

THE ROAD TOWARDS POLYCENTRIC DEVELOPMENT IN ROMANIA'S FUNCTIONAL URBAN AREAS. A GEOSPATIAL APPROACH

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ABSTRACT

Polycentrism, studied at any geographical scale, local, metropolitan or regional, represents a sustainable perspective of development regarding the settlements, employment and facilities systems. It is usual to find this kind of development in Western Europe, in contrast with the Eastern part of the continent. The context is an accelerated economic and demographic development of the main Romanian cities and of the communes adjacent to it, but unbalanced in relation to the nearby settlements. Socialist ideologies left their traces in the urban planning of cities built completely in the XXth century or through the systematization of historical centers and street configuration. The study areas that we chose for this paper are the functional urban areas of the main cities from Romania. We hereby study the distribution of the secondary nuclei within FUAs through a geostatistical perspective, using methods such as spatial autocorrelation and GIS tools. Among the explanatory variables that we take into account, there is the employment rate, number of commuters, density of facilities etc. The main issue that we are answering is whether these secondary centers have the potential to transform the FUA into a polycentric structure and therefore, to achieve an even economical, spatial and transport system development.

Keywords: polycentric development, OLS, functional urban area, commuters

INTRODUCTION

Polycentric development is a concept of territorial planning that is being discussed more and more in many parts of the world. This happens mostly in the more economically developed countries (MEDCs), the so-called Global North, as well as in today's emerging countries, such as China or South Africa. Polycentrism can be used not only in the subject of geography, but also in economics, politics or society, all referring to an even, balanced development of more than one entity.

In a polycentric structure, the spatial dimension plays a critical part from a geographical approach. This kind of structures can be viewed at different scales, as various authors emphasized [1]: local (inside a city), regional (a metropolitan area, a functional urban area, a county, a region), national or even international. In this article we are approaching the urban development centres compared to their adjacent regions. Even though this topic is not commonly discussed in Romania, academics and policymakers are taking steps to address it.

Through a geostatistical approach, the goal of our paper is to determine what led to a rather monocentric or polycentric development within the functional urban areas of

Romania's secondary tier cities. Several variables will be used in an Ordinary Least Squares linear regression to model their importance as indirect factors that led to this kind of development.

CONCEPTUAL FRAMEWORK

Polycentrism regarding urban structures can be seen from two points of view, as many authors noticed [2, 3]. The first one is the morphological aspect of the settlements, meaning population, facilities, enterprises, as absolute values or as densities. The second one is the functional aspect, i.e. the relationships among settlements. This could be the mobility, number of commuters, connectivity or money flow. Besides these, there are also qualitative factors, such as preferences for a certain job, school, supermarket, social habits, or the will to use public transportation instead of personal car. According to Halleux (2021) [1], polycentrism is achieved when a clustering of centres are sufficiently close to develop synergy through functional connections and, at the same time, sufficiently separated to avoid the merging of their labour markets.

During the last decades, a trend of transformation of the monocentric regions into polycentric ones can be noticed. This happened at different times in different regions of the world. Some have experienced rapid and natural polycentric growth since the coal mining industry (Midlands in the UK, Rhine-Ruhr in Germany), while others are still under the effect of the monocentric strategies imposed by the socialist regimes. Today, polycentric structures can be carried out with implemented territorial planning strategies and policies. Moreover, as Anas, Arnott & Small (1998) explains, "the spatial structure of modern cities was shaped, in large measure, by advances in transport and communication, as mobility between settlements is playing a key role when talking about polycentricity" [4]. Now, with improper management, the transport system is the one that can bring many problems to monocentric cities [5]. In comparison with Western Europe, where evidence of polycentric development policies is everywhere, Romania and many former socialist countries do not benefit as much. The importance of this kind of development has only become discussed recently, with the introduction of European policies. For example, the new Territorial Development Strategy of Romania is entitled "Polycentric Romania 2035" and other strategic projects regarding enhancing the relationships between settlements are expected to be implemented. Also, more and more cities have established metropolitan areas associations as legal entities, ensuring a uniform development inside them.

