European Journal of Geography Volume 6, Number 3:30 -41, September 2015
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QUANTIFYING POLYCENTRIC PATTERNS: AN EMPIRICAL APPLICATION ON EMPLOYMENT DATA IM MOLDOVA, ROMANIA

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Abstract

Polycentrism has been in the academic limelight ever since it was promoted in European Spatial Development Perspective as an a-priori view valuable to adopt. The scientific literature is abundant in studies which approach this concept from both a normative and an analytical point of view. The latter offers different methods for analysing polycentric patterns of development of a region. This paper uses elements of spatial econometrics to identify such patterns in Moldova – the eastern side of Romania. Hence, different indexes of spatial autocorrelation will statistically describe the spatial pattern of employment in Moldova revealing its spatial structure (scattered or polycentric) and will then be incorporated in a hot spot analysis which will point out spatial cluster topologies. The final output can serve as a starting point for further detailed analysis and in assessing the implications of the identified spatial structures on decisional level (stakeholders and policy designers).

Keywords: *polycentrism, employment, Hot Spot analysis, Romania, spatial autocorrelation*

1. INTRODUCTION

In recent scientific literature, there is a growing consensus about how the spatial structure of cities in developed societies is becoming increasingly polycentric (Vasanen, 2012), breaking with the paradigm of the monocentric city (Jaume, 2012).

The concepts of polycentrism and polycentric development have gained widespread currency (Meijers, 2008), being acknowledged as a central objective for spatial planning in Europe (Gløersen, 2007). Over the past fifteen years, a vast academic and policy literature has emerged focusing on these concepts (Burger and Meijers, 2012). Nevertheless, as shown by Kloosterman and Musterd, 2001; Bailey and Turok, 2001; Davoudi, 2003; Vandermotten et al., 2008 this does not imply that a consensus has been reached regarding their meaning; the theoretical foundations are far from being solid (Vasanen, 2012) the terms remaining one of the most versatile and elusive concepts around (Davoudi, 2003).

The word ‘polycentrism’ is both used in European official documents regarding urban planning and strategies and in academic approaches, which points to a normative interpretation rather than an analytical one – the suffix “-ism” being a proof in this respect (Green, 2007; Vandermotten et al., 2008). “Polycentricity” refers to any spatial structure following a polycentric pattern, whereas “polycentrism” represents a form of ideology based on the concept of polycentricity (Vandermotten et al., 2008).

The third concept – polycentric development – has a threefold approach: (1) a normative planning strategy which can be applied to different scales – metropolitan, national, transnational (Albrechts, 2001; Davoudi, 2003), (2) a spatial process resulting from the diffusion of urban functions (often high-order) from major cities to smaller nearby centres (Kloosterman and Musterd, 2001; Hall and Pain, 2006) and (3) a resulting spatial configuration of urban areas associated with concepts like 'urban region', 'mega-city-region', 'metropolitan area', 'global city region' (Meijers, 2005). In other words, one talks about polycentrism, measures polycentricity and observes in the territory the polycentric development.

In Europe, polycentricity has been presented as the result of the evolving of pre-existing hierarchic urban system (Jaume, 2012), as old vertical relationships between cities and towns have been replaced by horizontal ones. One way of studying the polycentric patterns is by identifying sub-centres within the urban systems, as they are considered the spatial result of the changes occurred in the relationships among the system elements – towns and cities. Researchers propose two approaches for identifying the sub-centres: by analysing the employment or population density or by studying the mobility flows. Due to the lack of official data regarding any flow data for the study area, the present research will use as a statistical variable the total number of employees.

In this context, the main question referred in the paper is whether the employment data is an appropriate variable for the identification of spatial cluster topologies which are significant for the polycentric development of Moldova, Romania. Hence, the aim of the paper is to analyse the polycentric patterns of the Moldavian urban system emerged from the spatial structure of employment in the region, and more precisely to identify (a) how employment sprawls out around cities and towns and (b) whether its structure can be regarded as polycentric or scattered.

The remainder of the paper is organised as follows. A brief inventory on relevant scientific literature will be presented in section 2 of the paper to provide a structured overview on the existing methods. Section 3 presents the study area and the methodology. The results are presented in section 4 together with the discussions about the main findings, while the conclusions are highlighted in the last part of the paper.

