Cross-Border Continuity of Socio-economic Indicators: Case Study of Czechia and Poland

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Summary
Many of the human activities are hard to measure. Nevertheless, the development of human society can be captured by statistical data and indicators. There exist differences in quality of life amongst European countries, especially evident in cross-border regions. This study assesses disparities of socio-economic indicators, representing socio-economic phenomena, by the analysis of their cross-border continuity using quantitative methods, GIS, and cartographic visualisation. On an example of the Czech-Polish border region, it is demonstrated how such a combination of methods is useful for comparison and evaluation of the socio-economic situation in neighbouring countries.

KEYWORDS: GIS, socio-economic data, continuity, Czechia, Poland

1. Introduction

According to Bell (2014), the word continuous means "'unbroken' or 'interrupted,' thus a continuous entity has no 'gaps.'" In geography, it is supposed that natural phenomena are continuous (in space and time). From the GIScience perspective, Goodchild (1992) claims that "what distinguishes spatial data is the fact that the spatial key is based on two continuous dimensions," meaning that there are no gaps in Earth's surface (DiBiase et al., 2014). Nevertheless, the socio-economic phenomena are mainly the product of human activities, which are not always continuous in space and time. In GIScience, this kind phenomena are commonly represented in a non-continuous way, i.e. using administrative or census units. These discrete objects represent the geographical world as a set of objects with well-defined boundaries in otherwise "empty space" (Longley et al., 2011). Although administrative units cover a geographical region seamlessly, aggregated socio-economic data within the units may change abruptly from one unit to another.

In the context of cross-border cooperation, it is supposed that sub-regions on both sides of borderline will share common characteristics and needs. According to Perkmann (2003), cross-border cooperation can be defined as "a more or less institutionalized collaboration between contiguous subnational authorities across national borders," which should generate a cross-border region. The cross-border region is characterised by "homogeneous features and functional interdependencies because otherwise there is no need for cross-border co-operation" (CoE, 1979).

In a case of Central and Eastern European countries (including Czechia and Poland), European Commission document (AEBR and European Commission, 2000), mentions that approaches to cross-border cooperation started to emerge after 1989 with the borders opening. In this region, it has been necessary to cooperate "in order to offset the geographical disadvantages of border areas and the huge disparities in income and infrastructure… amongst these countries themselves" (AEBR and European Commission, 2000). In the case of Czechia and Poland cross-border cooperation, these efforts were accelerated by EU programs (e.g. Phare or INTERREG), but still, the disparities are present. Studies on Czech-Polish cross-border cooperation were conducted mainly by Czech and Polish researchers,

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nevertheless with a focus on one specific geographical theme (Heffner, 1998; Szczyrba, 2005), sub-region (Mintálová and Ptáček, 2012; Runge, 2003), and/or a higher level of administrative units (ČSÚ, 2005; Kladivo et al., 2012; Dołzbłasz, 2013), with limited use of GIS.

In this study, the authors work with socio-economic indicators (within the local administrative units LAU 2) reflecting the social, demographic and economic situation in the Czech-Polish border regions. The research question is: Is there a cross-border continuity of socioeconomic phenomena (represented by respective indicators) in Czech-Polish border regions? In other words, authors are looking for (dis)similarities in society development; common historical, geographical and economic factors that have led to the current state of the development.

2. Study Area, Data and Methods

2.1. Study Area

For this study, the border region is depicted in Figure 1 and was selected similarly as in Kladivo et al. (2012). The overall area of the region is approximately 20,000 square kilometers (roughly the same size as the whole Slovenia), divided by the border into Czech and Polish part (more or less the same size). Both regions are composed of the smallest Local administrative units (LAU 2) defined by Eurostat (2015) for statistical purposes.
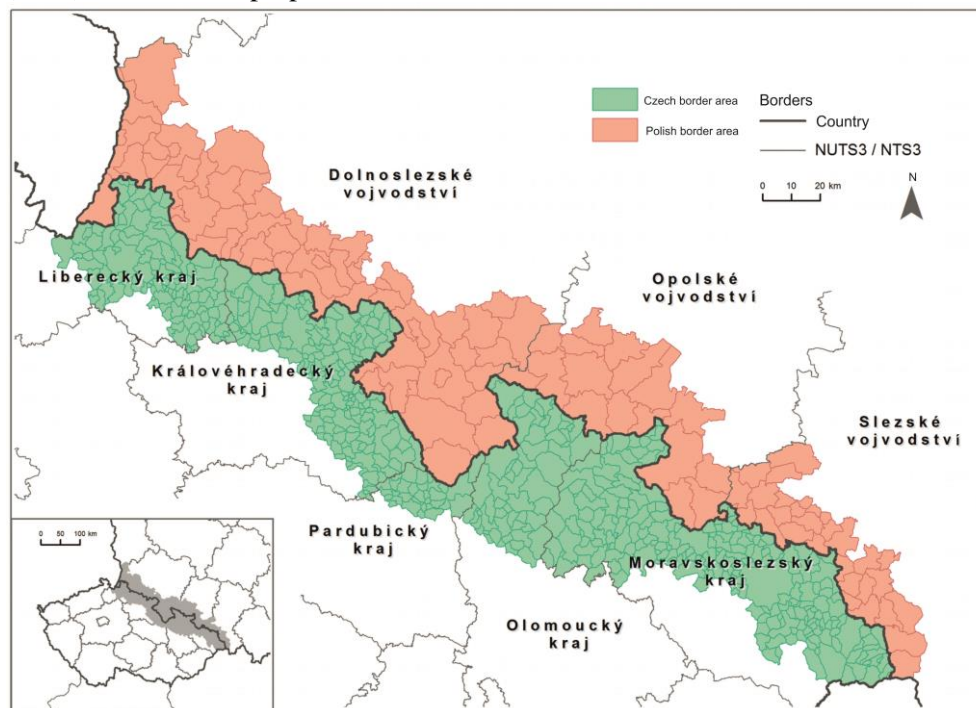

