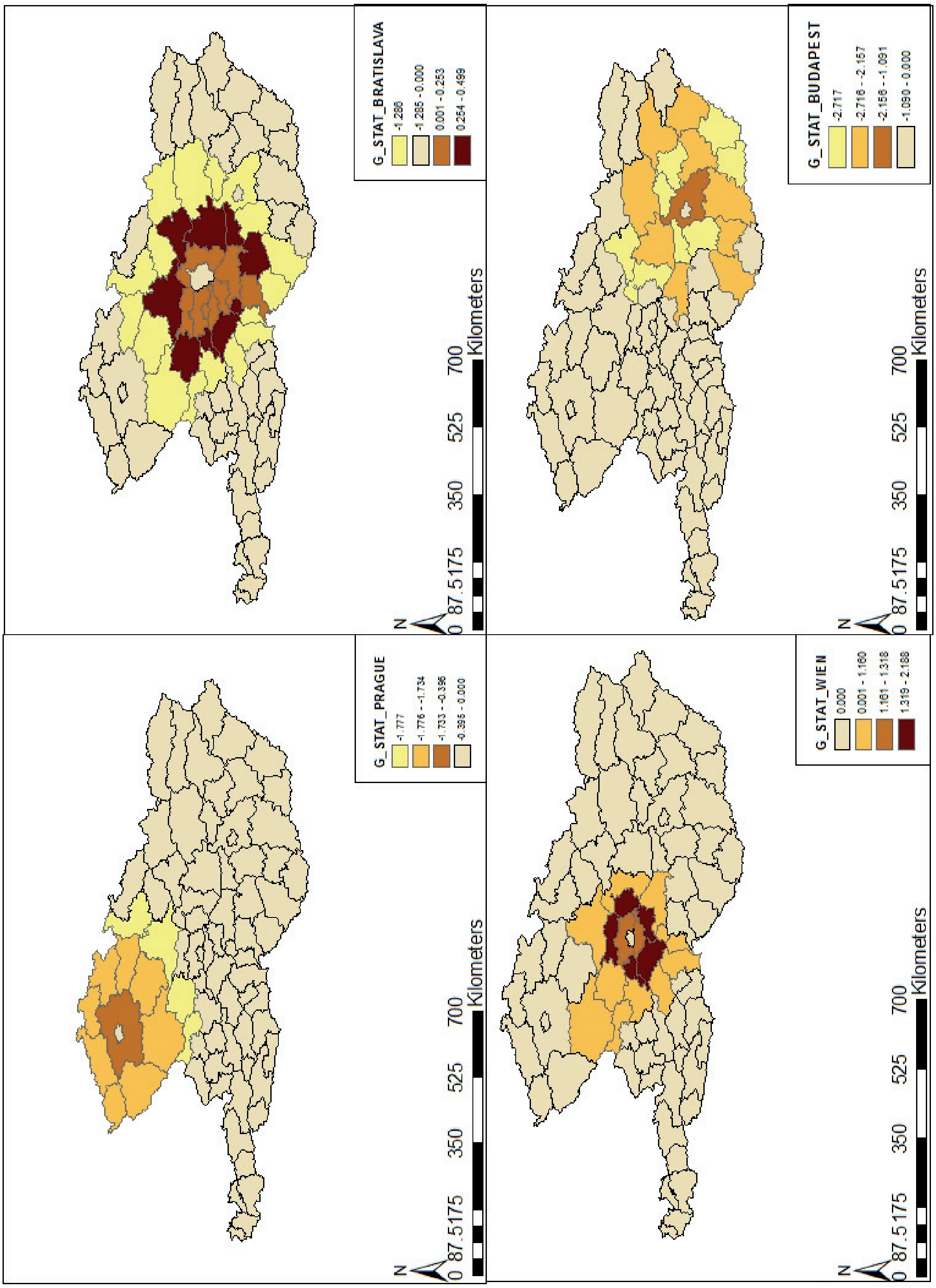


1: *a) spatial deployment of the GDP per Capita in regional perspective of CE countries, b) spatial autocorrelation perspective of regional structure of CE countries*
Source: own calculations, www.statistics.sk, www.ksh.hu, www.czso.cz, www.statistik.at

I: *Calculated statistics on NUTS III level for given distance unit*

Distance	Bratislava	Wien	Budapest	Prague
d1	0.49923431	1.160328052	−1.091785205	−0.396383382
d2	0.253272595	2.188359925	−2.71796238	−1.734038555
d3	−1.286368854	1.318456338	−2.157659015	−1.777003978

Source: own calculations



2: *spatial deployment of the Gi statistics values on 3-tier distance level around the core regions of CE countries* can observe both positive and negative values, which point on affecting centrifugal and peripetal forces, both respectively in examining regions. Positive values of G_i statistics indicate clustering of high values, but vice-versa, negative values indicate clustering of low values in terms of regional GDP/capita in CE countries.