2. THEORETICAL BACKGROUND

The scientific literature on analysing and understanding spatial patterns of employment (dispersed or polycentric) has evolved over the years and proposes different quantitative or spatial statistics methods.

Usually the researchers aim to identify sub-centres in the periphery of large cities by studying the patterns and changes of employment in a certain area. The most common method in this direction is the 'cut-off method' which consists of choosing two thresholds: one for the employment density and the other for the number of jobs (Giuliano and Small, 1991; Anderson and Bogart, 2001; Gaschet, 2002); it is also common to replace them with another variable – the ratio of jobs per resident population (Shearmur and Coffey, 2002). The approach is widely criticised on the one hand because the choice of thresholds biases the number of subcentres (Anas et al., 1998), and on the other hand by using different values it limits the comparability between different urban areas (Riguelle et al., 2007).

Another method takes into consideration the interactions between spatial units using as statistical variable the commuting flows (Burns et al., 2001; Roca et al., 2009 cited by Jaume, 2012). Green (2007) and Vasanen (2012) used this approach to analyse the functional organisation of a spatial system – the former by conducting a social network analysis and the latter by examining connectivity aspects of urban sub-centres.

There are also some authors who propose a third method: the identification of peaks - a set of spatial units that present a local maximum towards the neighbouring area (J. F. McDonald and McMillen, 1990; Craig and Ng, 2001, Ikonomou, 2011). But as Riguelle et al. (2007) pointed out this method is mainly suitable for cities that are still quite monocentric and not for those with several big subcentres.

Related to this approach is the analysis of employment density functions; it is focused on identifying positive residuals estimated from a smoothed semiparametric regression of employment density on distance from the CBD (McMillen, 2001) or from monocentric regression model of employment density using an exponential function (J. McDonald and Prather, 1994). However, this procedure as cut-off approach is sensitive to the cut-off points and the results depend critically on the size of tracts (Jaume, 2012).

The last category of methods is based on elements of spatial econometrics used to identify clusters with higher density than that of neighbouring areas. By applying Local Indexes of Spatial Autocorrelation (LISA), Riguelle et al. (2007) combine general and local indices of concentration with a Shift-Share analysis in order to empirically describe and explain the spatial structure of four urban regions in Belgium, concluding that jobs still remain concentrated in the city centres, edge developments preferring to locate in historical town.
Guillain et al. (2006) use indexes of spatial autocorrelation (Moran's I and Moran scatterplot) and spatial heterogeneity without arbitrary cut-off together with a sectoral analysis of the CBD to investigate the spatial distribution of employment in the region Ile-de-France; their method pointed out more clearly the emerging poles located beyond the immediate vicinity of Paris, and also the supremacy of traditional CBD compared with the neighbouring communes.

Exploratory spatial data analysis was also used by Baumont et al. (2004) in order to study the spatial pattern of total employment and employment density which revealed a much lower number of clusters than for instance the cut-off method, being significant in assessing the monocentric character of the analysed urban system.

However, the choice of method is important given that the number of subcentres and their boundaries is quite sensitive to measurement definition (Anas et al., 1998). This choice is often guided by the availability of data.

3. METHODOLOGICAL FRAMEWORK
Study area and data

Moldova covers an area of 46.174,62 km^2 having a total population of 4.7 million inhabitants at the last census (2011). It is located in the eastern side of Romania being affected by an economic delay due to: (1) the low accessibility to transcarpathian transport network which makes the western side of the country more attractive; (2) scarce natural resources; (3) an urban system hierarchically disrupted by the split of the historic Moldavia (Romanian region of Moldova and Republic of Moldavia) at the end of the second World War and by the artificial NUTS 3, (4) the hermetic character of eastern border of Romania. These aspects have become an issue for the process of economic convergence and for trans-border cooperation.

The east-west disparities are a cross-scale pattern of Romania; important differences between west and east are also present inside the study area: the eastern side is ruled by a core-periphery logic which determines a mixture of functionalities for the rural areas located in the proximity of towns and large cities, resulting a rather homogenous landscape; the counties from the western side have developed in a different socio-economic context (they had access to a wider variety of natural resources) which allowed them to define different economic functionalities (Muntele et al., 2010).

