BABEȘ-BOLYAI UNIVERSITY
FACULTY OF GEOGRAPHY
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DOCTORAL THESIS

Dynamics of spatial interaction flows in the functional influence area of Alba Iulia

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CONTENT

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According to Aristotle's rhetoric from the Third Book of Ethics (~350 B.C.), I will attempt to provide an argument for several fundamental questions(Sloan, 2010),a priori assumedin the current doctoral thesis.

Who performed the research and for whom?

The paper titled *Dynamics of spatial interaction flows in the functional influence area of Alba Iulia* reflects the results of my personal research within the Doctoral School of Geography, Babeș-Bolyai University. The thesis is divided into five chapters and was planned as an extended ISI paper which tackles the topic of urban influence according to the new international research paradigms. It proposes a novel research direction in the field of Urban Geography, focusing on the multivariate individualisation of functional and normative-formal

influence areas within the Alba County based on Spatial Statistics and Geographic Information Systems. Furthermore, itemphasizes the importance of recognising the legitimate role of influence areas as emerging territorial systems, highly beneficial in spatial planning and systematic management of urban convergence flows. It is also aimed at academia and the institutional system dealing with Urban Geography and complex and unbalanced territorial structures.

The analysis of urban influence methodologically contextualized is one of the most ”discriminating” research themes in international scientific literature. The focus is on the research of urban centres of influence based on the theoretical polarisation methodologically expressed through gravity models which are not always able to provide concrete answers to flow and complex territorial structure dynamics. Even more so, we are currently witnessing a sudden rise in popularity of one-criterium individualisation methods of urban influence. It is the case of functional urban areas, a method which proposes the demarcation of urban functionality solely based on the commuting flows exceeding 15% of the active population of an administrative-territorial unit. However, asurban influence spreads in a multidimensional, functionally complex and versatile space, multivariate research becomes top priority.

In terms of the other issues of the topic at hand, one must not ommit the stark subjectivism in some research methodologies. A good example is the forced inclusion in the urban influence gradient of some” enclave administrative-territorial units”, even though they do not meet the criteria subjectively set by the researcher in order to demarcate the influence area, them being considered as part of the whole. Other methodologically disfunctional examples are the application of the Reilly-Converse formula as a single and ecisive indicator! of urban influence areasor with the structural confuse spatial perception of the influence gradient.

The rigurous demarcation of influence areasis crucial, especially in the current context of sustainable spatial planning were rural-urban and urban-urban cooperation relations play an important role in mitigating territorial disparities and spreading wealth flows across the territory.

In what context were the central research hypotheses formulated?

Although Alba Iulia is topophilic space, it was not the main reasonfor choosing it as study area. The reason behind this choice is that the functional influence of the City of Alba Iulia has a methodological resonance. Starting at H_0 according to which *The prime centre of*

influence (Alba Iulia) exerts its functional influence on the entire administrative-county hinterland, we conceptualised the spatial relations in order to confirm or disprove this hypothesis, analysed through the global spatial (Global Moran I) and local (Anselin Moran I) autocorrelation. In contradiction with H_0, an alternative H_1 hypothesis was formulated, according to which *The prime influence centre (Alba Iulia) canonly spread its functional influence on the entire adminstrative-county hinterland as its function of county residence*.

What are the main research results?

Based on the new research paradigms in urban geography, the results reflect the detailed and standardized approach to spatial and psychological interaction from the functional influence area. There are several quantitative and qualitative variables that have emphasized the fact that the city of Alba Iulia has an emerging and dynamic area of influence despite the fact that its influence within inter-county context is diminished by larger competing urban centres such as Cluj-Napoca and Sibiu.

The multivariate analysis was doubled by an empirical research aimed at generating sets of ceoncrete data regarding the cultural-historical, political and diplomatic perception of Alba Iulia. Furthermore, we used opnion polls to analyse the perception of the concept of influence. Other original contributions of this research include:

i) critical and relational analysis of literature alongside CiteSpace v.5.7.R1 and VOSviewer v.1.6.15 computational exploration;

ii) proposal for a standardized research methodology of urban influence, assisted by Spatial Statistics and GIS;

iii) standardized analysis of spatial and psychological interaction flows through the multivariate spatial grouping method;

iv) extrapolation in a mesoscalar context of the analysis methodology of centrality and spatial syntax proposed by Sevtsuk (2010, 2018); Sevtsuk & Mekonnen, (2012); Sevtsuk & Kalvo, (2016) at intra-urban level.

Is Alba Iulia an intelligent city?

