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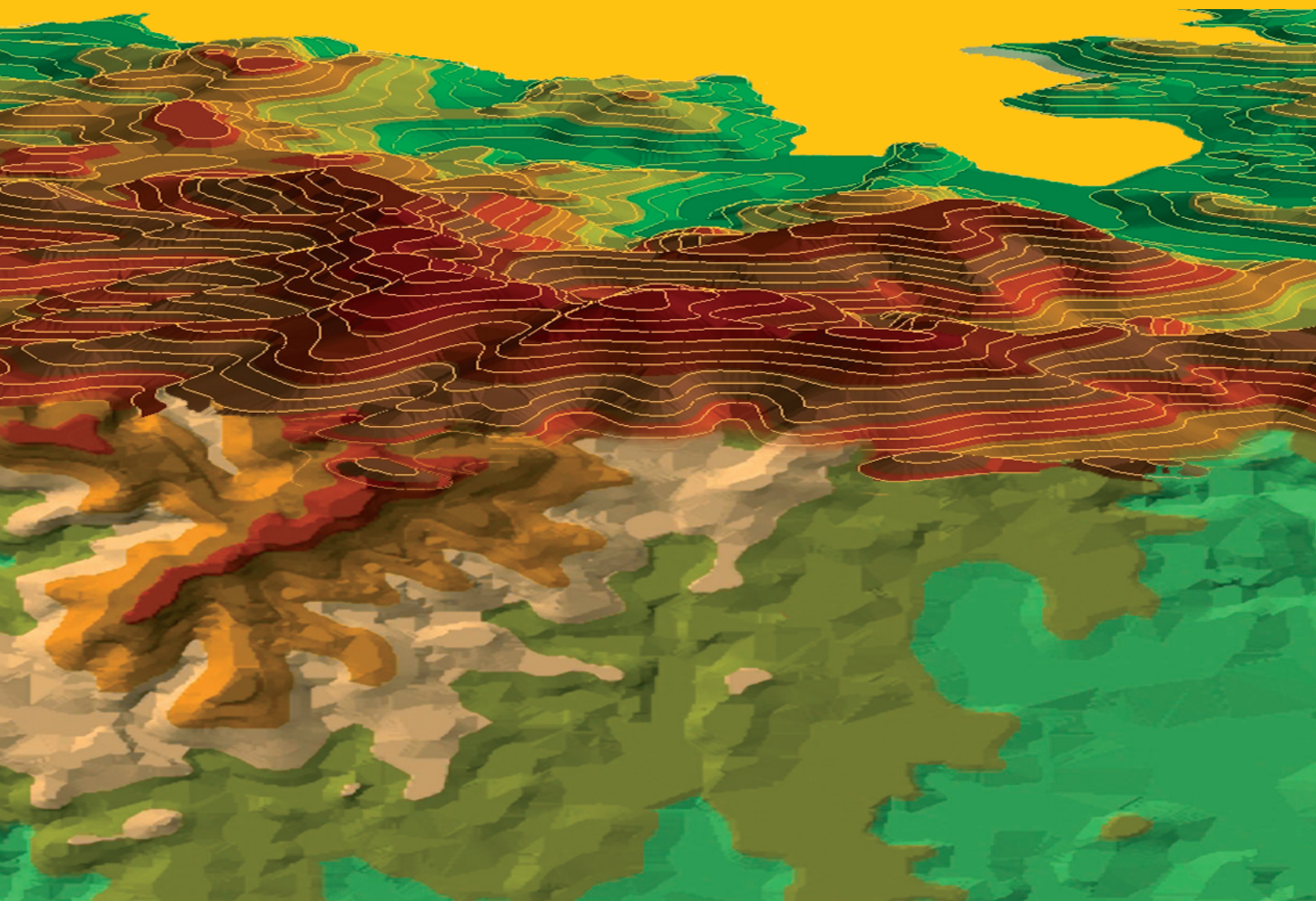

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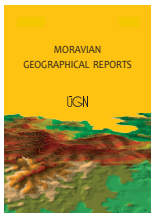

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Is there congruence in the spatial patterns of regions derived from scalar and vector geographical information?

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Abstract

Selected traits of the spatial organisation of a geographical environment which stem from two types of human behaviour (locational and interactive) are examined in this paper. An attempt is made to find and account for similarities in the spatial patterns of scalar and vector geographical data. In doing so, the paper analyses a core-periphery dichotomy, based on socio-economic information, and travel-to-work patterns. The paper uses the concept of a region as an integrating and focusing framework for the study. Formal regions (peripheral areas) are defined through the application of principal components analysis and cluster analysis; functional regions are defined by a standard rule-based regionalisation algorithm. The territory of the Czech Republic is used as an area for testing the basic hypotheses. The results show that there is some form of interrelationship and complementarity between the spatial distribution of scalar data and vector data, i.e. between spatial structure and spatial interaction patterns, which together form the spatial organisation of a geographical environment.

Keywords: *spatial organisation, human behaviour, spatial structure, core-periphery dichotomy, formal region, distance decay, spatial interaction, functional region, Czech Republic*

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1. Introduction

The spatial organisation of socio-economic phenomena is a long-lasting and recurring theme in geography and spatial science, and is represented and provoked by the seminal works of von Thünen (1826), Weber (1909), Christaller (1933), Lösch (1940), Perroux (1950), Isard (1956), etc. All of these foundational works were immensely inspiring for early quantitative geographers (see for instance the works of Berry and Garrison, 1958; Garrison, 1959a; Bunge, 1962; Curry, 1964; Haggett, 1965; and these are only a fraction of the total volume). These classic works have remained inspirational up to the present day (for a review, see Barnes, 2003), although they have encountered legitimate criticism, specifically based around the point that their concepts and conclusions are detached from very complex geographical realities.

Principally, the assumption of an isotropic space, the risk of privileging geometric representations of geographic space, and spatial separatism, have been the most asserted aspects of the criticism (see, for example, the early objections of Sack, 1972, 1973, 1974; or the Marxist-based discussions put forward by Soja, 1980). In this paper, we acknowledge the post-positivist approach of the so-called new quantitative geography (e.g. Barnes, 2004, 2010; Wyly, 2014), which is still based on the analysis of data, but which, among other factors, takes into account human behaviour and its influence on the "socially constructed" data used in quantitative analyses, stresses the importance of a geographical interpretation of results. Another piece of literature speaks of the critical quantitative geography, which acknowledges the need to fuse quantitative analysis with critical approaches based on challenging the spatial-social structures induced by capitalist economy (e.g. Barnes, 2009; Kwan and Schwanen, 2009; Schwanen and Kwan, 2009). We stress particularly the interpretation of results in the current paper.

The theme of the spatial organisation of socio-economic phenomena is very extensive and thus offers the opportunity to choose from a great number of perspectives. In this paper, two distinct problems have been selected and pursued as two complementary parts of the spatial organisation of socio-economic phenomena, using a quantitative, data-driven approach. First, there is the issue of a core-periphery dichotomy in the spatial organisation of socio-economic phenomena; second, there is the issue of functional socio-economic relationships in space, expressed for instance by

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one of the most frequent spatial interactions: travel-to-work flows. This choice opens up a more general research question as the former (the core-periphery dichotomy) can be particularly dealt with through the analysis of scalar data and the use of the concept of a formal region, while the latter (travel-to-work patterns) is a typical example of vector data, which can be analysed within the concept of a functional region. Building upon Ullman (1980), scalar data define the site context, vector data define the situational context of human existence and activity.

Therefore the objective of the paper is to add modestly and partly to the question of whether there is a common influence acting on the spatial distribution of scalar and vector socio-economic data; that is, to seek evidence and explanation as to whether both distributions have corresponding and complementary patterns and if so, to what extent. In other words, the paper seeks to look for the congruence[1] between the spatial distribution of locations and the spatial distribution of flows, in terms of their respective qualities and quantities. We can refer to the former as the spatial structure and to the latter as the spatial interaction pattern. The hypothesis to be reinforced is that, having the same agent, which is an individual, and having a common framework, such as an economic and a social system, there should be a certain dependence in the spatial arrangement of both types of information on human behaviour. Although the term "information" is used, with a broader meaning than the term "data" (Amedeo et al., 2009), it should be acknowledged here that the paper intentionally favours the quantitative approach to the issue raised, and that the analyses presented in the paper are based on statistical data.

The general objective of this paper needs further comment. The research question is very complex and cannot be solved in its entirety here, such that only a modest contribution to the complex field of the spatial organisation of society is put forward. What is the limiting framework of the current approach, which focuses the overall scope of the paper, then? Spatial structure and spatial interaction patterns are seen as manifestations of human behaviours, without further in-depth exploration of such behaviours. Apart from the roles of individuals and their aggregated behaviours, the concept of a region, as one of the oldest and most crucial geographical concepts, is employed in the present study in order to integrate various spatial manifestations of human behaviour and to focus the overall aim of the paper. Only a limited amount of geographic information is analysed. As the differences in the nature of scalar and vector information result in significant problems for any possible quantification of the research question, the paper explores only simple but feasible quantitative and graphical procedures in order to compare and assess the spatial distributions of scalar and vector geographical information.

Early attempts to analyse socio-economic geographical information on locations and flows date back to Garrison (1959b, 1960), although possible mutual interdependence in spatial terms was not discussed thoroughly. Berry (1968) put forward a general field theory of spatial behaviour, which attempts to synthesise scalar and vector information and define interdependency between them. This approach was criticised later by Greer-Wooten (1971), especially in terms of the procedures used. A literature review for the first period of this research is given by Griffith (1976). During the 1980s, this interdependence became a matter of increased attention (e.g. Bennett and Haining, 1985; Bennett et al., 1985). Only recently has similar research been carried out by Jones (2017), who used functional regions and notions of the urban hierarchy for his analysis.

There is also a relatively extensive literature combining spatial structure and spatial interaction in the field of spatial interaction modelling (see e.g. Curry, 1972; Cliff et al., 1974; Fotheringham and Weber, 1980; Fotheringham, 1981; and more recently, Tiefelsdorf, 2003; Griffith, 2007). With respect to the character of the information used in this paper, Griffith and Jones (1980) discussed the issue using the example of journey-to-work flows. Note, however, this group of works understands the term spatial structure differently than the current paper – or at least gives it a different quality. In these works, spatial structure is seen as "rigid" and model parameters reflect this given structure, in a similar manner to spatial autocorrelation indices. In contrast, we understand the spatial structure and spatial interaction patterns as a two-way flexible relationship, as an interdependence of two different types of information, both based on human spatial behaviour/behaviour in space, which can lead to spatial congruence between spatial structure and spatial interaction patterns (see also footnote 1). What both conceptions have in common is that spatial structure reflects the distribution of scalar information. Nevertheless, even the works cited in this paragraph acknowledge the existence of an interdependence between underlying geographical structures and distance-decay, i.e. interaction, parameters.

In order to answer the questions posed, this paper starts with a discussion of the relevant theoretical background, including human behaviour as the crucial framework for further considerations, the concept of a region, the concept of a core-periphery dichotomy and geographical hierarchies, and the concept of spatial interactions and the role of distance. The next section uses the territory of the Czech Republic as a case study in order to validate the hypotheses. In this section, the necessary methodological information on the identification of formal regions (in this case peripheries) and functional regions in the Czech Republic are presented and the results are discussed. In this section we also attempt to assess in a simple quantitative and graphical way, a comparison of the results of the identified spatial distribution of scalar and vector information. The final section returns to the question of the congruence in the spatial patterns based on scalar and vector information and concludes with the associated findings.

2. Theoretical background

2.1 Some notes on human behaviour in space

All socio-economic geographical information for individuals can be seen as a reflection of human behaviour in a broader sense, including a wide spectrum of influences such as general psychological demands and cognitive perception,

[1] The term congruence refers to obvious co-locations of place related information and place-to-place information of similar meaning in the sense that it expresses qualities such as centrality or peripherality, for instance. It must be noted however that this kind of spatial overlap or association can be induced by more or less latent interdependence between both types of information (scalar and vector) based on the human behaviour. Consequently there can be a certain kind of causal relation between spatial distribution of locations and spatial distribution of flows.

physiological prerequisites, behavioural strategies, decision-making processes, the broader economic framework, etc. Moreover, every manifestation of human behaviour is rooted, affected and conditioned in a space (for overview see e.g. Frantál et al., 2012). As the issues of spatial behaviour and behaviour in space are extremely variable, this paper only briefly presents the necessary basics with regard to the two general types of data analysed.

Not only individual information on human behaviour but also its aggregation in space, is of utmost importance for geographical and spatial analysis. This aggregation can be seen from at least two perspectives: as a general aggregation of individual behaviours; and as a "corporate individual", that is some kind of institution (public or private), active and acting in various environments. Both of these perspectives are partly conditioned by spatial behaviour and partly influence spatial behaviour. In both cases, a number of tasks are accomplished and a number of demands are taken into account. This results in the great variety of human actions.

For the purposes of this paper, two types of behaviour, whether individual or aggregate, are important: (i) locational behaviour, (ii) and interaction behaviour. The first type includes choices of location made both by individuals and by "corporate individuals". The second type includes considerations of spatial relations between two or more intervening locations. Golledge and Stimpson (1997) offer two views of human behaviour in this respect: functionalist and behaviouralist. The former partly follows the laws of classic location and interaction theories, such as utility maximisation and effort minimisation. The latter view takes into account probabilistic and spatial choice theories (see e.g. Mattson and Weibull, 2002; Han and Timmermans, 2006), motivations and the gaining of information: it can be said to reflect the current socio-economic reality, which is framed for instance by the existence of such factors as globalisation, information and communication technologies, etc. What holds true in any case is that an individual seeks some benefits from a location and from an interaction, and not necessarily economic ones.

2.2 Integrating concept of a region

As stated above, in order to verify the hypotheses of the paper it is useful to apply the concept of a region, which has an integrating role in this respect. The crucial criterion for further classification of regions is the character of information, on which the region is based (e.g. Grigg, 1965, 1967; Johnston, 1970; Parysek, 1989; Gregory et al., 2009; Agnew, 2013). Scalar information defines formal regions and vector information defines functional region (see e.g. Fischer, 1987). Both types of information are responsible for distinct structural characteristics of regions and their relative autonomy. Thus, formal regions manifest their autonomy in their internal homogeneity and external separation with regard to the region-organising or region-building information, and functional regions manifest in their internal coherence and external self-containment (see e.g. Smart, 1974; Fischer, 1987; Karlsson and Olsson, 2006; Farmer and Fotheringham, 2011; Klapka and Halás, 2016). As the result of these characteristics, the inner structure of formal regions is relatively simple (based on the hierarchical level, also the scale) and, in contrast, the inner structure of functional regions is significantly complex (see e.g. Klapka et al., 2013; Klapka and Halás, 2016). The spatial differentiation of a territory is based on different values of scalar region-building information, in the case of formal regions, and on characteristics such as intensity, orientation and length of vector region-organising information, in the case of functional regions.

As will be seen further in this paper, it is also suitable to distinguish between typological regions and individual regions (see e.g. Fischer, 1987). Typological regions consist of spatial units (region-building blocks) that need not necessarily be spatially contiguous; in contrast individual regions must be spatially contiguous in this respect. This classification has only a minor importance for the current paper, but it cannot be left out without this brief note.

2.3 Core-periphery dichotomy and geographical hierarchies

The division of space into developed (core) and less developed (peripheral) areas is a frequent phenomenon. As a matter of fact, it is not probable that areas with different environmental, historical, cultural and socio-economic conditions could develop in the same manner. This could only happen through an extremely strong levelling effort and intervention, which could negatively affect the usual competitive environment and jeopardise the external competitiveness of the territories (Halás, 2014). The analysis of the interactions between a core and a periphery is one of the basic research fields in human geography.

The core-periphery dichotomy can be analysed from four basic viewpoints (Leimgruber, 1994, pp. 8–11): geometric (i.e. spatial); social; economic; and ecological. From the temporal point of view, the dichotomy can be understood as a phenomenon that is:

1. relatively stable (including the attributes of location, population density, and transport infrastructure);
2. alterable in jumps (including the attributes of geopolitical position, participation in the world market); and
3. continuously alterable (including the econometric attributes).

The geographical view of the core-periphery dichotomy corresponds mostly with the geometrical approach and the first temporal characteristic, while the economic view builds upon the economic and social approach and on the third temporal characteristic.

The interdependence of the core-periphery dichotomy and the spatial distribution of flows and interactions was pointed out by Borgatti and Everett (1999). Using social network analysis, they tried to construct ideal images of core-periphery structures and to assess the extent to which these ideal images corresponded to real networks. They intuitively assumed that a core should be dense and cohesive and a periphery sparse and unconnected. Real structures can be approximated by various types of graphs, e.g. directed and undirected, valued and non-valued, etc. Concerning the orientation of flows and interactions, it should be noted that flows from peripheries to cores are prevalent. In contrast, Richardson (1977) was the first to use the term "polarisation reversal", pointing out that there are many alternative reverse flows and interactions, such as those oriented at new industrial locations induced by the presence of resources and labour force. Another example is the process of suburbanisation with prevailing outgoing flows from a centre.

There are two continua when exploring the core-periphery dichotomy geographically: the one that occurs at a particular hierarchical level; and the one that is represented by a scale of hierarchical levels. As for the former, the transition from core areas to peripheral areas

does not occur in jumps but is continuous. Based on this observation, Wallerstein (1979, pp. 95–118) introduced a transitional category, the 'semi-periphery'. Aware of the above-mentioned continuity, this paper uses the term "core-periphery dichotomy" as a symbolic simplification. As for the latter continuum, there are, in a generalised form, three hierarchical levels (Halás, 2014, p. 388):

1. global and supranational level (macro-regional level);
2. regional level (meso-regional level);
3. local level (micro-regional level).

The matter of scale is of crucial importance in geography (see e.g. Harvey, 1968), because different patterns and processes have different meanings and importance at different scales.

It is obvious from the preceding discussion that the phenomenon can be repeated at various hierarchical levels. Generally this is the case with fractals (Mandelbrot, 1967), as occurred in human geographic research in connection with Central Place Theory (Arlinghaus, 1985). Chen (2011, p. 619) points out the parallels in both theories and claims that the integration of the fractal theory into research in settlement and regional systems would contribute to the explanation of real dependencies in their spatial organisation. Halás (2014, p. 399) proposed a theoretical spatial model of the fractal arrangement of central and peripheral areas using the specific example of the Czech Republic (see Fig. 1). He also reminded us that in real space repeatability cannot be infinite, unlike theoretical fractal models, and it can only have a finite number of hierarchical levels.

2.4 Spatial interactions and the friction of distance

Spatial interactions can be seen as the aggregated manifestation of individual human behaviours in a space. They are induced by the heterogeneity of space and by various types of goals that an individual seeks to achieve and fulfil. In Human Geography, spatial interactions have no physical basis; they are rather influenced by psychological, economic and social factors. From the spatial perspective, the spatial interactions are conditioned by individuals' efforts to optimise their spatial "existence" (e.g. Zipf, 1947; Ullman, 1980; Fotheringham, 1986; Heldt Cassel et al., 2013; Halás et al., 2014a) and by the objective characteristics of space that can be articulated in the principles of complementarity, intervening opportunity, distance, etc. Distance, in particular, has frictional effects on the intensity of interaction as observed in Tobler's 'First Law' of Geography (Tobler, 1970), which can be paraphrased as "closer things are more closely related than distant things". This principle was later acknowledged by many researchers, including Alonso (1978), Sheppard (1978), Taylor (1983) and Stillwell (1991).

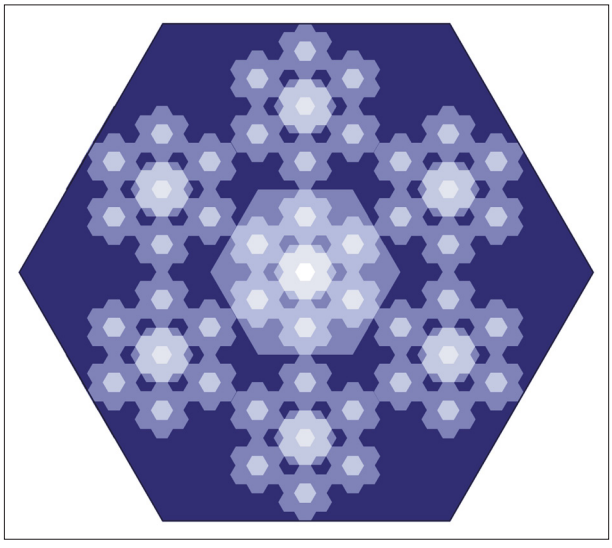

Fig. 1: Fractal arrangement of core (light) and peripheral (dark) areas. Source: Halás, 2014; adjusted

Spatial patterns of interactions and their characteristics, such as origins and destinations (i.e. direction) and intensity, have two important consequences. First they can be used for the definition of functional regions (see further comments, below), and second they are closely related to the concept of the core-periphery dichotomy. In the latter case, it is the so-called spatial polarity based on the dichotomy that affects the occurrence of horizontal spatial flows, and it can be assumed in a simplified way that peripheral areas have minimal or no interaction with core areas. In these areas, the boundaries of functional (particularly nodal) regions should be identified; nodal regions are special cases of functional regions – see Klapka et al., 2013; Klapka and Halás, 2016. This assumption can be seen to varying degrees at different hierarchical levels (see the preceding comments on fractals).