Data used in this study are provided by the National Institute of Statistics according to the last population census (2011). The institution offers register-based data for the all LAU1 units that cover the entire Moldova. Furthermore, in the analysis were also included the neighbouring Romanian counties, as the area functions like an open system establishing links not only within its boundaries, but also beyond them.

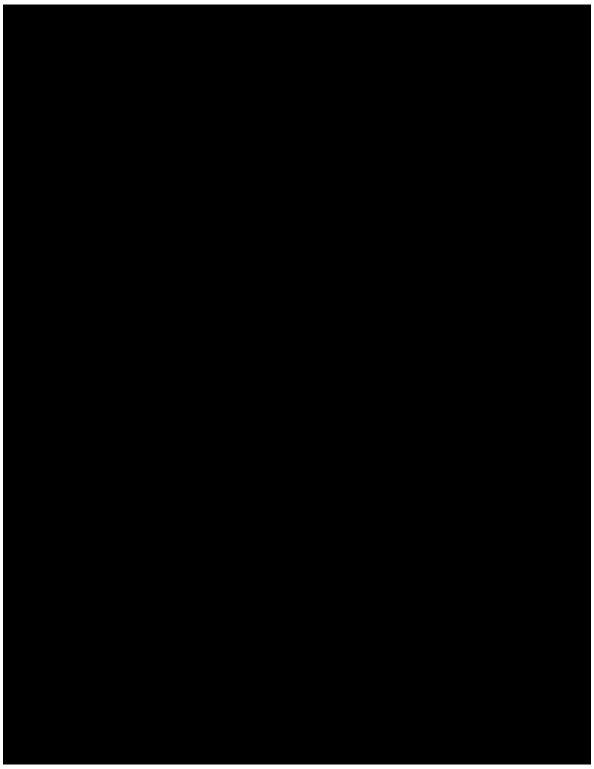

Figure 1. The study area as part of Romania

3.1 Methodology

ESDA (exploratory spatial data analysis) is a set of techniques aimed at describing spatial distributions in terms of spatial association patterns such as global spatial autocorrelation, local spatial autocorrelation, and spatial heterogeneity (Baumont et al., 2004). In other words, these techniques should aim to describe spatial distributions, discover patterns of spatial association (spatial clustering), suggest different spatial regimes or other forms of spatial instability (non-stationarity), and identify atypical observations (outliers) (Fischer et al., 1996, pp. 123).

These techniques were chosen for this paper as they allow using the spatial interactions between different spatial units and spatial weights matrices for extending the notion of neighbouring sites beyond the idea of contiguity. Hence, ESDA is an effective solution to the inconveniences of using an arbitrary cut-off threshold (Guillain et al., 2006; Riguelle et al., 2007) and it provides statistical tests which indicate whether the associations are significant or not.

Spatial autocorrelation can be defined as the coincidence of value similarity and locational similarity (Anselin, 2001 cited by Guillain et al., 2006). For instance, in the context of urban areas, positive spatial autocorrelation means that spatial units with high employment are clustered together.

Firstly a global index of spatial concentration was taken into consideration. Moran's I global autocorrelation index is an inferential statistic and gives a formal indication of the degree of linear association between observed values and the spatially weighted averages of neighbouring values. It measures spatial autocorrelation based on both feature locations and feature values simultaneously, having the following mathematical form (Guillain et al., 2006):

$$I = \frac{N\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})\sum_{i=1}^{n}(x_i - \overline{x})^2},$$

where N is the number of observations (points or polygons), $\overline{x}$ is the mean of the variable, X_i is the variable value at a particular location, X_j is the variable value at another location, W_{ij} is a weight indexing location of *i* relative to *j*.

The index is sensitive to the definition of neighbourhood used in its computation. Hence several methods were tested in this regard.