According to prior research (Nicula et al. 2020) and scientific literature focused on the smart city concept, the thesis emphasized that the implementation of apps and smart solutions

in the functional system of a city does not automatically bestow it the title of intelligent city. The city is without a doubt on an ascending trajectory in terms of smart city implementation, but comparing the current situation to actual smart city concepts proves that Alba Iulia is actually a digital city, with the possibility, for the medium future (2040 horizon), to become a functional smart city. Out opinion is that there are no functional cities in terms of urban intelligence at the moment in Romania.

What is the impact of the current researchand what does it bring to the table as novelty?

Through its novel content and methodological framework, the thesis is a scientific document with multiple pragmatic valences in the larger spectrum of Urban geography and Spatial Planning, focused on the scalar resize of functional territorial units. Likewise, the thesis reflects the main diachronic and current trajectories of the concept of influence from conceptual and methodological perspectives, enriched by the list of references.

Compared to prior urban geography research, the current paper proposes a new methodology for researching and individualizing urban influence areas based on data analysis and spatial statistic tools such as Global Moran I, Local Moran I (Cluster and Outlier) and Multivariate Clustering.

What is the aim of the thesis?

The main aim of the thesis is providing academia and the institutional system a correct, valid and representative scientific support in terms of research results. The doctoral thesis is basically a scientific opportunity through which its author can or cannot confirm the exploratory analysis capacity of the scientific documents form literature, as well as to propose an original methodology, one that would validate the premise with its results obtained during the doctoral school (thesis and additional scientific material).

In terms of the pragmatism invoked by urban planning, the thesis manages to respond to the previously mentioned final scope: **the multivariate demarcation of functional urban areas in a research environment that is as objective as possible**.

Chapter summary

Chapter 1. The introduction depicts the context and formulation of the research issue on one hand and the central aim of the paper on the other. The main issue addressed by the thesis is the lack of a standardized methodology which can individualize areas of urban influence. The aim of the thesis is actually to surmount this methodological predicament. The structure of the introduction did not present the research topic from its scientifically marketable perspective, but from the empirical elements and scientific novelty proposed by the doctoral thesis to academia and decision makers.

Chapter 2. Revision and literature synthesis firstly presents the critical and relational analysis of the concept of urban influence within the context of urban geography as well as from a multidisciplinary standpoint. Scanning the scientific literature reveals that the topic of influence cannot be considered că an exclusive attribute of urban geography, being found in other fileds of satudy such as: Geopolitics, History, International relations, Physics etc. In urban geography, the concept of influence is semantically comprised of a series of notions that do not offer the same meaning. The concept's versatility is further propagated by the scientific literature based on existing linquistic, epistemological and methodological differences that are found in several schools of throught from Europe and United States. Therefore, in international literature, the influence exerted by a central place and its territorial relations are mostly linked with notions such as: urban sphere of influence, urban field, hinterland, umland, tributary area, zone d'influence or banlieue. The chapter is divided into 5 sections, each critically and constructively analysing the classic Reilly-Converse and Central Place theories. In Romania, the Reilly-Converse theory is among the most widely used methods, despite being used only "accidentally" abroad, being replaced by complex econometric models such as Huff or the multiplicative-competitive interaction model (MCI) developed by Nakanishi & Cooper (1974). It is crucial to know that the Reilly method does not automatically generate the influence areas of two competing centres. This requires additional work, regardless if it is on a computer or the limits are drawn by hand. Thusly, another disadvantage emerges. What form shall the influence areas take? Beaujeu-Garnier & Chabot (1971) claim that these will take the shape of a circle with the attractor city in the centre. But as spatial anisotropy implies extremely varied morphologies, it is almost impossible for thse areas to have standard shapes.

The central place theory is a perfect copy of a theoretical urban system where services and small trade are the predominant urban function. After its translation into English, it garnered international attention leading to many scientific studies. It is considered by some to

be a refined intellectual product, while others scrutinised how Christaller's ideas fit into Nazi policies. The theory is currently on a descending slope in terms of scientific interest and heavily critiqued for its isotropic spatial utopia and spatial behaviour of consumers. The strong points of this theory consist in the consolidation of two important concepts in the settlement system: hierarchy and centrality.

The exploratory analysis of literature emphasizes the fact that the methods for researching urban spheres of influence can be divided into two main categories: empirical methods and model methods while functional urban areas are ariile demarcated based on a single criterium through pendular commuter movement. This chapter also mentions the concept of intelligent city where the focus is not on finding solutions for the problems of marginalized communities, but on digital technology development.

Chapter 3. Data and methodology has five sections comprised of graphical; representation and visualisation, locating the study area and normative-formal influence, data and metadata structures, determining the influence area, as well as accessibility, centrality and spatial syntax.