3. Lessons from the Czech Republic

In this section, the territory of the Czech Republic is used as a case study, where theoretical assumptions are tested. It consists of two methodological sub-sections, one dealing with the identification of typological formal regions (socio-economic peripheries), the other dealing with the delineation of functional meso-regions. The use of both types of socio-economic information, scalar and vector, is demonstrated. In the third sub-section, the results of both procedures are briefly commented on. The fourth sub-section presents several simple quantitative approaches that can be used to assess congruence in the spatial distribution of scalar and vector geographical information, as well as a synthetic graphical outcome.

3.1 Identification of peripheries

The identification of peripheries is in fact a problem in the definition of typological formal regions. There are a number of ways to define formal regions, which use the procedures of multi-dimensional analysis (e.g. numerical taxonomy, graph theory). The traditional approach that can be used, even at the present, consists of two steps (see Berry, 1961, among others):

i. mathematical orthogonalisation of original variables and selection of explanatory components or factors; and
ii. clustering of spatial units in typological formal regions.

The first step uses principal components or factor analysis; the latter uses cluster analysis (for general overviews of particular approaches and methods, see e.g. Lattin et al., 2003; Gan et al., 2007, Everitt et al., 2011). The definition of formal regions was a particular interest for geographers in the 1960s and 1970s (e.g. Berry, 1961; Johnston, 1965, 1970, 1976; Lankford, 1969; Spence and Taylor, 1970, Cliff et al., 1975), but currently the issue is less frequently researched (e.g. Murray et al., 2014).

The identification of the socio-economic peripheries of the Czech Republic is based on the multidimensional analysis of 19 indices, calculated from the 2011 census data. All indices conform to those used for the identification of the peripheries in the territory of the Czech Republic in the past

(Musil, 1988; Musil and Müller, 2008), in order to secure temporal comparability if needed. The indices can be divided into five groups:

1. indices of the age population structure (3 indices);
2. indices of the educational population structure (2);
3. economic indices (6);
4. indices on housing and household equipment (6); and
5. migration indices (2).

All indices are related to the so-called "general units" as defined by Musil and Müller (2008) and we refer to them further as the basic spatial units (BSUs). These units consist of both individual and amalgamated municipalities, which are the basic spatial units in the Czech Republic. The use of these basic spatial units enables one to compare achieved results with the existing works, and their lower number (in comparison to the number of municipalities of the Czech Republic) is more suitable for statistical operations and it also solves the problem of outliers.

For each basic spatial unit the following information/variables have been collected:

1. Proportion of the population between 0 and 24 years of age in the total population;
2. Proportion of the population older than 60 years in the total population;
3. Number of widows per 100 women older than 60 years;
4. Proportion of the population older than 15 years without secondary school-leaving certificate in the total population older than 15 years;
5. Population with university education per 100 persons older than 25 years;
6. Number of job opportunities per 100 economically active employed persons;
7. Proportion of unemployed persons per the total number of economically active persons;
8. Proportion of job opportunities in agriculture, forestry and fishery in the total number of occupied job positions;
9. Proportion of job opportunities in industry and building in the total number of occupied job positions;
10. Proportion of employers and persons with business activities in the total number of economically active persons;
11. Proportion of economically active persons in tertiary sector in the total number of economically active persons;
12. Proportion of permanently inhabited dwellings in houses built between 1980 and 2011 in the total number of permanently inhabited dwellings;
13. Proportion of uninhabited dwellings in the total number of dwellings;
14. Number of dwellings in family houses inhabited temporarily or in recreational houses per 100 permanently inhabited dwellings in family houses;
15. Proportion of permanently inhabited dwellings with gas fixture in the total number of permanently inhabited dwellings;
16. Proportion of permanently inhabited dwellings with sewer connection in the total number of permanently inhabited dwellings;
17. Proportion of households with personal computer and internet connection in the total number of households;
18. Proportion of intrastate immigrants in the total population; and
19. Proportion of intrastate emigrants in the total population.

Standard procedures were used in the analysis: principal component and factor analysis and then cluster analysis. The combination of two approaches is referred to as Factor-Cluster segmentation (Dolnicar and Grün, 2009; Kibicho, 2010). Though the procedure is criticised, particularly in the context of tourism studies and the reduction in the number of variables (Dolnicar and Grün, 2011), it is still used to define regions based on socio-economic characteristics (e.g. del Campo et al., 2008; Palevičienė and Dumčiuvienė, 2015) and it offers two advantages. The first one lies in the reduction in the number of variables, despite what was noted earlier, which facilitates further operations. The second and more important advantage lies in the elimination of redundant correlated variables. The entire procedure is described in the following.

A standardised matrix of the values for 19 indices is processed by Principal Components Analysis (PCA) and four principal components (commonly referred to as factors) are extracted according to the Kaiser criterion (Kaiser, 1960). Their eigenvalues exceed 1 and their cumulative proportion of variance accounts for 66%, which can be considered as sufficient explanation for the variability of the original indices. In the next step the transformation (rotation) of factors is carried out by the Varimax method in order to secure a better interpretation of results. The Varimax method is an orthogonal rotation, which produces factors that load highly on a limited number of the original variables, and load to a lesser extent on the rest of the original variables. It is a method that simplifies the factors. The simplicity function is given by the sum of variances of squared factor loadings in individual columns (Überla, 1971). Selected factors (F1–F4) can be characterised by the analysis of the factor loadings on individual original variables (U1–U19) – see Table 1.

Factor 1 is characterised by the highest weights of indices of employment, according to economic activity and branch, and by the educational population structure. Factor 2 strongly correlates with indices regarding the number of uninhabited dwellings. Factor 3 can be interpreted as the factor of employment and unemployment. Factor 4 strongly correlates with the age population structure.

The next step in the analysis is the calculation of factor scores of the selected factors (F1–F4) for all basic spatial units. There is a number of ways how to calculate factor scores that can be divided into two large groups: non-refined and refined (see e.g. Thompson, 2004; DiStefano et al., 2009; Uluman and Dogan, 2012). In this paper, the STATISTICA software was used for the analysis and it applies the refined regression method for the calculation of factor scores (Harman, 1976, p. 368). Refined methods aim to maximise validity by producing factor scores that are highly correlated with a given factor and to obtain unbiased estimates of the true factor scores.

Factor scores enter the next step of the multidimensional analysis instead of the values of the original indices. Cluster analysis is a method based on the comparison of the similarity of objects (BSUs) using taxonomic distance. We have used the agglomerative hierarchical procedure, where the results depend on the choice of linkage method and distance measure. We have tested the relevant combinations of centroid and Ward's linkage method and Euclidian and block taxonomic distance, which provided us with a set of four results. This choice was made according to the results

Index	Rotated factor loadings			
	F1	F2	F3	F4
U1	– 0.107	– 0.138	0.047	0.853
U2	– 0.124	0.251	0.015	– 0.854
U3	– 0.284	0.131	0.226	0.317
U4	0.749	– 0.232	– 0.417	0.084
U5	– 0.739	0.239	0.493	– 0.027
U6	0.121	– 0.013	– 0.968	– 0.010
U7	– 0.121	0.013	0.968	0.010
U8	– 0.287	0.672	0.147	0.081
U9	– 0.792	– 0.203	– 0.074	– 0.051
U10	0.688	0.372	– 0.056	– 0.016
U11	0.878	– 0.233	– 0.128	– 0.009
U12	0.387	0.016	– 0.396	0.546
U13	0.043	0.866	0.039	– 0.272
U14	– 0.010	0.806	0.056	– 0.253
U15	0.118	– 0.693	0.015	0.009
U16	0.210	– 0.571	– 0.033	– 0.003
U17	0.402	– 0.414	– 0.536	0.314
U18	0.348	0.125	– 0.104	0.187
U19	0.026	0.074	0.227	0.047

Tab. 1:. The rotated matrix of factor loadings
Source: Czech Statistical Office – 2011 census, calculated by authors
Note: Highlighted values of factor loadings represent the strongest correlations with a relevant index

of some preceding geographical studies (e.g. Lankford, 1969; Byfuglien and Nordgård, 1973; Fischer, 1980; Margules et al., 1985) and according to the suggestions made for instance by Gordon (1987), Ferreira and Hitchcock (2009), Rogerson (2010), and Everitt et al. (2011). Ward's method identifies clusters, which are approximately similar in their sizes. The result of the cluster analysis is a grouping of spatial units into regional types.

The question is which result should be selected and how many clusters should be optimally used. In the paper the results reached by the application of block distance and Ward's linkage method are presented because they were favoured by the values of Silhouette coefficient (as calculated by the STATISTICA software), which is used to identify an optimal solution out of four possibilities and the optimal number of clusters (see Rousseeuw, 1987). Ten clusters, i.e. typological formal regions, were the best choice. Four clusters show the least favourable values (e.g. the highest unemployment rate, percentage of uninhabited dwellings, the lowest number of employed persons, percentage of the population without a tertiary education, etc.) of the analysed indices and these clusters are considered to identify socio-economic peripheries. Two of these clusters are characterised by Factor 2 most importantly: they show the highest average values of score for Factor 2 (uninhabited dwellings). The remaining two clusters correspond most to the values of Factor 3 (employment and unemployment).

3.2 Delineation of functional meso-regions

The delineation of functional regions also has a long-lasting tradition in geography (see the overview in Casado-Díaz and Coombes, 2011, as well as Klapka and Halás, 2016). Apart from traditional graph theoretical approaches (e.g. Nystuen and Dacey, 1961; Holmes and Haggett, 1977) and more sophisticated graph theoretical and numerical approaches (e.g. Brown and Holmes, 1971; Masser and Brown, 1975; Kalsson and Olson, 2006; Farmer and Fotheringham, 2011; Kropp and Schwengler, 2014), probably the most successful approach is the family of rule-based algorithms devised at the Centre of Urban and Regional Development Studies (CURDS) in Newcastle (see e.g. Coombes et al., 1986; Casado-Díaz, 2000; Papps and Newell, 2002; Coombes and Bond, 2008, and others), although they have been questioned by some scholars (e.g. Cörvers et al., 2009; Farmer and Fotheringham, 2011; Watts, 2013). Only relatively recently, evolutionary algorithms have been used to define functional regions (e.g. Martínez-Bernabeu et al., 2012).

The definition of the functional meso-regions of the Czech Republic is based on the use of daily travel-to-work data. These data represent the most frequent regular and periodical daily movement of the population. Functional meso-regions can be identified by two approaches. Either basic spatial units (the smallest available with regard to the data used) are amalgamated, or some existing units at the micro- level are amalgamated into meso-regions. In this paper the latter approach is used. It has already been applied to the 2001 census data in the territory of the Czech Republic (for the results and discussion of several methods: see Erlebach et al., 2016). Functional micro-regions (in fact local labour market areas) defined by Klapka et al. (2016) are used as building blocks for further analysis in this paper.

Functional meso-regions are defined by the use of the third variant of the CURDS method (Coombes and Bond, 2008; Coombes, 2010), based on 2011 census data. This variant was slightly adjusted according to Halás et al. (2015), who used different self-containment measure and different constraint function. The procedure considers each basic spatial unit as a proto-regional core from the beginning and a crucial role is assigned to the operation with the so-called constraint function, which controls the trade-off between the size (number of employed persons in this case) and the self-containment of resulting functional regions. The values of four parameters (upper and lower limit of size, upper and lower limit of self-containment) are estimated using the approach proposed by Halás et al. (2015). First very low values for the parameters (size and self-containment) were set and larger number of primary regions was defined. These regions were put on the graph, where the x and y axes stand for the values of self-containment and size. Second a distinct gap is identified in the field of points and new parameters are estimated (this step can be repeated). These parameters provided us with the set of final regions (see also Halás et al., 2018).

The amalgamation of basic spatial units resides in the application of the Smart's interaction measure (Smart, 1974), which is given by:

$$T_{ij}^2 \Big/ \left(\sum_k T_{ik} \times \sum_k T_{kj} \right) + T_{ji}^2 \Big/ \left(\sum_k T_{jk} \times \sum_k T_{ki} \right)$$

where T_{ij} is the flow from spatial unit i into spatial unit j, T_{ji} is the flow from spatial unit j to spatial unit i, $\sum_k T_{ik}$ denotes all out-going flows from i, $\sum_k T_{kj}$ denotes all in-going flows to j, $\sum_k T_{jk}$ denotes all out-going flows from j, and $\sum_k T_{ki}$ denotes all in-going flows to i. After each amalgamation the interaction matrix is updated. This method enables one to set and adjust input parameters quite freely in order to optimise the resulting regional system.

4. Results and discussion

The socio-economic peripheries of the Czech Republic based on the scalar data are shown in Figure 2. The spatial pattern is conditioned by the distribution of settlement centres, including the prominent macro-regional role of Prague and the distinct influence of meso-regional centres (see Fig. 2). According to the relative location of peripheries with respect to the state boundary, there are inner peripheries and outer peripheries conditioned by the existence of physiographic barriers to a considerable extent (e.g. the micro region of Jeseník – Figs. 2 and 3). Figure 2 also shows the spatial distribution of two types of peripheries: the first is characterised by the indices of employment and unemployment (Factor 3); whilst the second is characterised by indices concerning housing development, dwelling equipment and the number of uninhabited dwellings (Factor 2).

In the overall spatial arrangement of peripheries, the pattern presented is very similar to previously-identified peripheries (Musil and Müller, 2008; Bernard and Šimon, 2017). The latter work is also inspired by Musil and Müller (2008), and for the identification of peripheral basic spatial units they used a combination of factor analysis and simple clustering methods to group basic spatial units based on favourable/unfavourable values of indices according to Musil and Müler (2008).

The objective of Bernard and Šimon (2017), however, was not to identify one particular group of peripheral units, but types of peripheries, which are affected by various socio-economic factors. An important finding arising from the comparison of our project and other works is that between 2001 and 2011 the spatial pattern of the main peripheral areas did not change. It can be concluded that despite significant economic growth of the Czech Republic

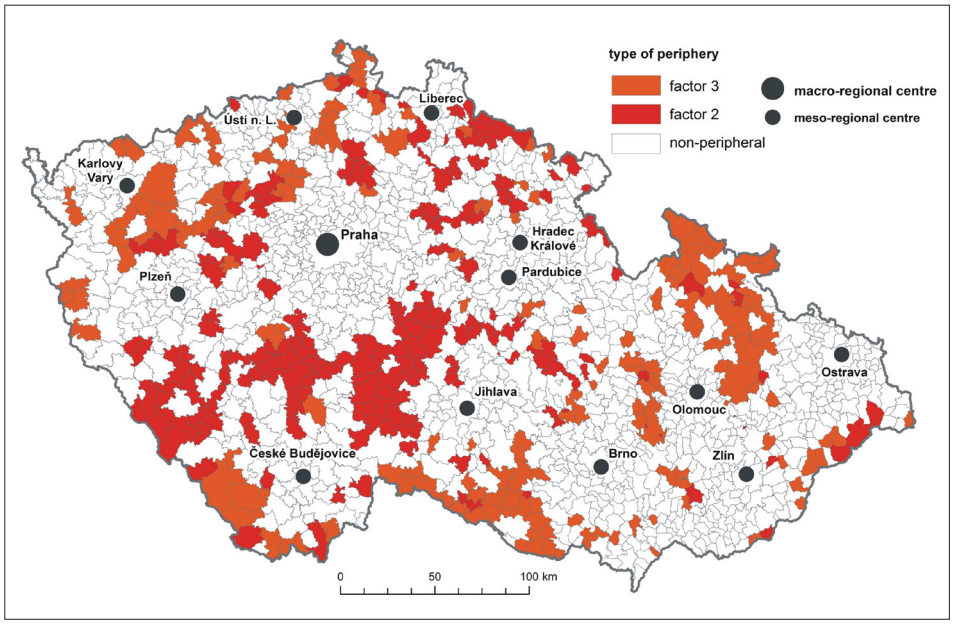

Fig. 2: Socio-economic peripheries of the Czech Republic (scalar data)
Source: Czech Statistical Office (2011 census), ÚRS Praha, a.s. (general units (BSUs)), authors' calculations

Fig. 3: Functional meso-regions of the Czech Republic (vector data)
Source: Czech Statistical Office – 2011 census, Klapka et al. (2016), own design

in that period (Czech Statistical Office, 2016), the spatial pattern of socially and economically underdeveloped areas remained stable.

Functional meso-regions of the Czech Republic based on the analysis of vector data (daily travel-to-work flows) are shown in Figure 3. Eleven meso-regions are formed around the present administrative regional centres with three exceptions (the Czech Republic has 14 administrative regions). The first exception is the capital city of Prague, which is a stand-alone administrative region, a natural centre of central Bohemia at a meso-regional level and of the whole country at a macro-regional level. The second exception is a meso-region in eastern Bohemia, which has the form of a two-membered centre (the cities of Hradec Králové and Pardubice, which are both administrative regional centres). These two cities are located very close to each other and are related by strong mutual interactions. The third exception is the meso- region in western Bohemia with its regional centre in Plzeň. This also includes the area around the city of Karlovy Vary. This centre is not able to organise its own meso-region. Detailed analysis of the 2001 commuting data has shown that according to the method used, the Czech Republic has between 8 and 12 meso-regions (Erlebach et al., 2016). Unlike the current work, the 2011 data clearly identify the functional meso-region formed around the city of Jihlava in a problematic area along the historical Bohemian-Moravian border. A similar spatial distribution of meso-regions can be found in the work of Halás et al. (2014b), who defined these regions using the distance decay function.

The congruence in the location of "non-peripheral areas" and "areas with high concentration of daily movements of the population" and in the location of "peripheral areas" and "areas with low concentration of daily movements of the population" is not easy to quantify in a direct sense, even though it can be graphically inspected, as in Figure 4. The problem lies in the different character of both types of analysed geographical information and also in the way they are processed and expressed. If a correlation were to be calculated, the intensity (levels) of peripherality would have to be used, but this project identifies core and peripheral areas within the concept of formal region, which is a different objective. The use of some measure of correspondence would require relativised scalar and vector information, which would eliminate the effects of different sizes of basic spatial units. Scalar information is relativised with regard to one basic spatial unit and vector information with regard to a pair of basic spatial units, however. This prevents us from carrying out correct comparison. Therefore it is necessary to use absolute values for flows (vector data), though it is not a standard approach, nevertheless it gives us the exact analogy to graphical comparison in Figure 4.

In order to quantify the level of correspondence between locations of areas in question[2] (as represented in Fig. 4), it is necessary to compare the number of non-peripheral BSUs to the same number of BSUs with the highest intensity of the commuting flows. This comparison shows us that the correspondence between two defined sets of BSUs (they have the same number of instances) reaches 84.5%. If the level of correspondence were not expressed by the number of BSUs but according to the population, it would reach 96.5%: non-peripheral BSUs comprise a population 9,610,045 and BSUs with the highest intensity of flows have a population 9,944,759.