As the index offers only an idea of the spatial structure of the overall area and furthermore the analysed phenomenon is spatially non-stationary, a local index of spatial autocorrelation (LISA) was computed in order to identify the patterns generated by employment at the level of the statistical units. LISA allows identifying (a) where the local autocorrelation differs greatly from the global measure and (b) significant local spatial clustering around an individual location (Anselin, 1995). Thus, a negative autocorrelation indicates dissimilarities in employment distribution, whereas a cluster of spatial units with a high employment distribution will show a significant positive autocorrelation.

In order to identify these patterns we have used the local Getis-Ord Gi* statistic which reveals whether features with high values or features with low values tend to cluster in the study area. It compares local advantages to global averages and identifies if local pattern is different to what is generally observed across the whole study area (Getis and Ord, 1992). The algebraic formulation of the index can be found in different studies - Getis and Ord, 1992; Ord and Getis, 1995; Fischer et al., 1996.The index was used in the computation of Hot Spot Analysis, which assess whether high or low values cluster spatially and was calculated by using a tool integrated into software developed by ESRI – ArcGIS 10.2. The methodology was performed on LAU[1]1 units of Moldova, excluding cities as they register the highest number of employees and bias the final output, being in the position of outliers.

3. RESULTS AND DISCUSSIONS

Moran's I global autocorrelation index gives a rough idea of how the communes with a high number of employees are spatially organized - if they are concentrated (positive spatial autocorrelation), dispersed (negative spatial autocorrelation) or rather randomly distributed. (Riguelle et al., 2007). For the computation of the index there were used several fixed band distances (15, 30, 50, 75 km) and in all cases the values suggest a concentrated pattern (see table 1). As the distance increases, the index tends to have lower values, but it does not affect its significance. Since it does not provide information on the location of employment clusters, a local index of spatial autocorrelation was calculated for further analysis, more specifically for the identification of hot or cold spots. The Hot Spot analysis was computed on local and regional level for the conceptualisation of spatial relationships being used four different distance bands – 15, 30, 50 and 75 km.

[1] LAU – Local Administrative Unit

Table 1 - Moran global autocorrelation for Moldova

Neighbourhood function	Moran's I	Z-score
Fixed band distance – 15 km	0.171	15.04*
Fixed band distance – 30 km	0.054	9.64*
Fixed band distance – 50 km	0.014	4.23*
Fixed band distance – 75 km	0.0085	3.93*

*Significant beyond 0.01% level

Figure 2. Hot Spot analysis within 15 and 30 kilometres distance

As a general observation, at the regional level the analysis highlights a west-east gradient – in the western side are clustered high values, while in the eastern side appear more areas that group low values of employment. Furthermore, the analysis emphases that the emergence of spatial interactions between the analysed units is still determined by the distance, which also has an important role in delineating hot/cold spots, in other words the self-contained labour areas.

As the distance increases, the patterns defined as hot and cold spots extend themselves. At 15 kilometres only the major cities of the regions were able to generate hot spots (Iasi, Suceava, Piatra Neamt and Galati) which correspond with their metropolitan areas. Other hot spots are to be found around towns with predominate touristic functions – Vatra Dornei and Slanic Moldova. An increase of 15 kilometres (fig. 2) determines some morphological changes of the territorial architecture of the study area: (a) the extension of the above mentioned hot spots either by including the second ring of suburban communes (in case of Iasi and Galati) or the towns located in the proximity (in the case of Piatra Neamt or Suceava) and (b) the emergence of cold spots patterns which cover almost the entire Vaslui county (Negresti, Vaslui, Barlad, Murgeni) and some areas from the northern part of Moldova (these are mainly remote rural areas where the subsistence farming is the main economic activity of the population).

At 50 kilometres the hot spots patterns tend to extend more in the western part of Moldova, including new towns (Campulung Moldovenesc, Gura Humorului, Brosteni) and their nearby communes, resulting a compact structure that extends towards east along the main transportation axe (Targu Neamt – Pascani – Targu Frumos); it is displayed on the map at a distance band of 75 km (fig. 3). On the other hand the cold spot structure from the north-eastern part of Moldova diminishes considerable being reduced to a few communes located near the border with Republic of Moldova. The other structure with the same patterns remains the main characteristic of Vaslui county, but it also extends in the nearby counties, including towns like Panciu, Tecuci, Adjud.