In order to trace citation and co-citation clusters, and the scientific impact of central authors and the mapping of the knowledge flow, we modelled the existing literature with the help of **open source software - CiteSpace and VOSviewer**. **CiteSpace** involves the generic process of mapping scientific literature. It has several components: totality of scientific literature, and ensemble of scientometric and visual analysis tools, metrici indicators which can spot significant patterns and trends in the dynamic of visualized intellectual structures. The software is mainly based on dynamic visualisations indicating the way bibliometric networks evolve over time. The scientometric methods provided by CiteSpace include author co-citation analysis, document co-citation analysis or word co-citation analysis. Representation techniques include graph and network visualisation, temporal structure visualisation, geospatial visualisation and coordination of multiple visualisation types. Metrics and research impact indicators include number of citations, the Hirsch index as well as a set of altimetrics on social media. In CiteSpace, the knowledge domain is under the scrutiny of different types of temporal network series. Alongside CiteSpace, **VOSviewer** is an open-source software used to create and visualise bibliometric networks containing information on journals, researchers, Big data individual publications. Compared to CiteSpace, VOSviewer allows the visualisation of bibliometric networks based on distance, thus making it more suitable for visualising large networks. These networks can have several thousand nodes and VOSviewer

carefully assigns them to clusters in such a way that each node in the network belongs to a single cluster. The number of clusters is determined by resolution, so the higher this parameter's value is, the higher the number of clusters.

The study area comprises 13 units, two being urban (Alba Iulia and Teiuș) and 11 communes (Berghin, Ciugud, Cricău, Galda De Jos, Ighiu, Întregalde, Meteș, Mihalț, Sântimbru, Stremț și Vințu de Jos) and is located **in the central part of Alba County**. The normative-formal influence of Alba Iulia is exerted within the 674.627 km administrative limit of Alba County, theoretically having a surface area of 6254.564 km^2, or 2.623% of the entire 238398.698 km^2 of Romania. In terms of its function as county residence, Alba Iulia coordinates 78 administrative-territorial units (fig. 9 left) - 4 cities (Aiud, Alba Iulia, Blaj, Sebeș), 7 towns (Abrud, Baia de Arieș, Câmpeni, Cugir, Ocna Mureș, Teiuș, Zlatna), 60 settlements that are part of cities and towns, 67 communes, 656 villages –39 part of cities and towns. Theoretically, each unit polarises an average of 9.179 settlements and 4191.384 inhabitants. The demographic size of a settlement is 456.603 inhabitants. The average population of a town is 17414.455, and of a rural settlement 192.013.

The data and metadata structures used come from field research and several institutions.

In order to determine the functional influence area, we applied standardized concept and spatial analysis methods. Thusly, we employed multivariate exploration and analysis based on spatial statistics and GIS. The **14 analysed variables** were firstly conceptualised with the **Incremental Spatial Autocorrelation tool, to determine** the distance from each spatial object from the vicinity of Alba Iulia and determine the scale of analysis. We then started the **Spatial Autocorrelation Global Moran's I**, and interpreted its results in the context of the null hypothesis. The Global Moran I answers to the interogation whether the analysed spatial entities are grouped or random. Starting from the covariance, this indicator enables us to determine the grouped, disperse or random values of some spatial locations and their attributes. Running said tool leads to five exit values in a report: Moran I index, estimated Moran index, Variance, **Z score** and **p value**. When the z score and p value indicate a statistical significance, a positive value of the Moran I index indicate a tendency for grouping, while a negative Moran I suggests a dispersion tendency. The z score and p value show if we can reject or not null hypotheses. The next stage in the methodological flow is determining spatial groupings with the help of **Hot Spot Getis-Ord Gi***. This index responds to the question if there are or not spatial groupins in the study area. The index algorhythm is based on the following logic: when a spatial object with a high value is surrounded by other objects with similar values we have hot spot groups, while when a spatial object with low values is

surrounded by other objects with simalr values, we have cold spot groups. Gi* is the standardized Z score and shows the spatial group intensity. Then resulting z-score and p values show where high value or low value features are grouped. This index allows the standardized mapping of spatial groups in the county of Alba, providing a general view on the plane-spatial dimesnion of the analysed variables. The usefulness of the results is also validated by its representativity in a comparative context with the results from the thematic din mapping or with those derived from running the Cluster and Outlier index (Local Moran I). **The Cluster and Outlier** identifies statistically significant hotspots and coldspots as well as unusual values in a set of spatial data based on Anselin Local Moran's I. A postive value of Local Moran I means that a spatial object has proximity features with similarly low or high values. A negative value for I implies that a spatial object has proximity features with dissimilar values, therefore the spatial object or entity has an exceptional value and can be considered an outlier. In both cases, the p value for the spatial object must have low values for the spatial grouping or outlier to be considered statistically significant. **The multivariate spatial analysis (Multivariate Clustering)** is an unsupervised standardized method, part of the learning-machine algorhythms, which aids in identifying natural clusters based on the values that define the analysed spatial objects. The method is based on K Means whose role is first to select the defining features of spatial objects and then to carefully separate them into clusters. Once the objects are identified based on similar features sunt, they are attributed to the closest (in data space) clusters. For each cluster of objects, a medium data centre is calculated, and each feature is reassigned to the closest centre. The calculation process of centres for each cluster and the feature reassignment to the closest centres continues until cluster affiliation is stabilised (up to 100 iterations). The two clusters from the study area were set, in a standardized form, with the aid of the multivariate analysis and the multivariate spatial grouping: cluster 1 grouping the 13 units from the functional influence area and cluster 2 comprising the remaining 65 units of Alba County. This method was later further verified using the **Huff model,** which has validated the results of the multivariate clustering.