Another way to compare the spatial distribution of vector and scalar information is to use results reached by the analysis of either vector or scalar data on one hand, and the results reached by the combination of both types of information on the other. In our case, from the set of non-peripheral BSUs based on scalar information (see Fig. 4) those non-peripheral BSUs, which did not manifest significant cross-border interaction (bi-directional vector of 100 and more persons),

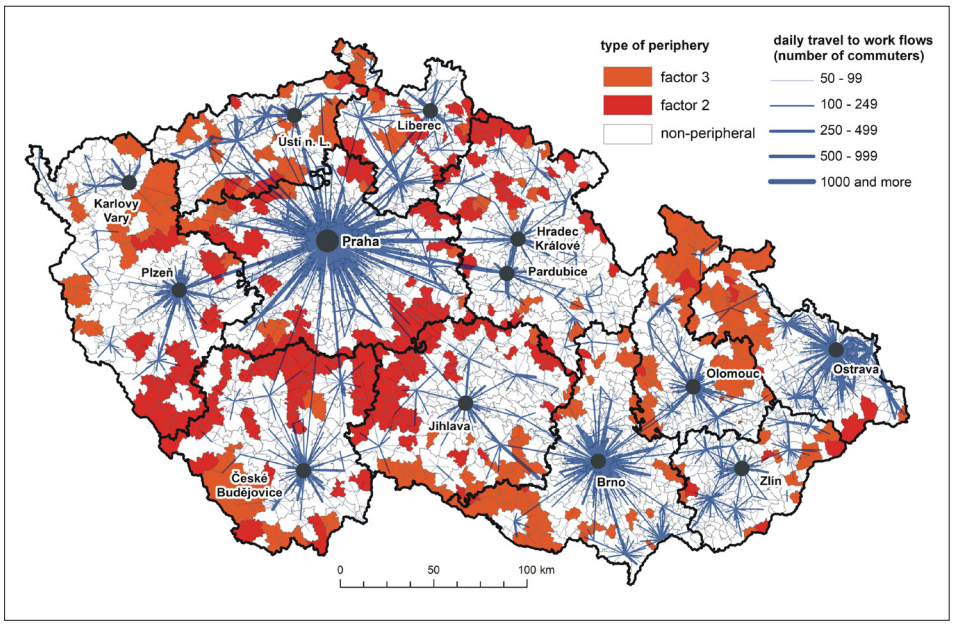

Fig. 4: Spatial arrangement of peripheries, boundaries of functional meso-regions and spatial pattern of interactions Source: Czech Statistical Office (2011 Census), ÚRS Praha, a.s. (general units (BSUs)), own calculations and design

[2] There is a question whether canonical correlation analysis could be used for the purpose. In general this kind of analysis serves similar, analogous purpose well. But there is still practical or technical issue how to tackle vector information, which has an origin and a destination (see also the attempt of Berry [1968] and the notes of Greer-Wooten [1971]). Therefore we leave the possibility of the use of canonical correlation analysis open to further research.

were removed. The correspondence between these two sets of BSUs is 86.5%. Analogically, from the set of peripheral BSUs based on scalar information those peripheral BSUs, which manifested significant cross-border interaction (bi-directional vector of 100 and more persons), were removed. The correspondence reached 86.7% in this case.

Finally, the location of peripheral BSUs in the vicinity of the borders of functional meso-regions can be taken into account. In this case, the spatial neighbourhood is assessed in a simple way. Almost 60% of peripheral BSUs is directly adjacent to meso-regional borders (BSUs of the "first order") and 25% of them are adjacent to the "first order" BSUs.

The synthesis of partial results is shown in Figure 4, which presents both the spatial distribution of socio-economic peripheries (scalar data) and functional meso-regions together with daily travel-to-work flows between individual municipalities, which are higher than 50 persons (vector data). Importantly, the delineation of functional meso-regions based on daily travel-to-work flows is in accord with the definition of peripheries based on socio-economic data and also in accord with the spatial distribution of daily travel-to-work flows. A schematic generalisation of the spatial distribution of core and peripheries, and functional regions is presented in Figure 5. Further comments regarding Figures 4 and 5 are registered in the conclusions.

5. Conclusions

In reality, geographical space cannot be and is not homogeneous (as fractals in Fig. 1). Therefore the distribution of all phenomena in a space shows varying degrees of irregularity. For instance, functional regions need not necessarily be only simple, nodal, monocentric structures. They can be polycentric or have other less regular arrangements. The hierarchy of functional regions, as with the distribution of cores and peripheries, does not manifest sharp distinctions but is continuous. In most practical regionalisations which require a certain level of generalisation, however, a unit-step hierarchy has to be used. For instance, in administrative geography several hierarchical levels have to be positively identified. In these cases, the size of regions at one hierarchical level can vary considerably. If the analysed territory does not have distinct physical geographical features and barriers, the regularity of the presented theoretical model increases and starts to resemble the central place theory model (Fig. 5).

Even though it must be admitted that these results and conclusions are based on a specific type of information, not generic, the findings of the paper have certain weight. Moreover, the paper relies on census data, since other suitable information, particularly vector data, is neither easily available (it has to be paid for), nor is it available in sufficient detail, nor does it cover the whole territory of the Czech Republic. The findings of this paper can be viewed in several contexts, from the most discernible to the most debatable: the spatial, hierarchical, and behavioural contexts.

As for the spatial context of the Czech Republic, the peripheries based on scalar information seem to generally fit the spatial pattern of the functional meso-regions based on the vector information (travel-to-work flows). Combining the spatial patterns of both types of data analysed in the paper, the peripheries appear to be the areas where no or little and weak spatial interaction occurs (Fig. 4). In contrast, the

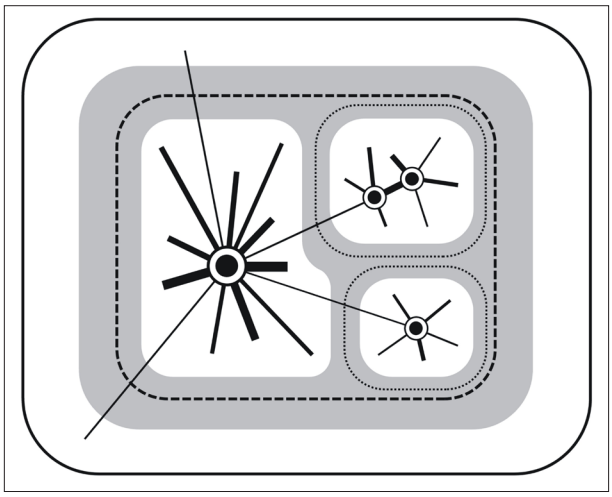

Fig. 5: Spatial interaction pattern, core-periphery dichotomy and boundaries of functional regions
Source: author's design

core (central) areas are typified by numerous and intensive interactions. This basic spatial distribution reflects the character of the settlement system. There is a distinction in the spatial pattern of Bohemia (the western two-thirds of the territory of the Czech Republic) based on a mono-centric settlement system. The distribution of peripheries conforms rather well to the theoretical model. In contrast, the polycentric settlement system in Moravia and Silesia (the eastern one-third of the territory of the Czech Republic) has a more uneven distribution of peripheries.

As for the hierarchical context, it is at the meso-regional level where the phenomenon is legible most effectively; however, in several cases it is documented even at the micro-regional level (for this see the functional micro-regions of Trutnov, Jičín, Tábor, Strakonice, Znojmo, Břeclav, etc. in Figs. 3 and 4). In this respect, the paper demonstrates that the explored issue is relevant for at least two hierarchical levels – meso- and micro-regional levels (this conclusion also applies to the macro-regional level, but this case was not researched thoroughly, and there is a significant role of the state boundary and also for orographic effects). The repeatability of spatial patterns at various hierarchical levels supports both the central place theory and fractal theory.

As for the behavioural context, two explanations can be ventured. Either there is a structuring effect of space (i.e. geographical environment in its most general meaning) on both human locational and interaction behaviours, or there is an integrating virtue over these types of human behaviour. It can also be expected that both explanations support each other. In the search for this integrating virtue, and with regard to the data analysed in this paper, either the economy or the social structures can play the integrating role for the locational and interaction behaviour. It is probably both of them and their interplay that forms the integrating virtue. In this sense, the spatial interaction models can be used to explain the linkages between the spatial structure and spatial interaction patterns, and it is also one of the possible directions for future research.

From what has been argued so far, it can be presumed that locational and interaction data are closely interlinked. Even so, several questions remain for future research. For instance, does leisure-related human behaviour 'look' the same? It would be harder to answer this question, because

of the lack of relevant data rather than because the question would differ theoretically and philosophically from the questions asked in this paper. It can also be assumed that a more concrete spatial manifestation of the leisure-based (or any other relevant) analysis would differ because of different behavioural aspects (particularly the regularity and intensity of the phenomenon), but the basic principles of spatial distributions should be maintained.

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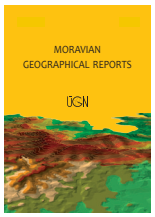

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The delimitation of planning regions on the basis of functional regions: An algorithm and its implementation in Turkey

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Abstract

The proper delimitation of planning regions is a critical issue in the success of regional plans, and it constitutes a rich domain of research. In this paper, it is argued that planning regions should be based on functional regions – if the main intention is to increase the driving power of the people behind the planning process. Within this context, the aims of this paper are twofold: (1) to develop an algorithm (FRGIS) for the delimitation of planning regions on the bases of functional regions, and to implement it by using the scripting facilities available in Free and Open Source Software for Geographic Information Systems (GIS); and (2) to delimit the planning regions in Turkey by using FRGIS and the script developed for this purpose, by employing the commuting flows occurring between districts in the case country (Turkey) in 2010. The results show that FRGIS is successful in terms of the formation of spatially-balanced regions having higher levels of self-containment compared to those of existing regions. Nevertheless, it is also evident from this study that a combination of the nomothetic and ideographic methods of science is inevitable if functional regions are to be employed as planning regions.

Keywords: *delimitation of regions; functional region; planning region; geographic information systems; Turkey*

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1. Introduction

One of the problems planners encounter during their engagement in a planning activity is the delineation of boundaries of the planning region (PR)[1]. In this respect, there are several alternatives for the delimitation of a PR. The first and easiest one, which has also been widely employed in Turkey (the case study country used here), is to designate administrative regions (normative regions) as PRs. Regional plans based on normative regions, however, are actually incapable of covering the geographical extent of the communities that are in interaction with each other, which eventually decreases the driving power of the people behind the planning process. This stems from the rigid characteristic of normative regions that may "continue to exist for reasons other than those that brought them into existence" (Wirth, 1937, p. 494). Indeed, while the number and magnitude of connections among the basic spatial units (BSU) involved in a country change over time, it becomes harder and harder for political authorities to change the boundaries of normative regions according to newly-formed relations between BSUs.

As a result of this situation, NUTS 1 and NUTS 2 regions of Turkey were defined in line with the provincial boundaries without taking into account the actual regional boundaries revealed by the interactions between districts. Parallel to this, it is observed that the majority of regional plans in Turkey have also been prepared for the normative regions whereas, as Wirth (1937), Tekeli (1972) and Geray (1997) argue, local administrative areas should be seen as supple tools for the accomplishment of a more beneficial socio-economic life. Thus, particularly from a planning point of view, the delimitation of PRs according to functional linkages, such as commuting patterns defining functional regions (FR) constitutes a substantial research area in terms of the establishment of geographical unity essential for the administration and planning of regions. The delineation of FRs on the basis of commuting flows has particularly become widespread during the last decades in many developed countries (Cattan, 2002).

In this regard, there have been several studies carried out for the delimitation of FRs or PRs in Turkey, considering

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[1] Many acronyms are used in this paper: for reference, they are listed at the end of the work. Readers may wish to print a copy of these acronyms, as they are spelled out usually only at first time usage in the text.

the whole country. The first one was conducted by DPT (1982) on the spatial organisation of settlement units in Turkey and covers all the districts in the country. Yet, it is not updated and it does not allow for the formation of FRs without the designation of some cities as central places. Among recent studies, only Öztürk (2009) pays attention to flow data. In his study, Öztürk (2009) uses migration flows that are not actually suitable for the delimitation of PRs. In another recent study conducted by Ecemis Kılıç (2009), employing an eclectic method, it is observed that the tendency to define PR in accordance with the normative regions continues. Overall, the studies conducted for the delimitation of PRs or FRs in Turkey suffer from an absence of considering commuting data, as well as proper methods of analysis.

Given these considerations, the main objective of this paper is to develop an algorithm (named FRGIS) for the delineation of PRs via the delimitation of FRs, and to reveal PRs in Turkey by using FRGIS. For this purpose, firstly the concept of FR is elaborated, together with the key issues and methods of delimitation of FRs as PRs, in order to present the theoretical framework of the study. In the third section, the characteristics of the commuting and spatial databases used is presented in order to demonstrate the inherent characteristics of the respective databases. In this section, FRGIS and the script created for FRGIS are also elaborated by explaining the phases and stages of this rule-based method. In the fourth section, the results of implementation of FRGIS in Turkey are presented and discussed in order to reveal the degree of success of FRGIS. Subsequently, some concluding remarks are drawn with reference to both the theoretical considerations and the findings emerging from the functional regionalisation analysis for Turkey.

2. The key issues and methods of delimitation of functional regions as planning regions

The idea of FR focusing on interconnections between BSUs rather than on the similarities between them owes much to early studies revealing the influence of urban centres over their surrounding areas (see e.g. Platt, 1928; Christaller, 1933). Parallel to these studies, the need in regional planning for the delimitation of PRs in line with FRs first emerged for the planning of growing metropolitan areas by taking into account the geographical extent where the constituent parts of the respective cities are strongly connected to each other through daily interactions such as commuting relations (see e.g. Wirth, 1942; Friedmann, 1956). Subsequently, the first serious analytical efforts made for the delimitation of FRs were reported in the 1960s. In this respect, Nystuen and Dacey's (1961) study on the use of graph theory for the delineation of FRs deserves special attention. Again within the context of a systematic application of graph theory to the analysis of spatial structures, Haggett and Chorley (1969) show how FRs can be delimited by using network analysis.

One of the first studies aimed at the delimitation of FRs with particular reference to the employment of these regions for planning purposes was conducted by Brown and Holmes (1971). In the subsequent decades, the need for the delimitation of PRs in line with FRs is also manifested in a number of other studies (e.g. Hemmasi, 1980; Keeling, 1994; Van der Laan and Schalke, 2001; Feldman et al., 2005; Klapka et al., 2014; Halás et al., 2015; Erlebach et al., 2016; Drobne, 2017) parallel to improvements of the methods of delineation of FRs and PRs. The use of FRs as PRs also received the attention of Coombes et al. (1986), the team developing the CURDS (Centre for Urban and Regional Development Studies) algorithm for the demarcation of FRs on the base of travel-to-work-areas (TTWA).

Considering the problem of the delimitation of FRs as a problem of the grouping of BSUs so that they can form different regions excluding each other, various studies (e.g. Masser and Brown, 1975; Coombes et al., 1986; Noronha and Goodchild, 1992; Halás et al., 2015) reveal that a FR should cover a group of BSUs whose interaction with other BSUs is organised in such a way that while the total amount of flows among the BSUs within the respective FR is maximised, the flows between them and other BSUs are minimised. The main expectation from this process is the creation of self-contained regions (Coombes et al., 1986). This basic rule constitutes the main rationale behind the delimitation of FRs. Thus, a FR is not something abstract, but rather "a reflection of the spatial behaviour of individuals in a geographic space" (Halás et al., 2015, p. 1175).

In this sense, an important issue in the delimitation of FRs as PRs is the scale of the regions concerned. FRs can be delimited by using daily travel-to-work flows at two different scales (Klapka et al., 2014; Erlebach et al., 2016); micro (e.g. labour market areas – LMA) and meso (e.g. NUTS 2 regions delimited on the base of local LMAs). In particular, at the meso-scale FRs can serve as a tool for regional planning (Erlebach et al., 2016). The main objective of FRGIS is also to expose those meso-scale regions by using a two-phase model. In addition to these scales, a macro level of region can also be defined by using other types of flows in the socio-economic system.

Since a FR is characterised by a high frequency of intra-regional economic and social interactions, spatial interaction matrices can be built by using not only labour commuting flows (Coombes et al., 1986; Andersen, 2002; Cörvers et al., 2009; Landré and Håkansson, 2013), but also migration flows (Brown and Horton, 1970; Holmes and Haggett, 1977; Hemmasi, 1980; Öztürk, 2009), housing markets (Hincks and Wong, 2010), telephone communication flows (Nystuen and Dacey, 1961; Clark, 1973; Clayton, 1980; Chi et al., 2016), commodity flows (Brown and Pitfield, 1990), inter-firm relational data (Van Oort et al., 2010), retail and wholesale shopping flows (Aydemir, 1978; DPT, 1982), banking relations and newspaper circulation (Clayton, 1980). Nevertheless, there is no doubt that the commuter flows are the most suitable database for the delimitation of PRs.

Another critical issue that is particularly relevant for the delimitation of PRs is the condition of adjacency. Internal contiguity is regarded as a major criterion in the delimitation of administrative regions and PRs (Andersen, 2002; Casado-Díaz and Coombes, 2011). Thus, if a FR is delimited for planning or administrative purposes, the formation of Multi-Polygon Regions (MPR) should not be permitted. Actually, one of the advantages of using commuting data for delimitation of FRs is that due to the restriction imposed by 'friction of distance' on the patterns of movement of people, the strongest interactions tend to occur between nearby BSUs (Coombes, 2000; Casado-Díaz and Coombes, 2011). As a result of this characteristic of commuting data, FRs formed after the analysis of interaction data are less likely to be fragmented.

Based on this finding, in FRGIS, particularly in the first phase of the delimitation of FRs, regions are formed on the base of a loose contiguity constraint by using Graph

Theoretical Geodesic Distance (GGD) between BSUs instead of a direct constraint. In graph theory, the distance between two vertices in a graph is the number of edges in a shortest path connecting them. This is also known as the geodesic distance. As evident from the definition, GGD does not correspond to physical distance. Actually, GGD can be considered as a measure of degree of contiguity and used as a parameter in the delimitation of FRs. Treatment of contiguity as a criterion is a common characteristic of the methods of delimitation of FRs as PRs.

There are various methods of delimitation of FRs. And there are different classification schemes for the respective methods. Coombes (2000) classifies these methods into three groups:

1. clustering methods;
2. methods using hierarchical algorithms;
3. rule-based methods.

In contrast, Erlebach et al. (2016) and Klapka and Halás (2016) create a separate category for graph-oriented approaches that are included by Coombes (2000) within clustering methods, and they group hierarchical algorithms under the clustering methods characterised by a numerical taxonomy approach. Rule-based procedures (also known as multistage methods) are again defined as a separate category by them.

In another classification scheme, graph-oriented approaches and hierarchical algorithms are classified by Klapka et al. (2014) and Halás et al. (2015) as sub-categories of (1) clustering and (2) rule-based methods, not as separate groups. Sub-categories of these two groups of methods are defined according to whether they are based on:

a. divisive or agglomerative;
b. hierarchical or non-hierarchical; and
c. numerical or graph-theoretical, procedures.

There are also other alternative classification schemes such as the ones developed by Van der Laan and Schalke (2001), Van Nuffel (2007), Casado-Díaz and Coombes (2011), and Farmer and Fotheringham (2011). A common theme observed for the first three schemes is the distinction between inductive and deductive approaches. The last two schemes, however, still pay attention to the distinction between rule-based algorithms and hierarchical clustering methods.

In this study, parallel to Klapka et al. (2014) and Halás et al. (2015), the methods of delimitation of FRs are classified into two main groups of methods based on (1) general cluster analysis and data reduction techniques and (2) specific algorithms relying on certain rules and stages. The preference to group cluster analysis and database reduction methods together stems from their reliance on pure statistical techniques. Application of purely statistical techniques, as Coombes et al. (1986, p. 946) remark, is largely deterministic and they exclude 'fine tuning' of the parameters that may be required to define FRs.

For those methods relying on statistical methodologies, Brown and Holmes' (1971) study employing the functional distance approach based on mean first passage time can be considered as one of the first examples of general cluster analysis by using various linkage measures. Keane (1978) and Cörvers et al. (2009) also employ this approach in their studies. The Intramax procedure developed by Masser and Brown (1975) on the basis of modifications introduced to Ward's (1963) hierarchical aggregation procedure, is another example. This approach that was further improved by Masser and Scheurwater (1978) who benefit from some graph theoretical procedures was applied in a number of subsequent studies (e.g. Brown and Pitfield, 1990; Fischer et al., 1993; Feldman et al., 2005; Öztürk, 2009; Mitchell and Watts, 2010; Drobne and Lakner, 2016).

Similar cross-fertilisations of various procedures can also be observed for the database reduction methods based on eigenvalues, such as Correspondence Analysis and Principal Component Analysis (see e.g. Clark, 1973; Clayton, 1980). As a data reduction method, Factor Analysis can also be used for the delimitation of FRs (see e.g. Illeris and Pedersen, 1968; Hemmasi, 1980; Nader, 1980). The results of database reduction methods can be further processed by employing graph theoretic techniques in order to reveal FRs (see Goddard, 1970; Clark, 1973; Van Oort et al., 2010, for the employment of graphs as supporting visuals for the delimitation of FRs). More recent and comprehensive implementations of graph theoretic methods for the delimitation of FRs can be found in Farmer and Fotheringham (2011) and Chi et al. (2016).