METHODOLOGY. STUDY AREA

The functional urban regions are among the least studied areas in terms of policentricity, as evidenced by the scales and instances listed above (FUAs). Its definition varies depending on each national coordinate, but general European guidelines say that "the Functional Urban Area is a geographic entity that consists of one or more urban centres and their commuting area" [6]. We believe that FUAs are the best areas to study polycentricity because they are based on the number of commuters and represent the entire area's workforce. We chose the FUAs for six of Romania's secondary cities: Iași, Cluj-Napoca, Timișoara, Craiova, Constanța and Brașov (figure 1). All of these cities have populations from 250 000 to 400 000 inhabitants and very dynamic economies (IT, administration, finance, tourism, heavy and light industry).

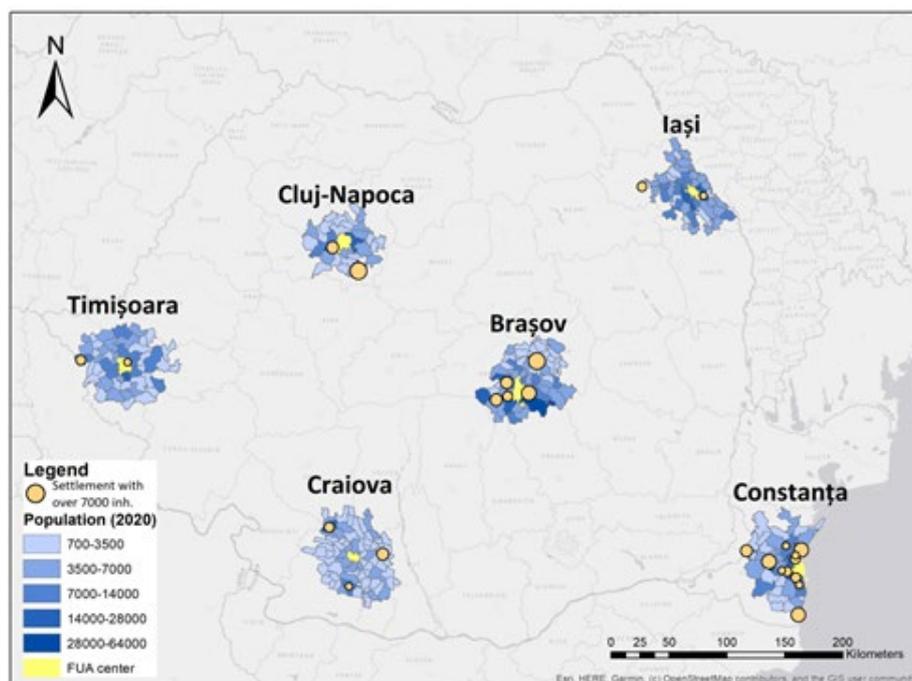


Figure 1. Study area: FUAs of the six secondary tier cities in Romania.

We worked with the LAU2 administrative units scale from these areas (communes, towns and municipalities). The studied FUAs do not intersect, and each LAU2 is inseparably linked to one of the six above-mentioned urban centers. Because of the large imbalances in the sizes of the FUAs calculated solely on the number of commuters of each LAU2, we adjusted these areas by enforcing a 45-minute (average) driving time to the FUA's urban center, resulting in the following areas. A number of 289 communes (LAU2s) were studied, with noticeable differences regarding population, facilities and economic development. At a first glance, if we were to take into consideration only the population, several sub-centers would be delimited (especially the cases of Constanța and Brașov).

POLYCENTRICITY INDEX

Because of the complexity of the factors determining such an area, no general index for assessing how polycentric it is has yet been identified, no unique index for assessing how polycentric it is has yet been identified. Suggested methods use population, spatial proximity among settlements [7], GDP, connectivity [8] or standard deviation based methods [9]. As a consequence, we propose an index that integrates two parameters: the population of a LAU2 and the mean time spent commuting to the urban center. The average time was calculated through the Network Analyst tool in ArcGIS 10.4.1, using a network dataset containing the roads, their lengths and their average speed. When these two are multiplied, the index represents the total energy consumed by the entire population of a LAU2 to get to the urban center, indicating how that LAU2 could contribute to a polycentric structure. For example, the communes adjacent to FUA centers that have very high populations (as it happens in the situations of Iași or Cluj-Napoca) would rather contribute to a monocentric development, compared to communes or towns with high populations that are spread around the whole FUA.

DATA

In addition to policies and initiatives that will be implemented, the present research is trying to determine which variables contribute the most to the development of a polycentric settlement structure. In this respect, the paper is using an OLS (Ordinary Least Squares) model based on quantitative data collected at the LAU2 scale. The data was compiled using information gathered from the National Institute of Statistics, census databases from 2011, and personal data processing. The Box-Cox technique was preferred with various settings to standardize the data in order to get the best results from the OLS.