In terms of the syntax and spatial accessibility **analysis**, we extrapolated the Urban Network Analysis index, developed by Sevtsuk (2010, 2018); Sevtsuk & Mekonnen, (2012); Sevtsuk & Kalvo, (2016); Sevtsuk, Mekonnen & Kalvo, 2016 to another scalar parameter - the functional urban influence area of Alba Iulia. Thusly, the original building variable was replaced with the term locality, while the road network was built at a regional and not intra-urban level as shown in the original methodology proposed by Sevtsuk, Mekonnen & Kalvo, 2016. Therefore, we analysed the Reach, Gravity, Betweenness, Closeness, Straightness

indicators. **Reach** is utilized to show the degree of accessibility of each settlement seen as a destination in the OD matrix on a certain radius in the road network. **Gravity** is an additional tool to Reach, measuring the spatial impedance required for the movement towards each destination. **Betweenness** was developed by Brandes (2001) and represents the segment between the shortest paths between pairs of different localities in the network to a reference point. In other words, Betweenness estimates potential traffic passing through a place in the network. **Closeness** represents the reverse of the cumulative distance necessary to get from a certain place to the other places in a system that fits in the search radius along the shortest route. Unlike Betweennness, Closeness shows how close a locality is compared to the surrounding localities at a certain distance threshold. **Straightness** reveals the way in which the shortest routes to an interest node (locality) to the other nodes (localities) from the study area have a relatively similar configuration to Euclidean networks. It captures positive deviations of travel that result from the geometric constraints of the road network compared to straight line distances found in a relatively anisotropically area.

Chapter 4. Results and discussions has 9 sections and comprises the dynamics of spatial interaction flows both quantitatively and qualitatively. The first section, **Intelligent city policy**, analyses the main development projects in Alba Iulia and its development strategy. It mostly presents the smart city projects implemented by the local authorities or those which are currently in testing. There is a great number of innovative digital apps (100), tested in real time through a collaboration with 45 partners, covering 11 strategic domains: intelligent public administration (e-Administrație, e-Guvernare), IC&T and public utilities, intelligent urban mobility (sustainable transport), innovation and intelligent local business, intelligent healthcare (e-Sănătate), intelligent tourism (e-Turism), intelligent education, environment, sustainable buildings (intelligent living), intelligent urban planning and public safety. The focus on testing intelligent solutions and innovative technologies in different areas is evident from the numerous companies partnered with Alba Iulia City Hall, such as: Philips, Microsoft, Siemens, Telekom, Orange or ZTE, as well 10 companies from the Cluj IT Cluster. The remaining sections depict the dynamic of spatial interaction flows from different points of view: commuting flows, internal migration flows, transport flows, sanitary flows, educational, economic, cultural, historical, and political flows. The results show that commuting, transport, health and education flows exhibit the most intense and frequent spatial interaction in the study area. Moreover, they immortalise the feeling of belonging, pride and topophilia of its

inhabitants. This phenomenon was discovered with the help of two opinion polls that took place during my doctoral field research.

Chapter 5. Conclusions display that the City of Alba Iulia is a centre of influence with a modest polarisation potential, unable to functionally exert its influence on the entire administartive territory of Alba County. Even more so, the city falls under the competing polarisation of Cluj-Napoca and Sibiu, which take over a great part of its demographic flows. The city can extend its functional area of influence if the current smart city and sustainable development policies succeed in curving the centrifugal workforce flows that are currently travelling to neighbouring centres for work. The City of Alba Iulia encapsulates constructive premises for the near future (2040 horizon) and can double its functional influence area, becoming a strong contender in amassing spatial flows. We believe this could have been achieved much sooner if the local authorities of Alba Iulia and Sebeș had implemented a synchronous regional development strategy, based on solving mutual disfunctions and promoting projects exceeding the personal interests of each city.