In the second group of methods corresponding to rule-based procedures, there are two major approaches for the delimitation of FRs by employing commuting flows:

a. delimitation of FRs around some central BSUs (e.g. CURDS algorithm used in Coombes et al., 1986; Andersen, 2002; Pálóczi et al., 2016; European Regionalisation Algorithm (ERA) used in Coombes, 2000; the local labour market approach used in Karlsson and Olsson, 2006; Drobne et al., 2010; Konjar et al., 2010); and
b. delimitation of FRs without identifying any central BSU (e.g. partly the 'commuting zone approach' used in Karlsson and Olsson, 2006; the newest version of the TTWA algorithm considering all the individual zones as proto-TTWAs in the beginning, as described in Coombes and Bond, 2008; 'commuting aggregation approach' (CAA) used in Konjar et al., 2010; and the grouping evolutionary algorithm (GEA) developed by Martínez-Bernabeu et al., 2012; Casado-Díaz, et al., 2017).

In the first approach, after the identification of central BSUs according to some pre-defined criteria, other BSUs are assigned to their respective BSUs along with the degree of interaction between them and the central BSUs. The CURDS algorithm (Coombes et al., 1986) is a typical example. It is a multi-phase and stage aggregation method in which firstly foci zones are identified from the set of BSUs. In the subsequent phase, unallocated BSUs are assigned to these foci. In the final phase, it is ensured that all the resulting regions satisfy the specified constraints. Parallel to the CURDS algorithm, in ERA (Coombes, 2000), there are up to five steps of which first three steps are in line with the first two phases of the CURDS algorithm.

In the second approach, BSUs are assigned to each other without identifying any central BSU, according to magnitude of interaction between them. For this purpose, in the newest version of the TTWA algorithm (Coombes and Bond, 2008), after ranking all proto-TTWAs (BSUs) in terms of their size and self-containment values, whether the lowest-ranked proto-TTWA satisfies the requirements to be considered as a TTWA is checked. If it dissatisfies the requirements, it is dissolved into its constituent zones and, subsequently, each zone is grouped with the proto-TTWA with which it is most strongly linked. After the calculating the size and

self-containment values of altered proto-TTWAs, the whole step is repeated to satisfy the parameters specified for the formation of LMAs.

Other methods (e.g. CAA classified under the second group of approaches) group BSUs to form FRs in several phases/steps. In CAA, after calculating the share of people commuting from one BSU to another one, in the first phase, Konjar et al. (2010) group the couple of BSUs having the highest degree of interaction with each other according to maximum share. In the second phase, the groups of BSUs are fused according to a measure of mutual dependence between them. Accordingly, groups of BSUs defined in the first phase and actually corresponding to small local LMAs, are included in the second phase as the building blocks of the analysis.

In FRGIS, parallel to the first phase, the second phase of the functional regionalisation is also based on the demarcation of regions according to the maximum share – instead of a mutual dependence measure that seems to favour the centralisation of some groups of BSUs over others. The introduction of a minimum population limit for FRs also seems to support the domination of some BSUs. The most problematic issue in the delineation of FRs around some central nodes is the dismissal of the possibility of a region without a dominant core. Indeed, it is possible to define centres on the basis of interaction flows without using additional data. Nevertheless, if FRs are delimited around some central BSUs, the designation of these centres implies that there is a strict hierarchy in the spatial organisation of settlement units. This implication contradicts with contemporary reality of the 'network model' of places, in which horizontal relationships between places of similar size are possible.

Although the majority of the early rule-based methods were actually hierarchical, as Coombes (2000) remarks, some of them have been improved to break away from being hierarchical. For example, in CURDS proto-FRs dissatisfying the population size and self-containment criteria, are dismembered and reallocated to other FRs, to meet the specified constraints (Coombes et al., 1986). Similarly, in the latest TTWA algorithm (Coombes and Bond, 2008), those FRs with minimum validity are identified and disaggregated into their constituent BSUs, and subsequently they are associated with more dominant FRs. In a similar fashion, in FRGIS, parts of FRs not satisfying the internal contiguity criteria are disassembled and they are not allowed to be members of the same FR in subsequent iterations. Thus, the number of regions produced by rule-based methods is actually not known beforehand.

In rule-based methods, a threshold level for the degree of interaction can also be introduced for BSUs to combine with each other or other centres. For example, in the local labour market approach, Karlsson and Olsson (2006) use a cut-off frequency in order to exclude the very few long-distance commuters. These threshold values can also be estimated during the process of the definition of FRs rather than setting them in advance (Halás et al., 2015). Nevertheless, in FRGIS, this threshold value required in the first phase of the functional regionalisation is predefined by observing the results of an analysis for various values. This allows the researcher to fine-tune the parameters and to select the best set of FRs by comparing the results obtained for various runs of the script (RS). A different kind of fine-tuning procedure is also available in the TTWA algorithm (Coombes and Bond, 2008) for the prevention of MPRs.

Another parameter taken into account in FRGIS is the maximum area occupied by a region. Although in many studies (e.g. those using CURDS, ERA, TTWA and GEA algorithms) the number of inhabitants is used as a constraint, in relatively large countries where the population is not distributed uniformly, the use of population as a restriction may result in undesired outcomes. For example, in Turkey, İstanbul is the largest metropolitan region, overflowing into contiguous provinces. In terms of the planning of such regions, it would be wiser to include all BSUs involved in the region. If a restriction is imposed on the total population of a FR, even the existing provincial boundaries of İstanbul may not be preserved. Actually, the regions resulting from the introduction of a population threshold in the delimitation of FRs correspond to, what Noronha and Goodchild (1992) call, equitable regions that can be taken as a unit of analysis for statistical and administrative purposes, but may not be suitable for regional planning purposes.

In this respect, for comparative purposes, the R package 'LabourMarketAreas' developed by Franconi et al. (2016; 2017) for the implementation of the newest version of the TTWA algorithm described in Coombes and Bond (2008), is also used in this study for the delimitation of FRs in Turkey. The algorithm implemented in R is based on the following components required in order for a cluster to be considered as an LMA (Franconi et al., 2016, pp. 3–4):

1. a set of parameters for thresholds on the population size of the LMA and the level of self-containment (LSC) (main parameters are *minSZ* (minimum number of employees for an LMA), *tarSZ* (target value for the population size of the LMA), *minSC* (LSC that is acceptable for cluster of large sizes), and *tarSC* (the target self containment of an area in order for a small cluster to be considered an LMA));
2. a condition of validity to form valid LMAs;
3. a measure of cohesion between a BSU and the clusters;
4. a reserve list consisting of unassigned communities; and
5. an iterative procedure selecting one community at a time, aggregating it to a different cluster, and defining the operations to be implemented.

Overall, compared with other studies reported above, in the FRGIS developed in this study there is no implication for the designation of the centres in line with the contemporary reality of a 'network model' of places. FRGIS also differs from other studies by introducing a limit for the maximum area that can be occupied by a region. It is argued that this can serve for the formation of PRs better than a population limit. Last, but not least in importance, this study contributes to existing methods for the delimitation of FRs by developing an auto-control mechanism for the internal contiguity within a FR via a graph theoretical parameter that is integrated into FRGIS in such a way that no interruption is required by the user during the running of the algorithm, as such due to the employment of GIS.

3. The databases used and the algorithm developed for delineation of FRs as PRs

The database employed is based on travel-to-work data. It has been compiled from data obtained from the Social Security Institution (SSI) of Turkey. SSI was established by the SSI Law in 2006 and it brings the Social Insurance Institution (SSK), the Social Insurance Institution for the Craftsmen and Artisans and Other Self Employers

(BAGKUR), and the General Directorate of Retirement Fund (Emekli Sandığı) under a single roof. As some of the fields included in the BAGKUR database were either not up-to-date or unavailable, the database used covers travel-to-work data (as of April 17, 2010) for the Turkish labour force registered in SSK and Emekli Sandığı. Accordingly, the total number of commuters is 10,430,994. For this study, districts (NUTS4) are designated as BSUs, which allows us to observe the formation of FRs without any strict restriction imposed at the province (NUTS 3) level. Some districts have been either split or aggregated, however, in order to prevent mismatch between the residential and work addresses. As a result of this process, the total number of BSUs is determined as 939 (see Fig. 1). It is important to note that only 34 BSUs out of 939 BSUs (3.6%) have a self-containment (share of commuters residing and working in the same BSU) above 70%.

As all the districts in Turkey are included in the commuting database, the majority of the cells are actually empty in the matrix, showing the commuting interaction between origin BSU (OB) and destination BSU (DB). Accordingly, only 165,408 cells out of 881,721 cells have values greater than 0 (18.76%), which is, as noted by Brown and Holmes (1971), an expected feature of interaction matrices showing commuting relationships in a country. Commuting flows amounting to at most 50 occupy 95.13% of these filled cells. Yet, they only represent 6.91% of commuters. Conversely, although commuting flows amounting to at least 500 occupy only 1.15% of the filled cells, they represent 84.49% of commuters. Actually, this is also an expected characteristic of the interaction matrices representing the commuting flows in a country and reflects the tendency of people to commute between BSUs located close to each other. Indeed, more than half of the commuting flows (51.27%) occur within the same BSU, and the flows occurring between the BSUs located within a GGD of 3 from each other amount to 84.22% of the flows.

According to the method of delineation employed in this study, the first step in the delimitation of FRs in a country requires the calculation of both shortest distance (SD) and GGD between BSUs. For the calculation of SD, the OSM (Open-Street-Mapping) road database for Turkey and the 'Origin-Destination Matrix' tool in Network plug-in available in gvSIG CE (Community Edition), are employed. For the calculation of GGD, the algorithm developed by Beyhan (2012, pp. 32–35) is used. Before the calculation of GGD in FRGIS, physically-disconnected BSUs (such as islands) separated from the other BSUs because of the sea or channels, have been connected to others via narrow strips in order to prevent the exclusion of these BSUs in the calculation of GGD.

The algorithm, FRGIS (Fig. 2), developed in this study is translated into a java script that can be compiled into a JAR file running as a plugin, 'Functional Regionalisation', in OpenJUMP, a Free and Open Source Software (FOSS) for Geographic Information Systems (GIS). As the plugin is built on top of OpenJUMP, it can draw on a series of functions that facilitate the analysis required to delineate FRs (e.g. geometry converter functions and spatial predicates in JTS – Java Topology Suite). For example, in addition to the calculation of GGD, the condition for the prevention of MPRs and the total area occupied by a FR before including a new BSU inside the region, is automatically controlled. Overall, it is assumed that FRs can be delimited as PRs by using a two-phase model. In the first phase, no restriction is imposed for the total area of a FR in order to unite BSUs. In this phase, the model used in FRGIS is similar to the first phase of CAA (commuting aggregation approach).

In FRGIS, it is assumed that the commuting database is organised in an edge data format showing the labels for OB and DB together with SD and the amount of commuting (AC) between them, and lastly the commuting level (CL) measured as the share of those commuting from OB to DB as a percentage of the total commuters residing in OB. It is further assumed that the rows of the respective database are sorted according to firstly CL in descending order, secondly SD in ascending order, and thirdly AC in descending order. This sorting operation helps us prioritise the parameters taken into account in the creation of FRs. Nevertheless, some restrictions are also taken into account in FRGIS in order to prevent the formation of MPRs or overly-large FRs (such as the maximum GGD (GT) that can be allowed between OB and DB, and the maximum area (AT) that can be occupied by a FR). CL is mathematically defined as follows:

$$(1) \quad CL_{ij} = \frac{\text{number of commuters from BSU}_i \text{ to BSU}_j}{\text{number of commuters residing in BSU}_i} \times 100$$

where CL_{ij} is the commuting level between BSU_i (OB) and BSU_j (DB).

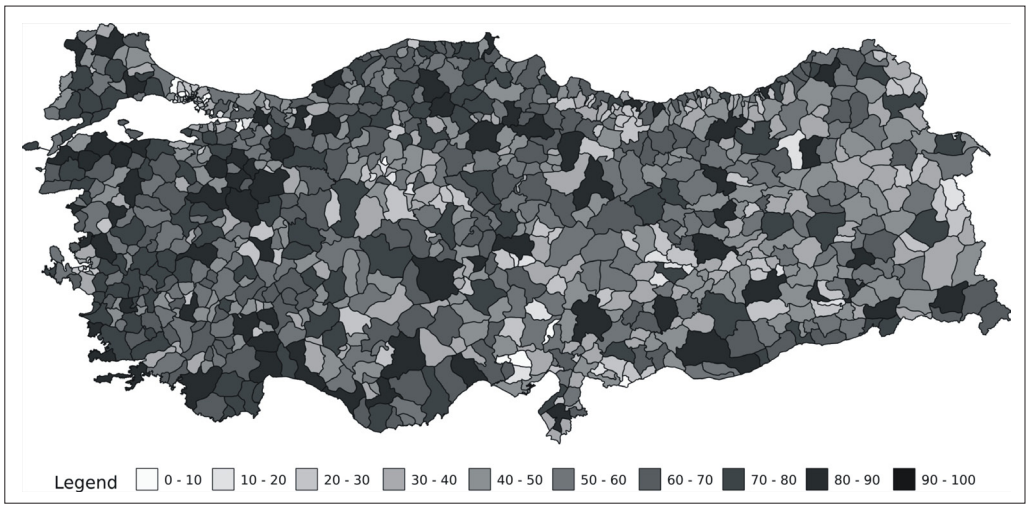

Fig. 1: The districts as BSUs according to the level of self-containment (% of total)
Source: author's elaboration

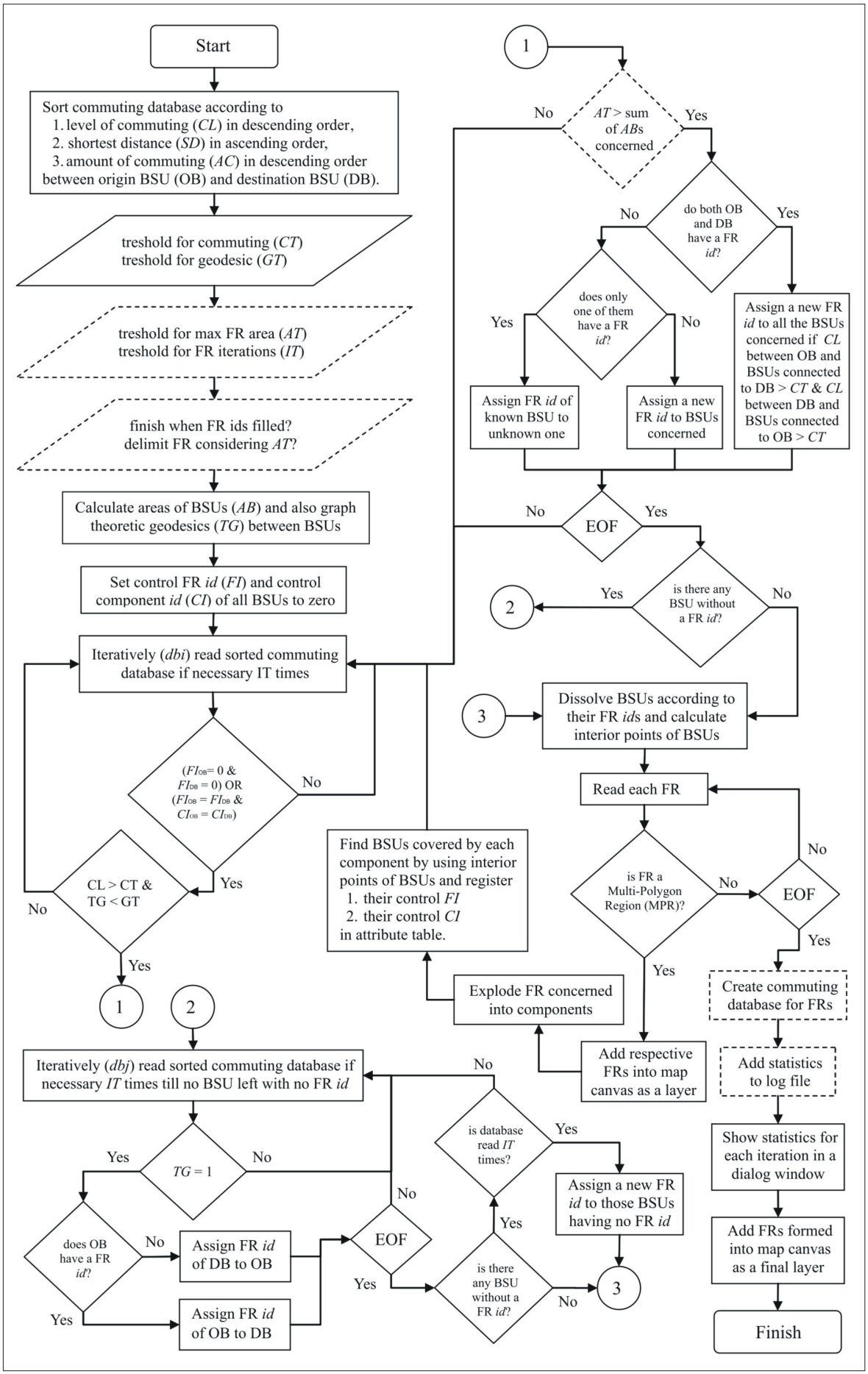

Fig. 2: Algorithm (FRGIS) developed for delimitation of FRs as PRs
Source: author's elaboration

A threshold value (CT) for minimum commuting level is also required as a parameter to be defined for the formation of FRs. Together with GT, this parameter allows us to observe the tendency of BSUs to merge. In the first phase of running FRGIS, in the first stage, the database is read in sorted order, row by row, and all BSUs are allowed to freely unite with each other within the limits of a given GT and CT to form FRs. Accordingly, only those couples of BSUs whose TG (GGD between OB and DB) is less than GT and whose CL is more than CT are taken into account. As revealed in Figure 2, formation of the first FR actually starts with the union of the couple of BSUs in the database's first row showing the highest CL for any pair of OB and DB. The FR concerned enlarges with the addition of new BSUs provided that their couple in the row read is previously included in the respective FR as either OB or DB. A new FR is formed if both OB and DB of the row read are not included in the existing FRs. The formation of a FR covering n BSUs in the first stage can be mathematically expressed as follows:

$$\text{first stage } FR = \bigcup_{i=1}^{n} BSU_i \tag{2}$$

for CL > CT and GT > TG

As some BSUs may not be involved in any FR because of CL values below CT, regardless of the phase, after the formation of FRs within the limits of a given GT and CT, in the second stage, the database is re-read in sorted order, if necessary IT (number of iterations) times, and each BSU that was not associated with a FR in the first stage is allowed to fuse with the adjacent BSU to which it is connected with the highest CL compared with CLs between it and its contiguous BSUs. Mathematically, this can be expressed for a FR covering n additional BSUs in the second stage as follows:

$$\text{second stage } FR = \text{first stage } FR \cup \bigcup_{i=1}^{n} BSU_i \tag{3}$$

for CL > other CLs and TG = 1

Thus, for each phase of running the script, FRs are actually formed by following a two-stage procedure. In the script, minimum CL (MCL) and the last line read in the database during these stages are registered, to be reported as statistics. Some statistics about BSUs connected to a FR in the second stage are also registered to the attribute table of the original map, together with the FR id (identity number) of each BSU (such as CL used to combine BSU concerned with the respective FR).

In FRGIS, each FR is also checked whether it is a MPR. If it is a MPR, each component (isolated part) in the FR is identified and BSUs covered by the FR are marked both with an component id assigned to the component covering them, and also with the FR id enveloping them. In the subsequent iterations of FRGIS for dbi (database iteration number) in Figure 2, those BSUs marked with the same FR id but different component ids are not allowed to be involved in the same FR. As MPRs are not desired, commuting statistics are not calculated and reported for the iterations involving them. It is assumed that the script will run until no MPR is formed within the given limits of IT. The main outcome obtained after RS is a report dialog window showing some statistics and a series of maps showing FRs and MPRs for each iteration, together with some basic statistics about them in the attribute table of the final FR map and original map. The results of the analysis together with the parameters used in them are also logged to a file after each RS.

4. The results of running FRGIS

Statistics obtained from various RS for the first phase are presented in Table 1. In the first three RS, BSUs are joined according to CL between only adjacent BSUs. If GT = 1, it is observed that the number of FRs is at least around 185. Nevertheless, after several other RS by relaxing the initial condition for adjacency, it is observed that the number of FRs can be reduced to 147 by allowing the couple of non-adjacent BSUs to be members of the same FR while preserving the spatial integrity of the FR in terms of prevention of MPRs and at the same time increasing LSC. From Table 1, it can be concluded that at the 12th RS for which both CT and GT are set to 4, MCL (for 'If GT = 1'), the minimum LSC, and the minimum area occupied by a FR can be maximised to better levels compared with other RS for various configurations of CT and GT. Thus, 147 FRs created after the 12th RS are considered to be the best candidates for the delimitation of PRs in the second phase with the introduction of AT (see Fig. 3).