The number of employees who work in the LAU2s, according to our initial hypothesis, defines polycentricity. We calculated the working population by dividing the number of employees by the total population of each LAU2. In addition, the number of commuters was taken into consideration (who have their jobs inside the FUA). We evaluated the ratio between the number of building authorizations issued in 2020 and the number of existing buildings in order to determine the dynamism of the LAU2s which also defines polycentricity.

The amount of facilities is also important: the more concentrated they are in a single area, the more monocentric the region will become, and people will have to travel to a single location for schools, hospitals, supermarkets, parks, and other amenities. We took into account the total number of educational units (kindergartens, primary and secondary schools, universities) as well as the total number of sanitary units (dispensaries, healthcare centers, hospitals).

Finally, the paper investigates a psychological factor: preferences for a certain school. Parents in the study area are known to prefer sending their children to the highest rated school over the closest school. In terms of educational quality, there are significant variations between rural and urban schools. We used data like the average number of students per teacher, the number of laboratories, and the number of technical devices in this way (computers, tablets etc.).

RESULTS AND DISCUSSION

The map above is describing the study area based on the population attribute. Though, this wasn't the only things that we thought about regarding centrality and we also considered distance (expressed as time). In this way, a LAU2 with a great population that is further away from the center of the FUA will lead to a higher centrality index than one that is adjacent to this main urban nucleus. Throughout the six FUAs that have been studied, we can distinguish various types of centrality. The most noticeable polycentric trends are in Constanța FUA, which has the main oil refinery and harbour in our country, and most of the resorts on the Black Sea have emerged over time, and in Brașov, which has been an industrial hub ever since the communist era (airplanes, trucks, tractors, industrial parts), and that also includes the main city of the neighbouring county, Covasna. FUAs such as Iași and Cluj proved to be more monocentric, with a great difference in development between the main city and their hinterlands. These differences consist in life quality, number and possibilities of jobs, education quality, infrastructure and so on. A trend of fast development of the communes adjacent to the urban nucleus is noticed (Florești near Cluj, Miroslava near Iași), and this can significantly get the situation worse, in case that only residential buildings are constructed. If, on the other hand, the new housing comes along with jobs and facilities, the traffic will be more evenly distributed

and the benefits of the phenomenon might spread further to the next row of communes as well.

The OLS analysis performed in ArcGIS 10.4.1 resulted in a model telling which of the discussed variables mattered the most in the polycentric development of the studied FUAs (table 1). First of all, to determine the validity and the significance of the model, we will need to interpret the obtained statistical values. The first thing that has to be checked is the distribution of the residuals. The Jarque-Bera test provided the value of 0,138519, meaning that it is not statistically significant ($<0,01$), so the model is not biased (residuals are normally distributed). The Koenker (BP) test is statistically significant (0,006598), meaning that we should rely on the Robust Probabilities to determine coefficient significance and on the Wald Statistic (0,000000*) to determine overall model significance. Next, the Variance Inflation Factor (VIF) shows no redundancy among our variables (all of the values are $<7,5$). After we checked all of these conditions, we can take a look at the measures of the model performance: adjusted R-squared = 0,608154 and Akaike's Information Criterion (AICc) = -2062,716573.

Table 1. OLS analysis results.

Variable	Coefficient	Probability	Robust_Pr	VIF
Intercept	2,738161	0,000000*	0,000000*	-
Employees	-0,000188	0,841593	0,849345	1,483281
Commuters	-0,000610	0,000002*	0,000000*	1,620882
Building authorizations	-0,001053	0,000527*	0,000486*	1,528846
Education institutions	0,006832	0,000913*	0,000150*	1,867286
Sanitary facilities	0,000081	0,647719	0,497749	1,760970
School equipment	0,004816	0,000000*	0,000000*	1,922171
Pupils / teacher	0,002261	0,000000*	0,000020*	1,170476

The model provided significant values for most of the chosen variables. Sanitary facilities and the number of employees didn't seem to influence the polycentricity that much, given the fact that their coefficients in the model's equation are the lowest too. For the sanitary facilities (hospitals, dispensaries, communal healthcare centers), the results are surprising, as they are included in the same hypothesis as the education facilities (institutions), that turned out to have the highest coefficient. The most significant variables are the number of commuters, as expected (they move the most inside a FUA and this is how this type of area is defined after all), and also the equipment of schools (showing how likely is for someone to choose a high rated school over a school situated in proximity) and the number of pupils per teacher (showing indirectly the quality of the education and where future teachers are willing to seek for jobs).