What is worth mentioning is the absence of hot spots structures around the main cities of the region (Iasi, Suceava, Galati) beyond the distance of 30 kilometres which points out a rather heterogeneous character of the communes within 50 and 75 km threshold regarding the distribution of employment. Furthermore, the communes located in the western part of Iași metropolitan area generated a cold spot highlighting a high dissimilarity with the rest of the units.

Figure 3. Hot Spot analysis within 50 and 75 kilometres distance

The same analysis was also computed for each county separately using only two distance bands – 15 and 30 kilometres - highlighting how local urban systems function inside the administrative territorial boundaries. The results are displayed in figure 4. At 15 kilometres the major cities of each county generated hot spot structures (Botosani, Suceava, Iasi, Piatra Neamt, Bacau, Vaslui, Barlad, Focsani, Galati) which highlight, in fact, their main polarisation area. At 30 kilometres the morphology suffers a few changes: (i) the hot spot patterns extend around the cities, (ii) Suceava, Bacau, Vaslui and Barlad no longer generate such structures (indicating a rather heterogeneous pattern around these cities), (iii) the emergence of a new hot spot concentrated around some former industrial towns (Moinesti, Comanesti, Darmanesti) and (iii) a clearer delineation of cold spots (in case of Roman and in the northern part of Galati county).

Figure 4. Hot Spot analysis computed at local level

The most conclusive results of the hot spot analysis both for local and regional level are summarised in a choremic representation (fig. 5), the main feature of the territory being the discontinuity between the western and eastern part of Moldova.

If the western side of the region appears to have some potentialities for the emergence of a polycentric system, the eastern side is clearly dominated by a monocentric pattern, cities like Iasi and Galati being able to generate hot spots only to a certain distance (30km). The rest of the territory (the one between these cities and those from the northern part) have clustered low values of employment generating cold spots, as most of these communes are characterised as remote rural areas.

Regarding the hot spot area from the western side of Moldova, it emphases a rather polycentric pattern as it comprises some subregional and local urban systems that have potentialities for such a development trend as they present functional heterogeneity due to the socio-economic context in which they evolved. The term "potentiality" is being used because the method does not point out the nature and direction of relationships between the analysed spatial units.

By changing the scale of analysis the topology of the eastern side is completed by local hot spots aggregated around cities (Focsani, Botosani) which can polarise the proximity only at this level.

Figure 5. Choremic model of Moldova

4. CONCLUSIONS

The present paper has analysed the spatial structure of employment empirically and it has shown how employment sprawls out around cities and towns in Moldova, Romania. In particular, it has considered the question whether this kind of data represent an appropriate variable for the identification of spatial cluster topologies which can offer a general overview upon the potentialities of polycentric development of the study area.

The exploratory spatial data analysis is a useful tool in identifying employment subcenters, but it does not take into account the nature and direction of the relationships between the spatial units; so, it allows a rather morphological delineation of polycentric patterns and not one based on the functionality of the territory.

The global and local indices of spatial autocorrelation revealed clustered patterns mainly around the major cities of the region (Iasi, Suceava, Botosani, Galati, Piatra Neamt), highlighting thus a core-periphery logic, especially in the eastern part of the analysed area, which has as a consequence the delay in achieving a functional heterogeneity of the rural areas and thus in emerging multidirectional linkages between them (cooperation being a key element in polycentric development).

The high values of employment clustered in the western part of Moldova (as indicated by the Hot Spot analysis) highlight the heterogeneity of the territory from a functional perspective, creating hence the premises for future polycentric development.

The study represents a starting point for further detailed analysis; the commune level is spatially too coarse and does not allow an exact identification of spatial units that have the potentialities to create a polycentric system thus, a more refined analysis being required.

Furthermore, hot spot analysis can also be used by decision makers to select areas with more pronounced problems and then allocate resources to those focus areas.

ACKNOWLEDGEMENT

This paper is made and published under the aegis of the Research Institute for Quality of Life, Romanian Academy as a part of programme co-funded by the European Union within the Operational Sectorial Programme for Human Resources Development through the project for Pluri and interdisciplinary in doctoral and post-doctoral programmes Project Code: POSDRU/159/1.5/S/141086.

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