Some statistics for the respective FRs are also given in Table 2, together with the statistics for BSUs before analysis. It is important to note that the minimum LSC increases from 2.90% (for a BSU) to 41.64% (for a FR). The average LSC also increases from 51.44% to 77.19%. In this respect, FRs that have been identified during the first phase of the regionalisation procedure partly conform to the criteria set in these recent studies. Indeed, in 117 out of 147 FRs, LSC exceeds 70% (see Tab. 2).

In the first phase, as explained above, AT is not used in the delimitation of FRs. The results of the analysis, however, show that there are huge differences between the largest and smallest FRs delimited during the first phase (Tab. 2). It is also observed that while the most crowded FR involves 21 BSUs, each of 30 FRs involves only 2 BSUs (see Tab. 3).

For both administrative and planning purposes, the area covered by a PR has critical importance owing to a number considerations: allocation of central funds to the administrative and planning units; organisation and supply of infrastructure services; and security issues. As the principal interest of this study is to identify regions that can be mainly used for regional planning purposes, one can speak of an optimum for the number of regional units and the area covered by the respective units. If it is considered that there are currently 26 NUTS 2 regions in Turkey, a NUTS 2 region roughly occupies an average area of 30,000 km^2. Thus, in the second phase, AT is used as a parameter in the delineation of PRs. In addition to this, some statistics regarding the density of population in the resulting PRs are also calculated in order to reveal some intuition about the distribution of population.

In the second phase, CT is set to 0 in order to let FRs combine with each other to form larger FRs that can serve as PRs. For the prevention of formation of MPRs, GT is mostly set to 1. From Table 4 showing the results of the second phase, it is observed that if GT = 2, LSC decreases compared with those obtained from RS for the same set of ATs when GT = 1. For the same set of ATs, the average area occupied by a PR also decreases if GT = 2, except for AT = 45,000 km^2 for which it remains the same. As expected, maximum density of a PR regularly decreases parallel to the increase in AT, which signals a balanced distribution of population in the country.

Table 4 reveals that, compared with the first phase, the results of this second phase are more successful in terms of the increase in LSC. If GT = 1, the average LSC for a PR

RS	NI	Limits		FRs	If GT = 1	MultiPol		Statistics for area of FRs (km^2)				Statistics for LSC (%)			
		GT	CT		MCL	MFR	Ps	max	min	med	mean	max	min	med	mean
1	1	1	2	188	0.11	–	–	28,109.5	197.5	2,876.5	4,215.9	93.75	41.64	76.53	74.05
2	1	1	3	188	2.13	–	–	28,109.5	27.6	2,814.1	4,215.9	93.75	41.64	76.04	73.66
3	1	1	4	185	2.13	–	–	28,109.5	62.0	2,814.1	4,284.2	93.71	39.24	76.04	73.82
4	1/2	2	2	157	0.24	4	9	25,098.4	27.4	3,105.5	5,048.3	93.79	24.36	78.11	76.03
5	1/2	2	3	156	0.22	4	9	25,098.4	27.4	3,255.0	5,080.7	93.79	24.36	78.55	76.17
6	1/2	2	4	158	0.22	3	6	25,098.4	62.0	3,144.4	5,016.4	93.78	41.64	78.11	76.08
7	1/2	3	2	147/146	0.51	10	20	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.99
8	1/2	3	3	147/146	0.51	9	18	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.99
9	1/2	3	4	148/147	0.51	7	14	27,117.6	275.4	3,386.4	5,391.7	93.78	41.64	79.18	77.19
10	1/2	4	2	145/146	1.45	12	24	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.99
11	1/2	4	3	145/146	1.75/1.45	12	24	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.99
12	**1/2**	**4**	**4**	**146/147**	**1.75/1.45**	**10**	**20**	**27,117.6**	**275.4**	**3,386.4**	**5,391.7**	**93.78**	**41.64**	**79.18**	**77.19**
13	1/2	5	2	146	1.37	16	33	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.97
14	1/2	5	3	146	1.75/1.37	16	33	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.96
15	1/2	5	4	147	1.75/1.37	14	29	27,117.6	275.4	3,386.4	5,391.7	93.78	41.64	79.18	77.17
16	1/2	6	2	146	1.37	16	33	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.97
17	1/2	6	3	146	1.75/1.37	16	33	27,117.6	27.4	3,387.0	5,428.7	93.79	24.36	79.50	76.96
18	1/2	6	4	147	1.75/1.37	14	29	27,117.6	275.4	3,386.4	5,391.7	93.78	41.64	79.18	77.17

Tab. 1: The results of running the script for different limitations set for FRs. Source: author's computations
Notes: RS – 'Run of Script'; NI – 'Number of Iteration'; GT – 'Threshold for maximum GGD'; CT – 'Threshold for minimum commuting level'; FRs – 'Number of FRs formed'; MCL – 'Minimum Commuting Level' used in the formation of FRs; MultiPol statistics for MPR, MFR – number of MPRs; Ps – number of components in MPRs concerned; LSC – 'Level of Self-Containment'. For NI, "1/2" indicates that FRs are delimited within the limits of two iterations, and for the respective of RS if cell values involve a division sign "/", numerator part shows the values for the 1st iteration and denominator part shows the values for the 2nd iteration. If there is no "/" sign in the cell, the value is the same for both iterations. Since no statistics regarding area and self-containment of FRs are calculated for MPRs, for RS involving 2 iterations MultiPol shows statistics for the 1st iteration that actually result in MPRs, and statistics regarding the area and self-containment of FRs belong to the 2nd iteration.

Summary statistics for LSC, CL (%) and area (km^2) covered by a BSU or FR	BSU	FR	LSC (%)	BSU		FR	
				frequency	%	frequency	%
Average area	834.7	5,391.7	0–10	28	2.98	0	0
Median area	649.7	3,386.4	10–20	91	9.69	0	0
Maximum area	5,349.9	27,117.6	20–30	149	15.87	0	0
Minimum area	5.7	275.4	30–40	189	20.13	0	0
Maximum LSC	89.91	93.78	40–50	182	19.38	3	2.04
Minimum LSC	2.90	41.64	50–60	158	16.83	10	6.80
Median LSC	51.49	79.18	60–70	108	11.50	17	11.56
Average LSC	51.44	77.19	70–80	32	3.41	46	31.29
Average CL from one BSU or FR to other	0.28	0.82	80–90	2	0.21	65	44.22
MCL taken into account (%)	–	1.45	90–100	0	0	6	4.08
Total number of BSUs or FRs	939	147	Total	939	100.0	147	100.00

Tab. 2: Comparison of statistics for FRs with those of BSUs together with the frequency and share of BSUs and FRs according to the intervals defined for the LSC. Source: author's computations
Note: Statistics regarding FRs given in this table are calculated for FRs obtained after the 12th RS

BSUs in a FR	FFR	BSUs in a FR	FFR	BSUs in a FR	FFR	BSUs in a FR	FFR	BSUs in a FR	FFR
2	30	6	11	10	6	14	3	19	3
3	22	7	7	11	7	15	3	20	1
4	17	8	8	12	3	16	1	21	1
5	12	9	8	13	2	17	2	Grand Total	147

Tab. 3: Number of BSUs in a FR according to the frequency of FR (FFR) concerned. Source: author's computations

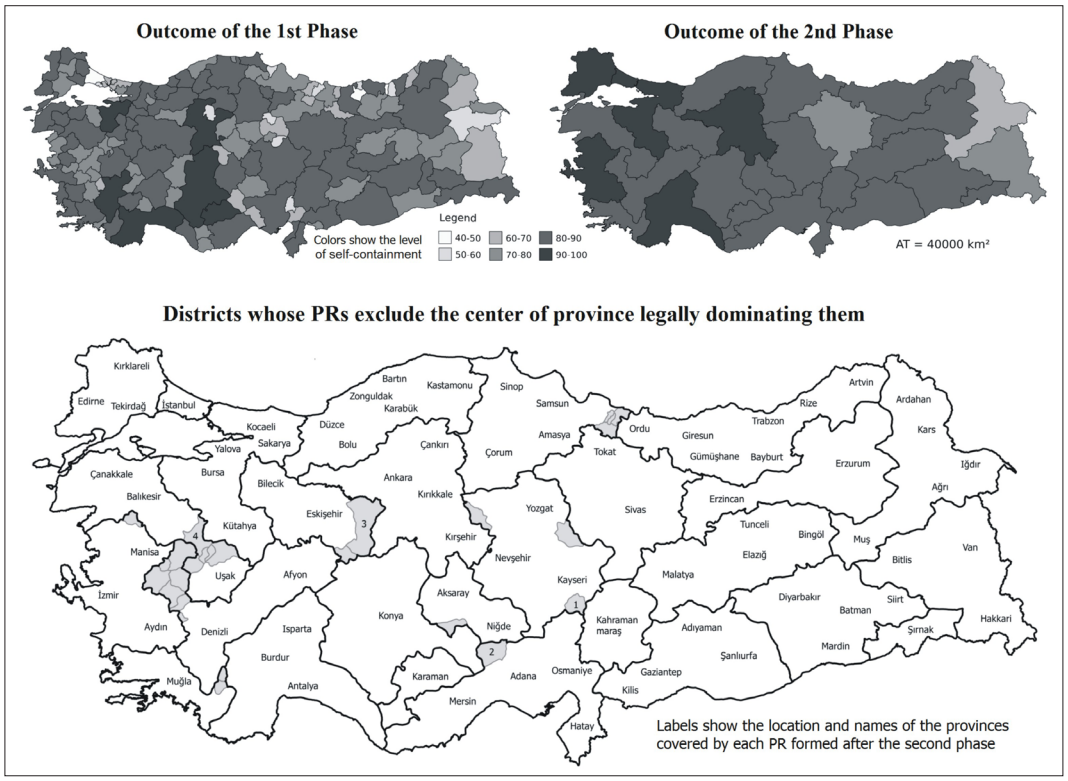

Fig. 3: The results of the 1st and 2nd phases of functional regionalisation of BSUs
Source: author's elaboration

RS	NI	Limits		PRs	MCL	MultiPol		Statistics for area of PRs (km²)				Statistics for LSC (%)				Population per km²			
		GT	AT			MFR	Ps	max	min	med	mean	max	min	med	mean	max	min	med	mean
1	1	1	15,000	62	0.04	–	–	27,117.6	4,635.0	12,803.9	12,783.6	96.75	59.64	83.93	82.94	1,157	10	60	94
2	1	1	20,000	49	0.14	–	–	27,117.6	3,737.8	17,158.9	16,175.2	96.76	65.00	84.23	83.42	906	19	60	87
3	1	1	25,000	41	0.11	–	–	27,117.6	3,829.2	20,357.1	19,331.4	96.78	65.00	83.19	83.86	781	19	59	87
4	1	1	30,000	35	0.06	–	–	29,958.4	7,365.6	23,874.7	22,645.3	96.74	65.00	84.03	84.71	626	19	61	86
5	1/2	2	30,000	31/36	0.06/0.11	6	12	29,958.4	7,365.6	23,721.7	22,016.3	96.74	65.00	84.80	84.66	626	19	58	84
6	1	1	35,000	30	0.26	–	–	35,003.5	5,410.2	29,396.1	26,419.5	96.89	67.09	85.54	85.55	562	23	58	90
7	1/2	2	35,000	28/34	0.07/0.11	6	12	34,566.4	5,410.2	25,497.7	23,311.3	96.71	65.26	86.07	84.98	596	23	56	88
8	**1**	**1**	**40,000**	**26**	**0.17**	**–**	**–**	**39,976.6**	**7,365.6**	**35,683.3**	**30,484.1**	**96.89**	**68.91**	**87.51**	**86.16**	**562**	**26**	**63**	**90**
9	1/2	2	40,000	25/27	0.04	3	6	39,976.6	3,827.0	35,227.3	29,355.0	96.66	65.26	84.37	85.07	488	19	64	85
10	1	1	45,000	24	0.10	–	–	44,517.8	3,827.0	38,073.3	33,024.4	96.81	68.31	86.89	85.79	453	19	52	82
11	1/2	2	45,000	21/24	0.10/0.10	4	9	44,427.2	4,740.5	38,073.3	33,024.4	96.81	65.26	86.73	85.53	453	25	54	84
12	1	1	50,000	21	0.06	–	–	49,948.0	7,644.7	38,579.8	37,742.2	97.19	67.09	84.37	85.64	431	22	61	85
13	1	1	55,000	19	0.44	–	–	54,790.6	7,644.7	47,241.6	41,715.0	97.25	72.21	86.55	86.63	388	22	61	85
14	1	1	60,000	18	0.59	–	–	59,136.4	9,195.3	47,241.6	44,032.5	97.25	72.21	87.71	86.98	388	26	64	87
NUTS 2 Regions				**26**		**–**	**–**	**59,531.1**	**5,212.1**	**30,722.8**	**30,484.1**	**94.88**	**68.03**	**86.57**	**86.10**	**2,543**	**26**	**73**	**186**

Tab. 4: The results of running the script for different limitations set for PR formations compared with the existing NUTS 2 regions. Source: author's computations

increases continuously parallel to the increase in the area covered by a PR, up to a certain level where AT = 40,000 km^2 (8th RS revealing 26 PRs). The median LSC also increases, though slightly fluctuating, up to the same AT level. The minimum density observed for a PR also increases to the same AT level above which it decreases, albeit it starts to increase slightly again after this decrease. Nevertheless, commuting level between the last couple of FRs (MCL) (0.17%) decreases compared with the functional regionalisation exercise for which AT = 35,000 km^2. Yet, except for this, MCL for 40,000 km^2 is higher than both previous MCLs and also MCLs for two subsequent ATs.

A comparison of some statistics from the second phase of functional regionalisation of FRs for the 8th RS with those of NUTS2 regions (last line in Tab. 4) in Turkey reveals that the resulting PRs are more successful in terms of maintaining relatively higher LSC and a balanced distribution of not only physical space but also of population among PRs. The maximum density observed for a NUTS2 region is 2,543 people per km^2. This value decreases to 562 for PRs delimited after the 8th RS. All PRs formed after the 8th RS for the second phase of functional regionalisation can also be seen in Figure 3, jointly with a detailed map showing the location and names of the provinces covered by each PR,

together with the districts (grey colour) that are included in a PR excluding the centre of the province to which they are officially connected. Overall, although PRs identified in the second phase by setting AT to 40,000 km^2 generally overlap with the administrative regions of Turkey, there are also differences between PRs and normative regions.

For example, Tufanbeyli, officially a district of Adana, actually has greater interactions with Kayseri in terms of commuting flows and, beginning from the first phase of the functional regionalisation, it is always connected to the region dominated by Kayseri (district No. 1 in the map at the bottom of Fig. 3). In a similar fashion, Ulukışla, formally within Niğde, is connected by FRGIS to the region dominated by the Adana-Mersin metroplex (district No. 2). Likewise, Polatlı is connected by FRGIS to the region of Eskişehir, rather than Ankara that legally covers it (district No. 3).

Although these kinds of PRs are actually an expected outcome of the study, some PRs are too small (e.g. Şırnak, Karaman and Muğla, each of which covers less than 14,000 km^2) compared with others. The tendency of small regions to remain isolated from main PRs does not readily mean that they can be designated as separate PRs. Indeed, isolation of these regions can be prevented by increasing AT. Another relatively unexpected outcome of this application of FRGIS is the formation of PRs having low levels of compactness. For example, the extension of FR covering mainly Çanakkale and Balıkesir includes Uşak and western districts of Kütahya in the form of a peninsula connected to them via Simav (district No. 4), whose removal leads to a MPR. In comparison, compact solutions in terms of the morphology of FRs are more likely to reflect a community of interest without creating an impression of the political gerrymandering of boundaries (Johnston and Rossiter, 1981).

Commuter statistics for the 1st phase of functional regionalisation

RS	FRs	People Residing in FR				People Working in FR			
		max	min	med	mean	max	min	med	mean
1	188	849,061	1,072	20,137	55,484	944,222	1,091	18,263	55,484
2	188	849,061	1,072	20,803	55,484	944,222	1,091	18,606	55,484
3	185	849,061	1,072	22,127	56,384	944,222	1,091	20,173	56,384
4	157	1,098,906	1,417	25,419	66,439	1,474,614	1,091	23,464	66,439
5	156	1,098,906	1,417	25,705	66,865	1,474,614	1,091	23,454	66,865
6	158	857,520	1,417	26,248	66,019	949,700	1,091	24,108	66,019
7	146	1,098,906	1,417	27,849	71,445	1,474,614	1,091	24,765	71,445
9	147	855,841	1,417	28,090	70,959	948,548	1,091	24,891	70,959
10	146	1,098,906	1,417	27,849	71,445	1,474,614	1,091	24,765	71,445
12	147	855,841	1,417	28,090	70,959	948,548	1,091	24,891	70,959
13	146	1,098,906	1,417	27,849	71,445	1,474,614	1,091	24,765	71,445
15	147	855,841	1,417	28,090	70,959	948,548	1,091	24,891	70,959
16	146	1,098,906	1,417	27,849	71,445	1,474,614	1,091	24,765	71,445
18	147	855,841	1,417	28,090	70,959	948,548	1,091	24,891	70,959

Commuter statistics for the 2nd phase of functional regionalisation

RS	PRs	People Residing in PR				People Working in PR			
		max	min	med	mean	max	min	med	mean
1	62	3,087,402	8,772	70,434	168,242	3,268,994	9,805	67,208	168,242
2	49	3,421,809	10,424	85,894	212,877	3,605,598	9,072	84,223	212,877
3	41	3,472,098	10,424	100,882	254,414	3,653,727	9,072	89,170	254,414
4	35	3,518,588	21,458	117,824	298,028	3,699,765	22,104	127,538	298,028
5	36	3,518,588	21,458	119,826	289,750	3,699,765	22,104	116,912	289,750
6	30	3,640,801	28,848	190,985	347,700	3,817,684	28,789	184,658	347,700
7	34	3,527,311	16,176	126,381	306,794	3,706,701	11,891	126,478	306,794
8	26	3,640,801	21,458	239,616	401,192	3,817,684	25,220	225,171	401,192
9	27	3,584,176	8,492	221,900	386,333	3,760,933	7,761	211,318	386,333
10	24	3,706,389	8,492	237,635	434,625	3,878,852	7,761	227,381	434,625
11	24	3,706,389	16,176	237,635	434,625	3,878,852	11,891	228,147	434,625
12	21	3,860,274	22,945	256,304	496,714	4,041,653	23,025	244,124	496,714
13	19	3,911,265	22,945	256,304	549,000	4,091,154	23,025	244,124	549,000
14	18	3,911,265	65,588	287,263	579,500	4,091,154	61,168	269,909	579,500

Tab. 5: Statistics for commuters for the 1st and 2nd phases of functional regionalisation
Source: author's computations

Again, it is considered that if AT is re-adjusted, these kinds of PRs can be prevented. Indeed, after several tests, it is observed that if AT = 41,000 km^2, Uşak and western districts of Kütahya are excluded from the PR covering mainly Çanakkale and Balıkesir, and connected to the PR covering mainly Denizli and Afyon. Overall, what is evident from this exercise is that although FRs can be processed to form PRs, some idiographic judgments based on the intuition of experts are inevitable for the designation of the final form of PRs. In order to produce these judgments, on the one hand, the outcomes of the script for various adjustments made for AT can be used, and on the other hand, social-historical factors shaping the institutional structure can be taken into account.

Comparison of the results of the proposed method of delimitation with the newest TTWA algorithm provides us with some further insights about the relevance of the restriction for the area that can be occupied by a PR. For this purpose, two additional tables are created, together with another figure (see Fig. 4) showing NUTS 2 regions and the LMAs delimited by using the R package LabourMarketAreas, designed to implement the TTWA algorithm (for the use of this package, see Franconi et al., 2017; Ichim et al., 2018; Franconi and Ichim, 2018). The first table (Tab. 5) shows commuter statistics for FRs and PRs delimited by using FRGIS. The second one (Tab. 6) shows the characteristics of LMAs delimited by using the TTWA algorithm for different values of minSZ, tarSZ, minSC and tarSC. Casado-Díaz et al. (2017) show that in the application of the TTWA algorithm in a country characterised by an unbalanced distribution of population over space, population size (employed residents) and self-containment can initially be adjusted to 5,000 and 85%, respectively.

Accordingly, in the implementation of TTWA algorithm in Turkey, minSC is initially set to 5,000 and tarSC is increased up to 100,000. Nevertheless, the minimum LSC calculated for the existing NUTS2 region in Turkey is 68.03. Thus, in this study, in the implementation of TTWA algorithm, minSC is at first set to 70% and increased up to 78% for various runs of TTWA algorithm. Yet, tarSC is at first set to 85% and increased up to 96%. Apart from the results given in Table 6, the TTWA algorithm has also been run for a set of other configurations of minSZ, tarSZ, minSC and tarSC (see Tab. 7).