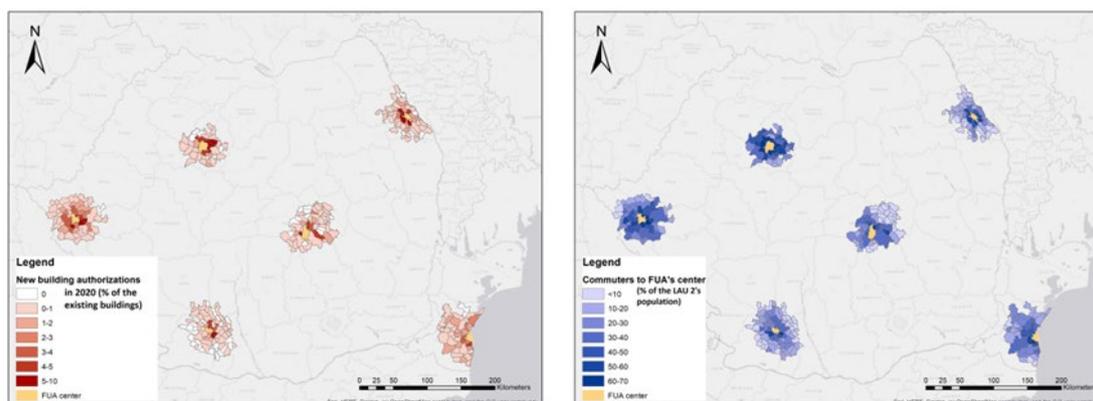


Figure 2. Left: New building authorizations per LAU2, compared to existing buildings. Right: Number of commuters who work in the urban nucleus of the FUA, compared to the total population of the LAU2.

The spatial distribution of the variables shown above (figure 2) shows a clear inverse proportionality between the value of the variable (either rhythm of construction, or number of commuters) and the distance from the urban nucleus of the FUA. Besides this, we can distinguish several sub-centers, being under the influence of the main city. This influence was shown in the low statistical coefficients resulted from the analysis.

LIMITATIONS

Among the limitations that we encountered and the things that made it difficult to reach a perfect analysis is the available data. There are some more factors that we could use in the model, such as the number of supermarkets in each LAU2 or the number of enterprises, but unfortunately there are no open source databases containing this information. Moreover, the data obtained had several outliers, but we couldn't remove them either because they represented other cities within a certain FUA, or because the values were relevant and the chosen LAU2s had to remain the same.

From a geographical point of view, we think that the discontinuous study area also led to errors in the calculation of the indicators mentioned above, and that's why a study over a single FUA or over more FUAs with less empty spaces among them would result in models with a better performance.

CONCLUSION

The polycentric type of development is an essential strategy that should be implemented at different scales. Today' Romanian biggest cities face a fast development of the periurban residential areas, but usually this is not happening for the daily basis facilities as well. While many people get tired of the downtown's agglomeration and move in the city's outskirts, the schools, parks, swimming pools, and most important, their jobs, remain inside the city. This process only leads to a monocentric trend, and that's why bringing the facilities to the periurban (or even metropolitan) area is a great solution for this.

The results proved that some of the most important factors for which a functional urban area becomes rather polycentric are the number of commuters, the pace of new buildings construction and the quality of education, which is very different from the urban to rural area. This validates some of our hypotheses. Others didn't turn out as true: not all the facilities seemed to have the same importance (sanitary institutions had a very small

coefficient in the final equation), and the number of employees is not significant as long as we don't know where exactly they work.

For a further analysis, we plan to obtain the data exemplified above (supermarkets, number of enterprises) through methods like web crawling, and to extend the study area for other cities in Romania as well, cities with a lower population but that still have a strong influence on their surrounding areas. Also, a comparison with other ex-socialist countries would be suited and would generate results related to the planning strategies that this regime brought.

Thus, the quantifiable variables that can lead to a polycentric development have been measured and discussed, to serve as a starting point for thinking planning strategies. In this way, the urban traffic would be more evenly distributed, the overall motion would be more varied and there would be less discrepancies in the development of cities and villages.

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