Figure 1 Study area of the Czech-Polish borderland

2.2. Data

Attribute data were acquired for the LAU 2 from national statistical offices with the reference date 2014. Although both statistical offices have a large amount of socio-economic indicators available to download, not all of them are available in the level of LAU 2 for both countries. Therefore, only those relevant indicators available for both countries for LAU 2 (sample of selected indicators is in Table 1) were included in this study in order to evaluate their continuity. In total, there are 109 LAU 2 units on the Polish side and 604 units on the Czech side, all with 26 attributes (indicators). Geographical data were obtained from CODGiK (Polish Office of geodesy and cartography) database, and from ArcCR® 500 database provided by Czech company ARCDATA PRAHA and State Administration of Land Surveying and Cadastre. The common environment for (geo)data processing was Esri ArcGIS for Desktop 10 and LibreOffice.

Table 1 Sample of selected socio-economic indicators

Abbreviation	Indicator
PD14	Population density 2014
TFR	Total fertility rate
TMR	Total mortality rate
RNI	Rate of Natural increase
RND	Rate of Natural increase
DR	Dependency ratio
UR	Unemployment rate
NCF	Number of completed flats

2.3. Methods

In order to evaluate continuity of selected socio-economic indicators, three methods were used:

- First, cartographic visualisation as a proxy for visual analytics was used. In total, 26 choropleth maps were made to depict (dis)continuity of each individual indicator,
- Second, statistical analysis was performed in order to (a) reduce a dimension of attribute data with the use of Pearson's correlation, (b) find groups of similar LAU 2 units (according to socio-economic indicators) by hierarchical clustering using Ward's method,
- Third, so-called social-economic profiles of socio-economic indicators' values in LAU 2 following cross-border development axes were calculated. This approach is inspired by topographic profiling, ordinarily used in physical geography.

Additionally, a toolbox in Esri ArcGIS for Desktop was prepared for more comprehensible visualisation and analysis of clustering results. Key features of the toolbox are (a) user defined threshold for LAU 2 unit area size, (b) LAU 2 distance from the borderline, and (c) basic statistics of socio-economic indicators in a particular LAU 2. For the statistical analyses, IBM SPSS Statistics and RStudio software was used. The rest was done in Esri ArcGIS for Desktop and LibreOffice.

3. Results

Cartographic visualisation reveals sub-regions with almost perfect continuity of particular socio-economic indicators (i.e. values of an indicator are in the same interval). Specifically, Upper Silesia region in the east of the study area is the most typical sub-region with cross-border continuity of most of the indicators (e.g. population density, marriage rate, dependency ratio). This sub-region is highly urbanised. Another example of sub-region showing the continuity of socio-economic indicators is the Euroregion Glacensis (western-central part of the study area). In comparison with Upper Silesia sub-region, Euroregion Glacensis is rather a mountainous region with well-preserved nature. Continuity for the remaining study area is apparent only in the limited number socio-economic indicators, so it is better to refer about discontinuity in these cases.