Table 5 demonstrates that compared with the second phase of functional regionalisation, commuter statistics for various RS in the first phase do not change much after the decrease of FRs to 146–147. Nevertheless, in the second phase, the numbers of people residing and working in a PR increase up to the 8th RS after which there is a slight decrease for all the measured statistics. As discussed above, compared with other RS, in the 8th RS, higher LSC is maintained with a more balanced distribution of physical space. This is particularly important when the results of the TTWA algorithm for different limitations set for LMA formations are analysed. In this regard, Table 6 reveals that, although compared with PRs identified by FRGIS relatively better minimum and average LSC values and commuter statistics are obtained from the TTWA algorithm, there are huge differences between the physical areas occupied by different LMAs. The result regarding the unbalanced distribution of physical space among LMAs delimited by the TTWA algorithm does not change for a set of other configurations of minSZ, tarSZ, minSC and tarSC (see Tab. 7 and Fig. 5).

An unbalanced distribution of physical space among the 26 LMAs delimited by the TTWA algorithm can also be seen in Figure 4. The maximum density observed for a LMA is 1,097 people per km^2 and it is high compared with the one observed for a PR. At the end of second section, it was argued that in countries where the population is not distributed uniformly, the use of population as a restriction may result in undesired outcomes. It is even claimed that if a restriction is imposed on the population of a FR, the provincial boundaries of İstanbul may not be preserved. Indeed, the TTWA algorithm based on population limitation creates two regions covering the parts of İstanbul province (see Fig. 4):

1. the European part of İstanbul, together with the other provinces in Thrace region except for the Gallipoli peninsula; and

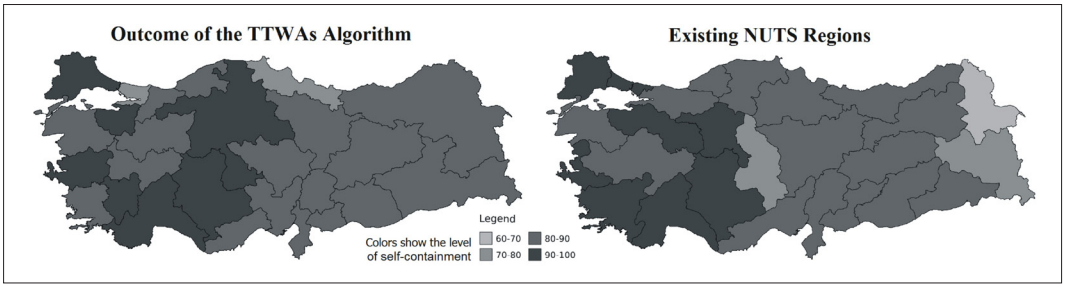

Fig. 4: 26 LMAs delimited by the TTWA algorithm compared with the NUTS 2 regions Source: author's elaboration

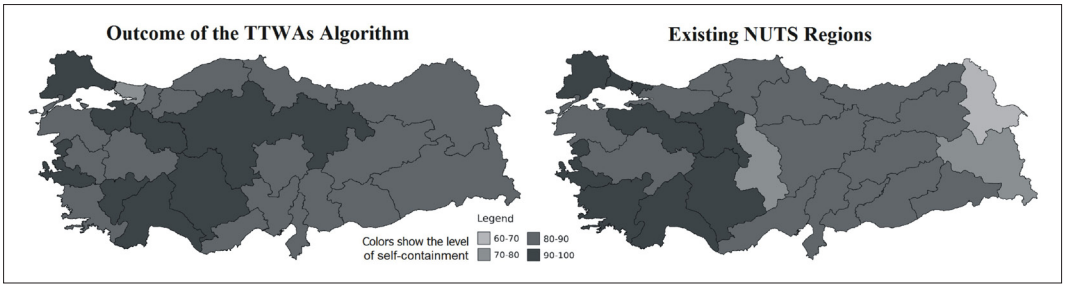

Fig. 5: 26 LMAs delimited by the TTWA algorithm for a set of other configurations of parameters compared with the NUTS 2 regions. Source: author's elaboration

Parameters used in TTWA				Num	MultiPol		Statistics for area of LMA				Statistics for LSC (%)				Statistics for Residents				Statistics for Workers			
minSC	tarSC	minSZ	tarSZ	LMAs	MFR	Ps	max	min	med	mean	max	min	med	mean	max	min	med	mean	max	min	med	mean
70	85	5,000	50,000	82	14	41	52,762	1,085	6,720	9,666	92.97	71.37	83.80	83.58	1,544,999	12,549	55,399	127,207	1,774,283	11,640	54,184	127,207
71	86	10,000	55,000	75	13	36	52,762	1,085	7,645	10,568	92.97	71.37	84.14	83.91	1,544,999	20,895	63,243	139,080	1,774,283	20,549	58,500	139,080
72	88	20,000	62,500	66	8	24	60,993	1,085	9,742	12,009	96.31	72.13	84.56	84.55	2,764,003	24,801	73,145	158,045	2,959,589	24,678	67,200	158,045
73	90	35,000	70,000	48	10	31	87,605	2,109	12,741	16,512	96.03	74.15	85.40	85.49	2,738,357	46,156	122,160	217,312	2,927,927	46,850	111,376	217,312
74	92	50,000	80,000	39	9	29	84,199	2,861	14,814	20,323	96.37	74.15	86.03	86.46	2,771,716	56,216	162,211	267,461	2,965,861	53,908	148,852	267,461
76	94	70,000	90,000	34	8	30	98,825	3,343	15,255	23,311	96.37	76.78	86.45	86.77	2,771,716	80,844	177,824	306,794	2,965,861	74,525	164,968	306,794
78	96	90,000	100,000	26	13	44	112,765	5,871	21,984	30,484	94.41	79.35	87.22	86.79	1,925,758	117,423	228,002	401,192	2,195,715	105,002	218,091	401,192
Existing NUTS 2 in Turkey				26	–	–	59,531	5,212	30,723	30,484	94.88	68.03	86.57	86.10	2,639,699	64,926	275,332	401,192	2,805,537	54,661	266,162	401,192
PRs identified by FRGIS				26	–	–	39,977	7,366	35,683	30,484	96.89	68.91	87.51	86.16	3,640,801	21,458	239,616	401,192	3,817,684	25,220	225,171	401,192

Tab. 6: The results of running the TTWA algorithm for different limitations set for LMA formations compared with the existing NUTS 2 regions and PRs identified in the study. Source: author's computations

Parameters used in TTWA				Num	MultiPol		Statistics for area of LMA				Statistics for LSC (%)				Statistics for Residents				Statistics for Workers			
minSC	tarSC	minSZ	tarSZ	LMAs	MFR	Ps	max	min	med	mean	max	min	med	mean	max	min	med	mean	max	min	med	mean
70	85	5,000	50,000	82	14	41	52,762	1,085	6,720	9,666	92.97	71.37	83.80	83.58	1,544,999	12,549	55,399	127,207	1,774,283	11,640	54,184	127,207
70	85	10,000	60,000	76	14	38	52,762	1,085	7,489	10,429	92.97	71.37	84.10	83.91	1,544,999	21,431	62,085	137,250	1,774,283	21,892	58,248	137,250
72	86	15,000	72,500	68	8	24	69,937	1,085	8,793	11,656	96.03	72.82	84.61	84.55	2,738,357	23,909	67,802	153,397	2,927,927	21,892	65,203	153,397
72	86	25,000	85,000	58	7	19	76,433	1,085	10,287	13,665	96.03	72.82	85.09	85.06	2,738,357	32,173	86,511	179,845	2,927,927	31,240	80,357	179,845
74	88	35,000	100,000	43	12	32	97,748	2,681	13,252	18,432	96.03	77.34	86.03	86.19	2,738,357	46,156	131,654	242,581	2,927,927	46,850	121,836	242,581
74	88	45,000	115,000	39	12	31	101,395	2,970	14,003	20,323	96.03	76.83	86.20	86.70	2,738,357	50,991	144,501	267,461	2,927,927	49,501	140,949	267,461
76	90	55,000	130,000	31	10	25	113,658	4,865	16,987	25,567	93.74	77.58	87.26	86.77	1,925,758	65,411	192,728	336,484	2,195,715	65,806	178,367	336,484
76	90	65,000	145,000	28	9	29	115,885	4,865	21,962	28,307	93.74	78.06	87.40	87.02	1,925,758	100,123	206,209	372,536	2,195,715	100,456	196,359	372,536
78	90	75,000	150,000	26	10	34	119,058	4,865	22,025	30,484	93.74	79.24	87.74	87.34	1,925,758	100,123	224,875	401,192	2,195,715	100,456	223,745	401,192
Existing NUTS 2 in Turkey				26	–	–	59,531	5,212	30,723	30,484	94.88	68.03	86.57	86.10	2,639,699	64,926	275,332	401,192	2,805,537	54,661	266,162	401,192
PRs identified by FRGIS				26	–	–	39,977	7,366	35,683	30,484	96.89	68.91	87.51	86.16	3,640,801	21,458	239,616	401,192	3,817,684	25,220	225,171	401,192

Tab. 7: The results of running the TTWA algorithm for a set of other configurations of parameters used for LMA formations compared with the existing NUTS 2 regions and PRs identified in the study. Source: author's computations

2. the Asian part of İstanbul together with the provinces of Kocaeli and Yalova, previously part of İstanbul province.

A similar kind of situation can also be observed for Çukurova Region, covering mainly the Adana-Mersin metroplex but extending to Hatay. Although FRGIS delimits this region as a single PR, the TTWA algorithm creates three LMAs for this well known region in Turkey:

1. Adana,
2. Mersin, and
3. Hatay and Osmaniye, previously part of Adana province.

Overall, in the western part of the country, compared with the NUTS 2 regions, some LMAs revealed by the TTWA algorithm are smaller, sometimes forming two LMAs approximately for a single NUTS 2 region. As argued in the second section, in terms of planning for such regions, it would be wiser to include all BSUs involved in the regions concerned. Nevertheless, this does not mean that overly large regions can be considered as PRs. In this respect, comparison of the results of the TTWA algorithm with the NUTS 2 regions reveals another positive aspect of the introduction of a limitation for the area that can be occupied by a PR in a country where the population is not distributed uniformly.

Indeed, Figure 4 shows that some LMAs revealed by the TTWA algorithm for the eastern part of the country and central Anatolia are overly large compared with the NUTS 2 regions. Some of these LMAs cover huge parts of two or three NUTS 2 regions. This contrast observed in the formation of the LMAs for the eastern and western parts of the country seems to stem from the unbalanced distribution of the population in the country.

5. Concluding remarks

Compatibility of the administrative regions with FRs and subsequently with PRs is desired because the lack of compatibility usually leads to both planning problems and tensions between different administrative regions. In this context, this study used FRs based on the commuting patterns of people as PRs. In this framework, an algorithm (FRGIS) designed to run as a two-phase model is developed and used in order to delineate FRs that can serve as PRs in Turkey.

In terms of the employment of a nomothetic method of science, the results of the analysis show that FRGIS is generally successful in terms of the formation of spatially-balanced regions having higher LSC compared with those of existing NUTS 2 regions. Although the minimum and average LSC values of the resulting PRs are not as high as the results from the TTWA algorithm, compared with LMAs, the formation of regions according to the proposed method of delimitation is spatially more balanced. This is actually an expected result of the study. The distribution of population in terms of density is also more balanced in the resulting PRs. Thus, it can be argued that the objectives of the research are mostly fulfilled.

It is also concluded, however, that the formation of very small PRs or PRs having low levels of compactness, may not be prevented. This can be considered a disadvantage of the method of delimitation used in this study. It seems that alternative methods for the delimitation of FRs, however, also suffer from similar problems. The introduction of some other constraints, such as the minimum area occupied by a PR and the calculation of the morphometric characteristics of the PR, may prevent the undesired outcomes mentioned above. Nevertheless, some idiographic judgments seem to be inevitable if FRs are to be employed as PRs. For example, in this regard, it is suggested that the outcomes of FRGIS for various adjustments made for different parameters used for delimitation of regions, as well as social-historical factors shaping the institutional and spatial structure, can be taken into account in the designation of FRs as PRs. Another disadvantage of FRGIS is the lack of a direct control on the minimum LSC. This is particularly noticeable for the outcomes in the first phase of the functional regionalisation process. Since FRGIS is actually designed to exhibit PRs, the outcomes of the first phase should be considered as an intermediate stage for designation of final FRs that can then be employed as PRs.

There are various advantages of the proposed method of delimitation of FRs as PRs in this study. First of all, it does not require any information nor have any implication for the designation of some BSUs as central places. Another advantage of the approach used in this study is its simplicity in terms of the steps of FRGIS and the preparation of the database used in the analysis. The first and second phases of FRGIS are actually based on the same stages except for the parameters used to constraint the formation of FRs or PRs. Last, but not least in importance, the employment of GIS that facilitates the spatial analysis required to delineate FRs, is another advantage of this study.

In this respect, FRGIS draws on a series of functions and libraries available in FOSS for GIS for the calculation of GGD between BSUs, the prevention of MPRs, and the calculation of the total area occupied by a FR. With the introduction of GGD as an indirect and loose control of the condition for contiguity that can easily be checked in the GIS environment, and for the automatic prevention of MPRs, no interruption is required by the user to control MPRs in the delimitation of FRs and PRs. In alternative approaches, the prevention of MPRs is a lengthy process requiring intervention of the user for each run of the script produced to reveal FRs.

Compared with other functional regionalisation studies conducted in Turkey, this is the first research project to use an algorithm (FRGIS) and script specifically developed for this purpose and drawing on the commuting flows occurring in the country. As the plugin produced in this study is based on FOSS, it may trigger further developments in this field for other countries. The database employed in this study also allows for a more accurate delimitation of the boundaries of the metropolitan regions or sub-regions. Within this context, future studies can explore the geographical extent of the metropolitan regions and improve FRGIS by adding considerations for the automatic determination of the parameters leading to the formation of optimal FRs. Future studies may also take the morphometric characteristics of the FRs into account in order to produce the formation of more compact FRs.

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Appendix 1: List of abbreviations

- AC: Amount of Commuting
- AT: Threshold for maximum area that can be occupied by a PR
- BAGKUR: Social Insurance Institution for the Craftsmen & Artisans & Other Self Employers
- BSU: Basic Spatial Units
- CAA: Commuting Aggregation Approach
- CL: Commuting Level
- CT: Threshold for minimum commuting level between BSUs
- CURDS: Centre for Urban and Regional Development Studies
- dbi: database iteration number – number of iteration to read database
- DB: Destination BSU
- Emekli Sandığı: General Directorate of Retirement Fund
- EOF: End of file
- ERA: European Regionalisation Algorithm
- FOSS: Free and Open Source Software
- FR: Functional Region
- FRGIS: Algorithm for Functional Regionalisation in GIS with Auto-Prevention of MPR on the Base of GGD and Areal Restriction
- GEA: Grouping Evolutionary Algorithm
- GGD: Graph Theoretical Geodesic Distance
- GIS: Geographic Information Systems
- GT: Threshold for maximum GGD between BSUs
- id: identity number
- JTS: Java Topology Suite
- LSC: Level of Self-Containment
- LMA: Labor Market Area
- MCL: Minimum CL
- minSC: Level of self-containment that is acceptable for cluster of large sizes
- minSZ: Minimum number of employees for a cluster to be considered an LMA
- MPR: Multi-Polygon Region
- NUTS: Nomenclature des Unités Territoriales Statistiques
- OB: Origin BSU
- OSM: Open-Street-Mapping
- PR: Planning Region
- RS: Run of the Script
- SD: Shortest Distance
- SSI: Social Security Institution
- SSK: Social Insurance Institution - former Workers' Insurance Institution
- tarSC: Target self containment of an area in order for a small cluster of communities to be considered an LMA
- tarSZ: Target value for the size of the cluster in terms of occupied persons
- TG: GGD between OB and DB
- TTWA: Travel-to-work-areas

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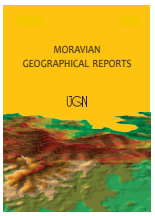

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Bus and train connections between towns in Lower Silesia under different operational models: Competition or complementarity?

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Abstract

Relationships between the activities of bus carriers and rail passenger traffic (and the railway offer) are examined in this article. The study was carried out in peripheral areas located at the Polish and Czech borderlands in Lower Silesia province. High quality rail transport generally increases the demand for transport services. Therefore, the proper development of transport offer plays a key role in the functioning of public transport systems, the backbone of which is rail transport. The study also shows that under conditions of transport market deregulation, bus carriers have developed a competitive network which is not complementary to rail transport. As a consequence, the deregulation of the transport market has increased the risk of transport exclusion.

Key words: *public transport systems; peripheral areas; integrated transport systems; rail transport; bus transport; transport exclusion; Poland*

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1. Introduction

The market for Polish transport services undergoes frequent changes. The transformation that took place in Poland in the 1990s and, after Poland's accession to the European Union, primarily affected rail and bus transport (Taylor, 1998, 2004; Cantos et al., 2012; Połom and Goliszek, 2017). In both organisational and spatial dimensions, such changes generally limited the availability of public transport to residents (Taylor and Ciechański, 2017).

The public bus transport market experienced strong fragmentation. It was connected with the functioning of two categories of transport companies: private independent carriers, and companies created from the previously-operated state-owned enterprises (Ciechański and Taylor, 2017). The number of carriers and their transport offer were subject to continuous change and the spatial scope of their activity was mostly subordinated to free-market principles. Consequently, they operated mostly (or only) on the most profitable routes[1]. Many of them were significant competitors to rail transport (Smolarski and Suszczewicz, 2017).

Polish rail transport also experienced significant organisational changes. One of the manifestations of these changes was the appearance of self-governing companies, including the Lower Silesian Railways. This can be seen as the drive to create more efficient transportation systems, which was particularly intense at the turn of 20th and 21st centuries (Taylor, 2006; Taylor and Ciechański, 2006; Taylor and Ciechański, 2010, 2011). In the Lower Silesia province there were also significant changes in the volume of railway transport operation (mainly resulting from reductions of railway lines and suspension of passenger traffic) and bus services (liquidation of state-owned companies called Państwowa Komunikacja Samochodowa (hereinafter PKS).

Such changes mostly affected the rail company PKP[2]. They were connected with relatively lower financial expenditures on railway infrastructure compared to Western European

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[1] An example is the local transport in Wałbrzych (the Lower Silesia province) where bus transport operating on free market principles is often based on microbus fleets (Smolarski and Jurkowski, 2016).

[2] PKP: Polskie Koleje Państwowe S.A. – Polish State Railways which is the dominant railway operator in Poland.

countries (Nash, 2010). Consequently, a series of railway lines were closed, many of which were of significant importance to local communities and enabled their access to the public transportation system. Studies on the social consequences of the suspension of passenger traffic were carried out in many countries, including Poland (Taylor, 2006), France (Thevinin et al., 2016) and Great Britain (Patmore, 1962).

Regional and local public transport is based on rail and bus connections. Their appropriate coordination and the creation of an integrated public transportation system connecting two or more means of transport within one journey, are of key importance (Ciechański, 2006; Šťastná et al., 2012; Šťastná et al., 2015; Chowdhury and Ceder, 2016; Chowdhury et al., 2018; Jurkowski, 2018). Relations between rail and bus transport on specific routes may contribute to changes in public transport accessibility (Guzik, 2016; Kowalczyk, 2018). This is particularly important under conditions of deregulation and the lack of coordination of the transportation system in peripheral areas of provinces threatened with transport exclusion[3]. Mees (2010) also emphasised the issue of coordination, referring to the network effect in planning public transport. The system should rely on various means of transport.

In this article, we aim to identify the associations between the activity of bus carriers and rail passenger traffic. It should then be possible to answer questions of whether bus and rail carriers compete with each other under the conditions of deregulation and the lack of coordination, or whether they complement their transport offers; in addition, responses to how their relations change over time depending on the transport offer and the demand for transport services are illustrated. Moreover, the article examines whether, and to what extent, the transportation system formed may affect transport exclusion. The Polish transportation system is based on rail transport, which is organised by central authorities (fast and international connections) or voivodships (regional transport). On the other hand, bus transport is characterised by a lack of coordination. Following the reorganisation of the Polish bus transport market, state enterprises (PKS) were transformed and divided (some of them were liquidated or privatised: see Taylor and Ciechański,2018). In addition to these types of companies, there are many private enterprises that create some transport offer mainly due to economic calculations.

2. Theoretical basis

Most authors either treat the public transportation system jointly (Šťastná and Vaishar, 2017; Šťastná et al., 2015) or focus on only one means of transport, e.g. in Cyprus (Kepaptsoglu, 2017). Others compare various rail systems (Fraszczyk et al., 2016). There are relatively few studies concerning relations between various means of public transport, particularly in the context of mutual competition between bus and rail carriers. For example, Ben-Akiva and Morikawa (2002) indicate that a high-quality offer plays the key role, and the selection of the means of transport (a bus or a train) is thus of secondary importance.