Fig. 2 shows the spatial deployment of the G_i statistics values on 3-tier distance level around the core regions of CE countries. The results have shown-up on relatively great differences between the core regions of Prague (CZ), Budapest (HU) and Wien (AT), Bratislava (SK), respectively. In case of Wien and Bratislava, statistics get positive values (except of Bratislava on the 3rd distance level), what indicates clustering of the high values in the proximity of both regions, thus we could suppose acting of centrifugal effects in neighboring areas. Empirical evidence from national statistical databases of CE countries, acknowledge higher GDP/capita in neighboring regions, well above the common median of GDP/capita of CE countries. The results in the case of the Prague and Budapest, statistics get negative values, what indicates clustering of the low values in the vicinity of both regions, thus we could suppose acting of centripetal effects in neighboring areas. Moreover, evidence acknowledges lower GDP/capita in neighboring regions below the common median of GDP/capita of CE countries, additionaly in case of Hungary remarkably lower.

DISCUSSION

Both pictures together indicate polarized form of the development and dividing economic gap between the west and east of the region in general. These phenomena has its roots in recent history. Austria, old member state of the EU, has established market economy for some centuries and also historically, Austria was home of former nobility, later transformed on capital forming elite, which was driving the development of the society in terms of investment and industrialization. Also we have to consider the impact of other regions (Germany), which don't attend the examination. Czech republic, Slovakia and Hungary are former socialist countries, which had been for almost fifty years under the communist rule. The way of the organizing of the economy, market, proprietor rights was absolutely different, in comparison with the west.

Specifically, when looking on transition countries with focus on inequality, most important factors driving overall inequality upwards are to be found in the field of changing labour market outcomes (Milanovic, 1999). The situation of wage disparities was shaped by enormous and still ongoing changes in the labour markets of the Eastern European countries, driven by transitional recesions and by enormous structural and sectoral shifts in the period of recovery from the mid 1990s onwards (Leitner, Holzner, 2009).

CONCLUSION

The paper focuses on examining regional disparities in CE countries in spatial perspective. In the first part it concerns by the measuring of the spatial economic inequality within the region of CE countries in terms of GDP/capita. For this purpose, we have used two methods of examination – Moran's coefficient of spatial autocorrelation and the Geary's C coefficient of spatial autocorrelation Both coefficients demonstrated a relatively strong degree of spatial autocorrelation within the region of CE countries, meaning that regions are creating clear different clusters. Consequently, the interval distribution of the studied character – GDP/capita (Fig. 1b) has confirmed apparent "three-way" level of development of the region of CE countries: developed west, converging north and lagging east and south.

In the second part, paper concers by the measuring of the possible present centrifugal and peripetal effects acting namely in the proximity of the core regions of the CE countries. Results of empirical examination, according the $G_i(d)$ statistics demonstrate both phenomena in Vienna, Bratislava and Prague, Budapest respectively. Fig. 2 shows the visual presentation of mentioned phenomena in terms of the intensity of the effects on a particular level of distance.

Underlaying the results in Vienna and Bratislava have measured positive values for all three levels of the distance (except of Bratislava), thus acting of the centrifugal effects we can't rule out. Neighboring regions, have in average higher level of GDP/capita, also we might suppose spatial dependence relations between the both core regions. The impact of the other regions, which have not been taken into account (Germany) is also not minor. In despite of the results, we consider also the opinion, that development in the proximity of Bratislava and Vienna is rather based on historical roots, than on centrifugal effects, however core regions should also play a minor mission on developing process.

In case of the Prague and Budapest, the results have acquired negative values both on three levels of the distance, which indicates acting of the centripetal effects. Neighboring regions have in average far lower level of GDP/capita, so we can suppose the impact of core regions in terms of deconcentration of productive factors from proximal regions to the core.

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