Cluster analysis allowed evaluation of the continuity more comprehensively since it is not intuitive (if possible at all) to do so by looking at individual indicators separately. Clustering analysis created five groups of LAU 2 (excluding those with an area less than 30 square kilometers) according to socio-economic indicators combined all together (Figure 2).
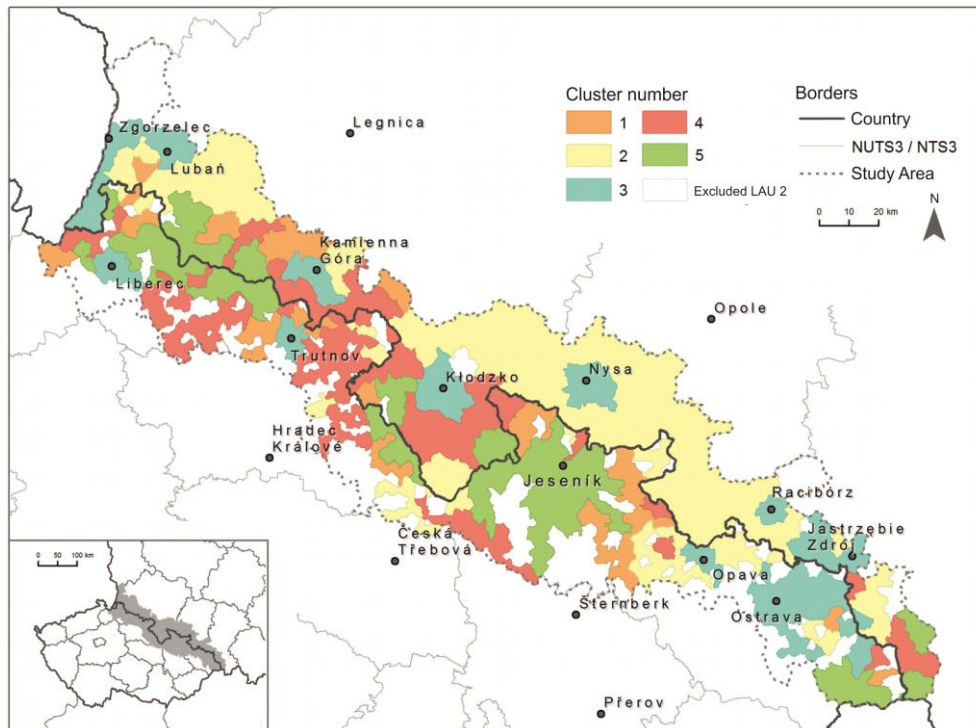
Figure 2 Results of the cluster analysis

The most cross-borders continuous sub-region is the Upper Silesia with a prevalence of cluster number 3. The cluster number 3 is composed mainly of urban LAU 2, thus the socio-economic indicators' values are similar. Continuity can also be seen in the whole western-central part of the study area. Again, in the Euroregion Glacensis LAU 2 units are mostly members of cluster number 4, which is typically composed of sub-mountainous LAU 2 with several towns increasing the importance of urban-related indicators (e.g. population density, built-up area ratio, a number of flats). Going further to the west, cluster number 5 is dominant in the Euroregion Nisa (and partially in the western parts Euroregion Glacensis). Cluster number 5 is composed LAU 2 that are located in the mountains, are typically rural villages with a well-preserved natural landscape. There is not that strong pattern of cross-border continuity in the rest of the study area. Therefore, in a simplified way, the cross-border discontinuity occurs in those sub-regions (obviously with some exceptions).

Socio-economic profiling offers a different angle of view on the (dis)continuity. It is possible to evaluate an increase (or a decrease) of socio-economic indicators continuity in one direction across the border. Or "ridges" (high values around a borderline gradually decreasing towards inner parts of a country) and "valleys" (vice versa to "ridges") of the indicators' values around a borderline can be identified. Then, socio-economic profiles with zig-zagging pattern signify the discontinuity.

4. Conclusion

The analysis of cross-border continuity of socio-economic indicators was performed in order to find out if the border sub-regions share common characteristics expressed by the statistical data. The main aim of the cross-border cooperation is to balance overall quality of life in participating sub-regions. One possible way how to evaluate the cross-border cooperation is to use "hard" statistical data. Authors of this study used quantitative methods in combination with GIS analysis and cartographic visualisation to assess the cross-border cooperation. Mutual deployment of these methods seems to be helpful for this purpose and could be used in other European cross-border regions.

5. Acknowledgements

6. Biography

Vít Pászto is currently an assistant professor at the Department of Geoinformatics, Palacký University Olomouc. His scientific interests cover issues as GIS modelling, spatial statistics, geocomputation, and geovisualisation. He publishes scientific papers on these topics and is active in geospatial communities in the Czech Republic as well as abroad.

Karel Macků is a PhD student at the Department of Geoinformatics, Palacký University in Olomouc. His main research is focused on the evaluation of the quality of life using quantitative methods and spatial/statistical data. His other professional interests are data processing, statistics, and visualization.

Jaroslav Burian received his PhD in Cartography, geoinformatics and remote sensing from Charles University in Prague. He is currently an assistant professor at the Department of Geoinformatics, Palacký University Olomouc. He is focused primarily on the issues of modelling of the urban processes in GIS. He developed GIS model "Urban Planner."

Jiří Pánek is currently an assistant professor at the Department of Development Studies, Palacký University Olomouc. He writes and presents on issues of GeoParticipation, participatory GIS, and emotional mapping. He is the author of many papers and/or books and is active in the field of voluntary geography.

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