It must be noted that in many countries (in Western Europe in particular), there is often no basis for studying relations between rail and bus carriers as they operate based on the principle of complementarity and, in fact, fulfil separate functions. Therefore, the dependencies between rail and bus transport networks were mostly studied in the context of so-called feeder lines, e.g. using optimisation models which determine perfect access to railway lines (Wirasinghe, 1980; Kuah and Perl, 1988; Chien and Schonfeld, 1998; Jurkowski and Smolarski, 2017a).

Another problem involves imperfections of public transport in rural areas. Petersen (2016) has described this problem in Britain, where they are referred to as 'patchy' due to low frequency and limited running time (e.g. no public transport in the evenings and at weekends). Rural areas can be characterised by low population density and, consequently, low passenger demand (Nielsen and Lange, 2007). One of the few studies about the relationships of rail and bus networks in Central and Eastern Europe is an analysis of the coordination of rail routes, and the introduction of integrated systems is suggested to be the most effective solution (Kudlać et al., 2017).

It must be noted, however, that there are significant differences between the organisation of public transport in metropolitan, urban, rural and peripheral areas[4]. Malikova (2013) considers the transport accessibility of cities as one of the indicators of marginalisation and peripheralisation in Slovakia and the Czech Republic. Boruta and Ivan (2010), however, have used the example of the Jeseník region in the Czech Republic to show that a public transportation system including road and rail connections may be effective, even in rural areas which are relatively economically under-developed (Ivan and Boruta, 2010). In contrast, Jaroš (2017, p. 258) stresses that "high area mobility is typical of core areas, while low area mobility is usual in rural or peripheral areas". Differences in the organisation of the system are also visible in urban centres of various sizes. For example, in cities with less than 100,000 inhabitants, a bus-line system is unnecessary. In turn, in large agglomerations, it works perfectly, allowing one to bypass the city centre when travelling (Nielsen and Lange, 2007).

Data on passenger flows may help in determining to what extent a city is connected with its region. While towns usually generate local traffic, cities and agglomerations are more fequently connected with more distant areas. Kraft et al. (2011) studied the influence of urban centres in the Czech Republic (the capital cities of Czech regions) based on vehicle traffic flows. They identified differences in the transport connections of particular cities based on access to work and vehicle transport flows. Halas et al. (2010) conducted similar studies related to the access to work in Prague and Brno.

Peripheral areas are characterised by specific public transport conditions, such as departure times, low frequency of departures, lack of direct connections and the lack of coordinated interchange systems (Petersen, 2012, 2016). Even areas with seemingly high transport accessibility potential, for example those located close to urban agglomerations, are often referred to as "car dependent suburban areas" (Hickman and Banister, 2014, p. 141). The researchers indicate that in this case, it is necessary to use local rail and bus systems more widely. Šťastná et al.

[3] Effective public transport connections can act against the marginalisation of peripheral, problematic areas. This dependence has been identified on the Czech-Slovakian-Austrian border by Vaishar (2008).

[4] Nash (1982) has distinguished rural, interurban and urban transport.

(2015) also stress the role of transport organisation in peripheral areas and point out that the authorities should take major steps in this regard in urban and metropolitan areas. Some European countries have introduced para-public transportation systems, such as 'Anruf taxi' in Germany and 'Publicar' in Switzerland (Velaga et al., 2012), but they can also be minibuses, taxis, or school buses (Nielesen and Lange, 2007).

Problems related to the development of transportation systems are observed as particularly acute in post-socialist European countries, in which economic transformation caused huge changes after 1990 and in many cases led to chaos in the functioning of transport. Public transport networks were reduced and many local railway lines were suspended in Poland and the Czech Republic. Taczanowski (2012) has identified significant differences in the number of local rail routes which were closed down in Poland and the Czech Republic. He indicates that 90% of third category railway lines and 44% of second category railway lines were closed down in Poland between 1989 and 2011, and 14% of local routes were suspended in the Czech Republic. This process was particularly intense in the Lower Silesia region (Smolarski and Raczyk, 2017).

Rail infrastructure can be considered as the backbone of public transport. Santos et al. (2010) also stress the role of transport infrastructure, particularly in rural areas. Tomeš et al. (2014, p. 275) note that the "competitiveness of railway transport is crucially dependent on the quality and capacity of the infrastructure". Wegener et al. (2005, p. 27) stress that "the relationship between transport infrastructure and economic development has become more complex than ever". They also state that the construction of a new railway line between peripheral and central regions may improve the economic situation of the peripheries (Wegener et al., 2005, p. 28). A complex upgrading of existing routes and the introduction of attractive timetables may also improve transport accessibility. For example, Jurkowski and Smolarski (2017b) note that the transport offer on the Wrocław-Warsaw route significantly improved after one of its sections had been upgraded.

The creation of a reliable and simple transportation system could be the solution. This would involve developing co-ordinated interchange systems in local interchange nodes in peripheral areas. According to Buehler and Pucher (2012), this kind of system exists in Germany. Switzerland deserves special attention as it has one of the highest numbers of public transport journeys per person among European countries (Buehler and Pucher, 2012), and a specific public transportation system in rural areas (Petersen, 2016). The simplicity of the transport system can be considered as a factor encouraging people to use public transport. If the potential passenger is able to understand its operating principles, there is a greater chance that s/he will become a real passenger. Car users often base their decisions on the choice of individual transport as they are not able to clearly use the public transportation system (Nielsen and Lange, 2007).

The role of integrated systems, understood as a joint rail and bus transport system, is especially important in creating regional transport connections. The first systems of this type were formed in Germany, Switzerland and Austria (Šťastná, 2015). An integrated transportation system helps avoid transport exclusion (Šťastná and Vaishar, 2017, p. 112). Moreover, it allows people unable to use road transport to use public transport (Lucas, 2012), for example, children, the elderly and disabled people (Šťastná, 2015).

According to Chowdhury and Ceder (2016), integrated transportation systems should be based on five elements of integration: [1] network integration; [2] information integration; [3] integrated timed-transfers (connections, where transfer time is reduced to a minimum[5]); [4] fare integration (Sharaby and Shiftan, 2012); and [5] physical integration. The systems should offer the possibility of a smooth journey using various means of transport. In rural areas, transfers are inevitable, therefore the role of connections between various means of transport and interchanges is growing in importance (Nielesen and Lange, 2007).

Studies carried out in the rural areas of England and Wales revealed the problem of transport exclusion of elderly people, with the result that they had difficulty accessing hospitals, clinics, local centres, etc. (Shergold and Parkhurst, 2012). The problem of the negative perception of public transport was identified in rural areas of Scotland – while 50% of inhabitants of urban areas considered public transport to be a convenient means of transport, this opinion was only shared by 20% of residents of rural areas (Velaga et al., 2012).

It should be noted, however, that mobility levels are highly dependent on local and national conditions. Buehler (2011) shows that 8% of journeys in the rural areas of Germany are made by public transport, compared to only 2% in the United States of America.

The functioning of transport also depends, to a significant extent, on formal principles pursued in particular countries. Deregulation should not be carried out in an uncontrolled and unorganised way, because it can affect the efficiency of the transportation system (Mees, 2010). Knowles and Hall (1992) use the example of Great Britain to assess the deregulation of the public bus transport which was carried out there. On the one hand, it increased the economic effectiveness of transport, but on the other hand, the main bus traffic flows were moved to densely populated areas with the highest transport potential. This creates the risk of insufficient transport services in rural and peripheral areas. The issue of public transport deregulation after 1990 in the countries of central and eastern Europe was the subject of study conducted in Hungary (Nelson et al., 1997). The study on competition in rail transport in the Czech Republic showed a significant complex problem and the lack of unambiguous (only negative or only positive) consequences of the liberalisation of the rail transport market. Tomeš et al. (2014) noted that new carriers most often run on routes with the highest passenger volumes and exclude local and peripheral routes.

With regard to rail transport, Fröidh and Nelldal (2015), using the example of Sweden, show that the deregulation of regional connections led to increased segmentation of passengers into those who paid attention to price (the problem of travel costs) and those who paid attention to time (the problem of travel time). Furthermore, Fröidh and Byström (2013) noticed that deregulation has improved the quality of rail transport services.

[5] As Mees (2010, p. 84) points out, obstacles to the creation of integrated transport systems are poorly organised transfers, which require, among other factors, additional costs or significantly longer travel time.

3. Study areas and methods

This study was conducted in two sub-regions: Jelenia Góra and Wałbrzych, according to the NUTS 3 classification. The examined areas are considered to be problematic and are thus treated as peripheral in spatial, social, economic and transport terms in both the reference literature (see: Ciok, 1991, 1994; Churski, 2010; Kolejka et al., 2015) and planning documents (e.g. Plan zagospodarowania... 2014; Koncepcja... 2011, p. 172). The eastern and western areas under study are characterised by difficult access to the nearest large urban centres (Stępniak et al., 2013). At the same time, due to their natural sites and tourist attractions (e.g. two national parks), these areas have high potential in terms of tourist movement and the use of public transport. Dickinson and Robbins (2008), among others, indicate the important role of public transport in areas of high tourist potential. The analysed sub-regions are, at the same time, border areas with relatively low transport accessibility to metropolitan centres in Poland and the Czech Republic. A study on inter-municipal rail connections in Polish and Czech border areas showed significant differences between the Polish and Czech rail transportation systems, and indicated that their organisation was worse on the Polish side (Smolarski, 2017).

This study was intended to cover the most peripheral units at the highest risk of transport problems (see Fig. 1). To this end, nine nodes were specified: Węgliniec, Zgorzelec, Lubań, Jelenia Góra, Szklarska Poręba, Wałbrzych, Kłodzko, Międzylesie, Kudowa Zdrój (border towns on the Polish side were also treated as nodes). The basic units of observation were towns and cities located within sections between the aforementioned nodes.

With regard to rail transport, the general number of rail connections and the total number of passengers were examined on sections between the nodes specified above. They were calculated as the sum of passenger volumes at all stations located between the specified nodes. This approach made it possible to analyse particular sections as traffic generators. It took account of the number of passengers getting on at particular stations regardless of their final destination. The study excluded long-distance connections

Fig. 1: Research area. Source: authors' elaboration

(reaching beyond the regions) due to the lack of data on this type of connection. It must be stated, however, that these are of little importance for the number of connections and passengers and that they play a marginal role in the formation of local transport connections. Data on rail offers were taken from public train timetables for stations in particular towns and cities available at the website rozklad-pkp.pl.

With regard to bus transport, the study covered all lines connecting specific cities and towns with each other. In this case, connections reaching beyond the region were also excluded from the analysis because they do not affect local transport connections. As it was impossible to receive more detailed information, only the number of connections was taken into account. Data were obtained from the website e-podróżnik.pl[6], and the websites of relevant carriers. Every outbound bus connection in the cities and towns studied was classified as one of two types: networked or competing with a rail route, and assigned to one of the organisational forms depending on the carrier type: independent (private enterprises) or PKS (state-owned enterprises)[7] (Fig. 2).

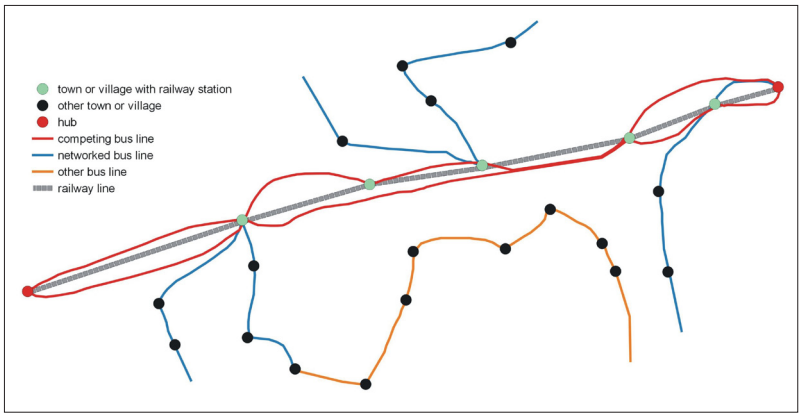

Fig. 2: Competing and networked bus lines (schematic)
Source: authors' elaboration

[6] Given the lack of public transport coordination in Poland, especially regarding buses, the website is a nationwide database for most bus journeys. In order to improve public transport coordination, a complex search engine for finding public rail and bus transport connections should be created, e.g. similar to the Czech website: jizdnirady.idnes.cz

[7] State-owned bus carriers are enterprises formed after the transformation of the enterprise Państwowa Komunikacja Samochodowa (PKS). At present, they are the property of local governments, worker-owned companies and state-owned companies (Taylor and Ciechański, 2017, p. 115).

A bus connection was considered as competing with a rail route when most of its route covered the same cities and towns as the rail transport. In other words, the course of the bus route was more or less parallel to a train route. A bus connection was considered networked when its route was perpendicular to a rail route on a given section of a railway line and could potentially function as the so-called feeder bus, transporting passengers to nodes from areas having no railway network.

While the basic reference units were cities and towns, a higher level of aggregation was used for the purpose of analysing the results obtained. The study involved 50 cities and towns located on eight inter-node sections. They were the basis for data analysis. This research approach was used because analysis of single towns and cities would have made it difficult to obtain more general patterns due to their specific and unique conditions. In many cases, such general patterns can only be identified at a higher level of aggregation (inter-node sections).

This is the approach that is usually applied in the reference literature. While studying the metro system, Derrible and Kennedy (2010, p. 278) stated that "a metro node is not a node if it does not offer a transfer". It must be remembered, however, that the possibility of an interchange is necessary for a given station to be considered a node (Derrible and Kennedy, 2010, p. 278). When studying the quality of rail and air connections in Eastern Europe, Janić (1997) also referred to the largest cities (nodes) without analysing particular towns between the nodes. Peeters et al. (1998, p. 369) draw attention to the issues of social and economic activities which are most often concentrated in the largest transport nodes. They state that "the main nodes of the transportation network are likely to be the local points of an economic geography in which human activities become … footloose".

The study was conducted using the following indicators of demand, supply and assessment of the effectiveness of rail and public bus transport:

1. the size and market share of private and state-owned bus operators;
2. the number and market share of networked and competing journeys;
3. weekday-weekend disparity (differences between the number of weekend and weekday connections)[8];
4. the number of bus and rail connections; and
5. the efficiency of rail connections in terms of the detour index (Śleszyński, 2014, pp. 190–191).

Data concerning the number of passengers using passenger transport were taken from weekly measurements of passenger volumes conducted on trains in the period from 3 to 9 April, 2017. The selected period was characterised by normal traffic intensity close to the yearly average. It included typical weekdays and weekend days with no (statutory) bank or public holidays. Moreover, there were no complications on the road and rail networks at that time which could interfere with bus and rail traffic. Data about the number of rail and bus connections concern the same time period.

4. Results and discussion

Two public transport companies operate in the study area: Koleje Dolnośląskie S.A. and Przewozy Regionalne S.A. Koleje Dolnośląskie is managed by regional authorities (the Marshall's Office of Lower Silesia Province). Przewozy Regionalne operates nationwide so its activity has not been studied. Koleje Dolnośląskie carries out 89 % of rail transport in the Lower Silesia province[9]. The analysis allows the issues connected with rail transport in the region to be captured with high precision. It must be mentioned, however, that Koleje Dolnośląskie provides services for some 36% of all passengers (including those travelling by other means of transport) in the region.

As far as Polish bus enterprises are concerned, the PKS state-owned companies operated in five cities in the area under study (2017): Jelenia Góra, Kłodzko, Lubań, Bolesławiec and Kamienna Góra. In recent years, three companies have been closed down: in Świdnica, Zgorzelec and Wałbrzych.

4.1 Rail offer and generators of passenger traffic

The study results were analysed with respect to rail transport and bus carriers. A general assessment of the transport offer was made using a synthetic indicator because studying the actual number of connections or travel time could have been unreliable since it is difficult to state which factor is the decisive one.

The synthetic indicator[10] included the most important components of the transport offer influencing passenger behaviour as most often described in the literature (van Lierop et al., 2017):

a. the number of rail connections: this indicator refers to Chakour and Eluru (2016) who noted that public transport stops offering a greater number of connections generate higher passenger volumes;
b. time effectiveness of rail transport in comparison to individual transport on a given route (the so-called detour index): Rodrigue et al. (2009) and Mouwen (2015) note that travel time
c. speed – travel time and travel speed are as important as frequency of departure and the quality of timetables (Stuart et al., 2000); and
d. intervals (meaning the time between departures) – Weinstein (2000) and Mouwen (2015).

The study results show that the highest value of the synthetic indicator was reported on the Wałbrzych - Jelenia Góra section, which had the highest number of pairs of connections per day (13) and trains were much faster than road transport. A high indicator value was also obtained on the Węgliniec–Zgorzelec section. Despite a significantly lower number of connections per day (8), travel effectiveness was of high importance. The lowest values were obtained on the Szklarska Poręba–Jelenia Góra and Kłodzko–Kudowa sections. In the first case, the number of pairs of connections was low (5), resulting in extended intervals between departures. In the second case, a slightly higher number of connections (7) was accompanied by low speed (33 $km.h^{-1}$ on average), which resulted in almost doubling train travel time compared to car transport.

[8] A high-quality weekend and weekday public transport offer is an element of daily routine travels, which are a significant aspect of life (Nutley, 2003).

[9] Source: Office of Rail Transport, 2017.

[10] After the normalisation process, the mean value of the characteristic was determined as a synthetic indicator.

It was important to study correlations between the transport offer and the number of passengers, i.e. the supply-demand relationships in rail transport. Other studies on this type of transport offer (e.g. van Lierop et al., 2017) show that they significantly affect passenger volumes on particular lines, indicating that this factor is important particularly in peripheral areas, where uniform rail quality standards occur less often than within an agglomeration. In order to eliminate the factor of different passenger volumes in particular units, the index of the mean rail passenger volume over 24 hours per station of a given line has been incorporated in this study. (This indicator was the quotient of the total passenger volume getting on at all the stations of a given line, as well as the total number of stations on this line: see Fig. 3). The study shows significant differences in passenger volumes on particular lines – it was almost three times higher on the Wałbrzych–Jelenia Góra section than on the Kłodzko–Kudowa Zdrój line. This confirms that a good transport offer generates high passenger volumes and a low-quality transport offer adversely affects the number of passengers (Fig. 3).

4.2 Bus offer

The greatest number of bus connections is offered on railway routes with a low-quality transport offer and low passenger volumes (see Fig. 4). Moreover, a greater number of rail passengers is accompanied by a smaller number of bus connections in these areas. In extreme cases (e.g. on the Węgliniec–Zgorzelec section), there are no bus carriers due to very high rail passenger volumes.

4.3 Competing and networked journeys and types of carriers

Bus carrier routes constitute a significant problem for the functioning of local and regional transportation systems. In general, even 77% of all the examined bus lines were competing with train routes, meaning that both means of transport compete with rather than complement one another (Tab. 1). It must be stressed that the number of competing connections was the highest on two of the least-used railway lines at 95 % (Kłodzko–Kudowa) and 100% (Jelenia Góra–Szklarska Poręba). If the quality of railway offer is low, bus carriers focus almost completely on taking over rail passengers along those routes. If, however, the rail offer is more attractive, the share of networked bus connections is increased. The lowest share of competing connections was reported on the Jelenia Góra–Lubań line.

Some relationships can also be observed in the market share of private bus operators. Generally, it was lower along well-functioning railway lines with high demand, e.g. no private carrier operated on the Kłodzko–Międzylesie section and the share of private carriers amounted to slightly more than 25% on the Wałbrzych–Jelenia Góra section. At the

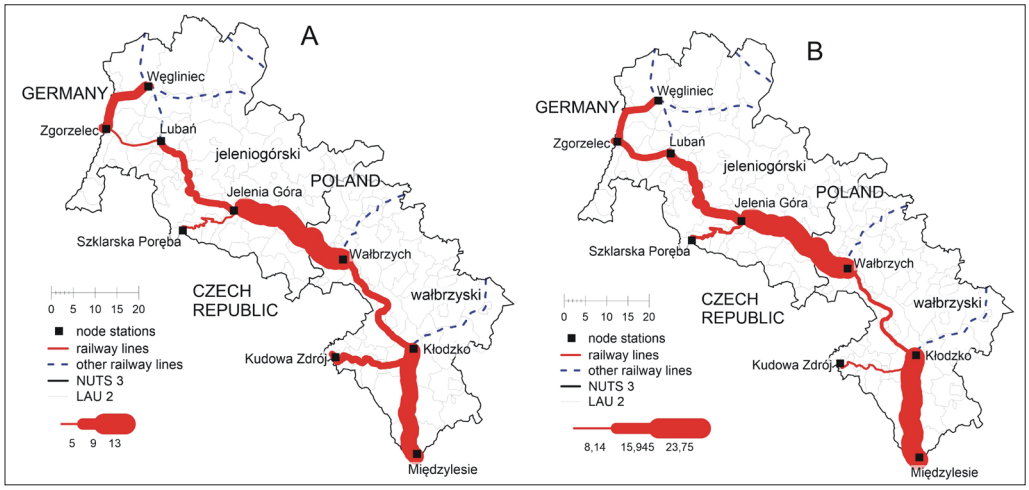

Fig. 3: The number of rail connections (A) and the indicator of the mean volume of passengers entering trains per station (B) on sections between transport nodes in the study area. Source: author's elaboration

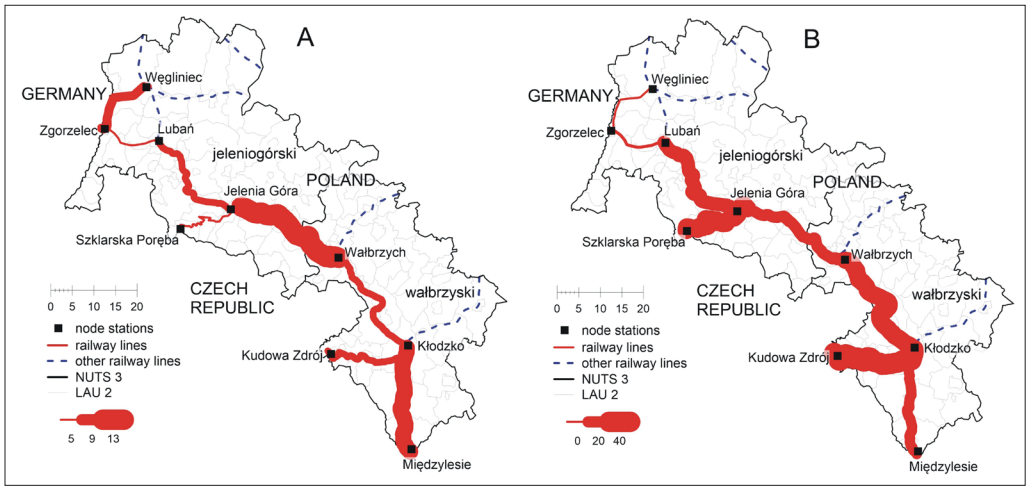

Fig. 4: The number of rail (A) and bus (B) connections on sections between transport nodes in the study area Source: authors' elaboration

Line	Competing courses (%)	Networked courses (%)
Węgliniec–Zgorzelec	no bus carriers	
Zgorzelec–Lubań	66	33
Lubań–Jelenia Góra	56	44
Jelenia Góra–Szklarska Poręba	100	0
Jelenia Góra–Wałbrzych	77	23
Wałbrzych–Kłodzko	75	25
Kłodzko–Międzylesie	73	27
Kłodzko–Kudowa Zdrój	95	0
Average	**77**	**22**

Tab. 1: Competing lines and networked lines
Source: authors' elaboration

same time, the share was almost 50% along railway lines with a low-quality offer (e.g. Jelenia Góra–Szklarska Poręba). This indicates that the network of connections developed by public bus carriers was more in line with the provision of an integrated transportation system. Private carriers mostly responded to existing demand rather than to the needs of local communities at risk of transport exclusion. In general, this may also result from the smaller number of weekend bus connections by which private carriers gain greater market share even when providing services on one route only (see Tab. 2).

4.4 Weekday – weekend differences in bus transport

A characteristic feature of the area under study is the weekday–weekend difference in bus connections (Tab. 3). The average number of Saturday journeys was 32% of weekday journeys, and the average number of Sunday journeys was less than 17% of weekday journeys. At the same time, some lines had no weekend offer (e.g. the Zgorzelec–Lubań and Kłodzko–Międzylesie lines). Moreover, there was a very low share of Sunday journeys on the Lubań–Jelenia Góra and Jelenia Góra–Wałbrzych routes. The lowest decrease in the number of weekend connections amounting to some 40–48% was reported on the Jelenia Góra–Szklarska Poręba, Kłodzko–Wałbrzych and Kłodzko–Kudowa sections. Such a significant reduction of the bus offer at weekends, even if this is not a continuous phenomenon, may lead to periodical transport exclusion.

When analysing the structure of carriers on Saturdays and Sundays, it is noticeable that private carriers operated on all sections, thus clearly increasing their share of the transport market. This is due to a smaller network of connections provided by private carriers, who mostly operate on routes with the highest demand and competing with rail routes which also need to provide services at weekends. Moreover, PKS carriers also provide their services on many networked routes characterised by low weekend demand. This leads to a reduction of PKS's share of weekend transport and an increased share for private carriers, which additionally highlights the fact that both carriers have different ideas on how they should function under conditions of transport system deregulation.

The indicators selected for the analysis characterising the functioning of transportation systems are modifications of the transport accessibility test methods. There are four basic components that make up the availability (Geurs and van Wee, 2004): land-use, transport, time and individual use. The first two are crucial for public transport research (Komornicki et al., 2010, p. 21). The transport component is the same as travel time, while the use of space is the distribution of needs and opportunities (Rosik, 2012). The transport component can be considered as a transportation system (Komornicki et al., 2010, p. 34). Public transport research should concern various transport branches (Komornicki et al., 2018). Other accessibility indicators may include: distance in a straight line, distance on the communication network, driving time, travel costs or the quality of public transport (Curtis and Scheurer, 2010).

5. Conclusions and recommendations

This study shows that a good railway offer almost always indicates a relationship with rail transport services. It does not unambiguously determine to what extent the transport offer was the main reason for the increase in this demand, however, but it underlines its importance in shaping public transportation systems.

The study made it possible to identify very detailed associations between the demand for rail transport and bus offers. On railway lines with an insufficient transport offer and the resulting low demand for rail transport services, bus carriers developed mainly a network of connections which were competitive rather than complementary to the rail transport. This regularity was observed mostly among private carriers operating under market conditions and aiming at profit maximisation. Some measures taken by public bus transport (PKS) conform to the requirements of the integrated approach.

Line	Post PKS carriers (%)	Private carriers (%)	Post PKS carriers weekend (%)	Private carriers weekend (%)
Węgliniec–Zgorzelec		no bus carriers		
Zgorzelec–Lubań	100	0	100	0
Lubań–Jelenia Góra	55	45	40	60
Jelenia Góra–Szklarska Poręba	43	57	37	63
Jelenia Góra–Wałbrzych	72	28	50	50
Wałbrzych–Kłodzko	42	58	48	52
Kłodzko–Międzylesie	100	0	100	0
Kłodzko–Kudowa Zdrój	78	22	73	27
Average	**70**	**30**	**64**	**36**

Tab. 2: The market share of bus carriers on weekdays and weekend days
Source: author's elaboration

Line	Saturday irregularity (%)	Sunday irregulatity (%)
Węgliniec–Zgorzelec	–	–
Zgorzelec–Lubań	0	0
Lubań–Jelenia Góra	21.7	8.4
Jelenia Góra–Szklarska Poręba	71.7	19.8
Jelenia Góra–Wałbrzych	27.4	7.1
Wałbrzych–Kłodzko	48.6	31.2
Kłodzko–Międzylesie	3.5	3.5
Kłodzko–Kudowa Zdrój	49.4	47.0
Average	**31.7**	**16.7**

Tab. 3: Weekday–weekend differences in bus transport. Source: authors' elaboration

The study indicates that under conditions of deregulation and lack of coordination of transportation system development, most bus connections duplicate the railway system. This means that there are activities related to competition between both modes of transport (rather than their mutual complementarity). If transportation systems in the area under study are not based on integrated public transport, many towns will face the risk of transport exclusion. This will increase the peripheral character of the area and reduce its competitiveness, which may adversely affect the pace of its social and economic development. The scale of this phenomenon requires separate studies of coordination of public transportation system to be conducted.

Analysis of the weekday–weekend differences in bus and rail offers shows that rail connections are relatively similar throughout the week. There are definitely more differences in bus transport – on all the examined lines, the number of bus connections at weekends amounted to less than 50% of bus connections on weekdays. Therefore, basing the regional transportation system only on private bus transport can contribute to transport exclusion of local residents (Jaroš, 2017) – if not in a continuous mode, then certainly in a periodical dimension (non-working days, evenings, etc.). This indirectly indicates that from the point of view of the connections stability, rail transport should be the starting point for shaping a regional communication system.

With respect to the lack of a coordinated transport policy and the fact that bus transport is mostly based on market principles, there is a risk that bus carriers will further reduce their services at weekends (the so-called 'weekend transport exclusion' – as a derivative of 'transport related social exclusion': Jaroš, 2017). The general solution to this problem might be the development of a transportation system based on rail transport. Weekend bus transport can be based on feeder line systems or be an element of a flexible transportation system. This requires the creation and implementation of a supra-local, integrated public transport policy taking transport exclusion into account.

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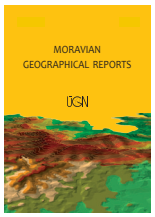

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The role of the novel in shaping a city's image and its choice as a tourist destination: The case of Łódź

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Abstract

Following in the footsteps of one's favourite literary characters has become a significant part of tourism. It remains unknown, however, how many readers decide to visit the places described in a book, or what factors determine their decision to do so. This issue was analysed using the example of Łódź, the third largest city in Poland, which struggles with a negative image. In contrast to the research on literary tourism conducted so far, a questionnaire was completed by readers and not by tourists visiting the places described. The readers remembered many real locations and had become familiar with the city's topography. Some declared their reluctance to accept its stereotypically 'bad' image, while others were fascinated with its 'unique atmosphere'. To many the city has become more familiar and a significant number of readers have changed their perception of it as a result. By means of linear modelling, several factors were established which encouraged readers to visit the city for tourism purposes. These factors included the size of the reader's home location, changes of opinion, and the first impression the book made. This research project clearly points to the significant role of the novel in creating images of the places it depicts.

Key words: *literary tourism, tourism, crime story, city image, Łódź, Poland*

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1. Introduction

Literary tourism is a component of cultural tourism which has become a common phenomenon over several recent decades. Following in a writer's footsteps or travelling to places described in a book, can be either an element of or the sole aim of a tourist trip. Until the present, research has usually been concerned with the space created by the writer or has been conducted among tourists directly at the literary reception site. Using such approaches, researchers did not study the influence of literature on the readers in the context of choosing a tourist destination, focusing only on those who had made such a choice. They did not consider all the readers of a specific publication. Reijnders (2015) believes that with this approach, there is a risk that the emotions and experiences of travel will overshadow the memories of the stage when decisions were being made, and that the study will include only 'successful' cases of the influence of literature.

We present another approach to these issues: to include research conducted among readers who are only potential literary tourists. This comprises the latest novel by a renowned Polish author of crime stories, Katarzyna Bonda (2016), and it is set in Łódź, the third largest Polish post-industrial city, currently experiencing depopulation problems and negative images. The book which is analysed here is in fact the second novel – after ´The Promised Land´ by the Nobel Prize winner, Władysław Reymont[1] – to be so strongly related to Łódź. The city is more than just the background in this novel: it is an important protagonist, because the author herself emphasises that it's a novel about a place. This results in quite an accurate depiction of 'reality' in the book, in terms of spatial, historical and cultural contexts.

As researchers, we focused on the influence of the book on perceptions of individual elements of the city, analysing the associations and remembered places, as well as enquiring about willingness to visit the city after reading it, which is most significant from the point of view of tourism organisers. The results obtained are the starting point for a consideration of the role of literature in the promotion or marketing of a place, as well as an example of literary tourism in the context of the tourism potential of a city.

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[1] Reymont was a Polish novelist and Nobel Laureate for Literature in 1924.

The aim of the paper is to establish to what extent a novel shapes the image of a city and motivates the reader (potential tourist) to visit it, as well as what features (of both the book and its reader) are determining factors. This research project clearly points to the significant role of a novel in creating images of the places it depicts.

2. Theoretical background

2.1 Literary tourism – characteristics

Literary tourism is a very old phenomenon, probably dating back to the early history of the written word, and the first journeys to writers' graves were made in Antiquity (Smith 2012). This phenomenon, however, concerned only a small number of people because of the rarity of literature, rates of illiteracy, the cost of books and the amount of free time, as well as the cost of such journeys which could be afforded by few. To a certain degree, we may regard the famous Grand Tour (Adler, 1989; Towner, 2002) and Petrarch's journeys as literary travel. The latter are considered by Hendrix (2009) to be the first fully organised literary trips. Another example is the 19th Century journeys to sites from popular novels, legends and myths in Great Britain (Watson, 2006; Ellis, 1989, 2001).

In recent decades, travel related to literature has become increasingly popular. A commonly accepted definition of literary tourism was proposed in 1986 by Butler (2000), who stated that its main purpose was to reach specific places related in various ways to literature. Such travel may entail visiting the present and former homes of writers and poets' and true and imaginary places described in literature, as well as places referring to literary characters and events. A similar definition of literary tourism was proposed by Busby and Klug (2001, p. 319), who claimed that it takes place when "the popularity of a literary depiction or the stature of an individual author is such that people are drawn to visit the places that he/she wrote about or was associated with." Stasiak (2009) divides literary tourism into two categories: biographical tourism (where the destinations are places connected with writers); and literary fiction tourism (including, for instance, visiting real and fictional settings of books, reading literature outdoors, staging theatrical events, workshops, summer schools, theme parks, etc.).

Thus, literary tourism is a part of cultural tourism, which is defined (after WTO, 2005, p. 9) as "all movements of persons to specific cultural attractions, such as heritage sites, artistic and cultural manifestations, arts and drama to cities outside their normal country of residence. In order to structure the way cities can be looked at as destinations for cultural tourism a framework has been developed based on the predominant (cultural) product of a place and the type of place, such as village, town, city and metropolis." This domain of tourism is developing very rapidly and, as UNWTO reports, became a significant part of cultural tourism (Mintel, 2010, 2011; Mansfield, 2015; Jiang and Xu, 2017). Unfortunately, it is difficult to establish what percentage of cultural journeys are those which could be regarded as literary tourism. Many examples from the literature, however, point to the growing significance of literary travel. A strong relationship between literature and tourism was visible in the interviews conducted by Reijnders in 2015, where over half of the respondents declared their willingness to visit places they knew from their 'beloved' tales. Watson (2006) even claims that in Great Britain literary tourism has gained the status of a commercial phenomenon. A good example is the story of Dracula, which is the main attraction drawing tourists to Romania (Light, 2007). He is a fictional character who the Romanians themselves do not like, as it depreciates the historical figure that Dracula was modelled on. It is still, however, the foreigners' strongest association with this country, which is an excellent foundation for creating tourism products (Cosma, Pop and Negrusa, 2007).

The huge tourism potential 'hiding' in literature can be the consequence of a variety of reasons. The reader who is not familiar with the place they are reading about, often wants to experience the world created in the novel by travelling to the real places described in fiction. This blurred boundary between fiction and reality is fundamental to making decisions on visiting such a place (Andersen and Robinson, 2002). Readers often identify themselves with the characters, want to have similar adventures and delight in similar views. If the novel interests the reader, they spend long hours with it and in this way they 'enter' the literary world, which (apart from the fictional plot) is realistic and is not difficult to visit. Reijnders (2011) remarks that ´places of the imagination´ offer fans the possibility of having a transcendent experience between two worlds: an imagined world on the one hand and that which is considered to be the 'real' world on the other. In this way, the reader who travels to places described in literature may 'experience' a substitute of the story that fascinated them.

2.2 International examples of literary tourism

There are numerous examples of literary tourism taking advantage of places connected with the lives of renowned writers or places where their stories are set, and every country has tens or hundreds of them. For instance, William Shakespeare attracts over 4.9 million tourists annually to Stratford-on-Avon (the town where he was born, with only 25,000 inhabitants). The same concerns his writings: Hamlet attracts people to the castle of Kronborg in Denmark and Romeo and Juliet is the basis of the tourist industry in Verona, Italy (Stasiak, 2009). In Europe, people visit places described in the novels by James Joyce (Dublin from Ulysses), Mikhail Bulhakov (Moscow from The Master and Margarita), and Arthur Conan-Doyle (Sherlock Holmes). The cities which attract tourists interested in great writers include, for instance, Prague (Kafka), Florence (Dante), Paris (Moličre), Weimar (Goethe) and hundreds of others (Stasiak, 2009).

The latest examples include Scandinavian crime stories, such as Stieg Larsson's books, attracting tourists to Stockholm (following in the footsteps of the characters was announced as the best literary trip in the world by Lonely Planet Publishing in 2014), or the writings of Henning Mankell, popularising Ystad in Sweden through the character of Inspector Kurt Wallander; trips following the trails in Dan Brown's novels (Rome, London, Paris, Florence, Bilbao, Barcelona: Skyscanner, 2009); or a journey around New Zealand, inspired by the film adaptation of The Lord of the Rings and Hobbit by J.R.R. Tolkien (Li, Li, Song, Lundberg, and Shen, 2017). The National Geographic magazine (2011) lists St Petersburg, Portland, Melbourne and Santiago among 'the most literary cities of the world'. Some literary references are often used to promote whole regions, such as the 'Catherine Cookson Country' in Northumberland (Herbert, 2001), 'Shakespeare's Stratford', 'The Brontes' Yorkshire', and 'Hardy's Wessex' (Squire, 1994). Ryan, Yanning, Huimin

and Song (2009) suggest that evidence exists that novels, films, and television series can and do attract visitors to destinations, but the record of increasing visitor numbers states little about what it is that actually motivates them. The examples presented above show that the location of a novel's setting may cause greater interest among readers and encourage them to make a tourist visit.

2.3 Polish examples of literary tourism

So far, in Poland, no city has been able to create a coherent tourist product based on literature, despite many individual activities and small undertakings (Pudełko, 2015). In several Polish cities, tourist trails have been created, following the traces of characters from novels (mostly crime, e.g. Eberhard Mock's trail in Wroclaw and the trails following crime stories set in Krakow). There are also several museum exhibitions dedicated to writers or literary characters. In recent years, many successful books have been made into films (e.g. Miłoszewski's crime stories). The most popular form of promoting a city by referring to famous novels is a thematic walk (e.g. in the company of the author) and urban games (there have already been several dozen organised in Poland) (Pudełko, 2015).

Nevertheless the authorities of Polish cities hardly ever woo the writers or ask them to place the city in their story. There are two exceptions to this: a literary competition in the town of Piła for the best crime story set there ('piła – in English 'jigsaw', which makes the name of the competition – 'Criminal Piła' – a witty pun, as it can also be read as 'Criminal Jigsaw'). The other exception is the festival in Wrocław with its annual competition for the best short story related to it. In both cases the winners can publish their writings as a prize (Pudelko, 2015).

2.4 Similarities with film tourism

Such undertakings, however, cannot be compared to the global trend called 'set-jetting' (the term was first used in 2008 by Gretchen Kelly in an article for the New York Post, and it means 'travelling to film sets'). Several decades ago people working in the tourism industry had already realised the value of location in films and tried to have some influence on this process. For instance, film directors and producers are informed about the chance to take unique shots at a specific place which is to be promoted (Kavaratzis and Ashworth, 2006), which is then treated as an effective form of advertising. Examples which we can quote here include the famous films by Peter Jackson, The Lord of the Rings cycle, Woody Allen's series of films set in European capitals (Reijnders, 2015), the promotion of Scotland in Braveheart, and the current tourism boom in Dubrovnik from the Game of Thrones (Martin-Jones, 2014, Rodriguez, 2015).

In comparison to film tourism which is based on the director's vision, where the spectator is provided with a view of the setting, in literature it is the reader who creates the final visualisation. According to Watson and Saunders (2004), it is the reader who interprets the words written by the author into their own vision of reality and actually 'generates' the place, not the writer. A place interpreted in such a way has greater, even intimate, significance for the reader, who becomes strongly attached to it. Thus, place plays a very important role in literary tourism, particularly in literary fiction tourism. Writers may create and define space anew through their works, and literature can reflect the real place and how it is used (Andersen and Robinson, 2002).

Even if literary tourism differs from that inspired by films, the suggested marketing tool (promotion via cultural elements) (Hudson and Ritchie, 2006) can be adapted to literary tourism, in which authors may actively promote individual destinations. In this way, such destinations may be positively distinguished from competing places by being 'positively planted' in the minds of consumers, which may have an impact on the tourists' behaviour (Echtner and Ritchie, 2003; Pike and Ryan, 2004; Hudson and Ritchie, 2006).

2.5 Research methods on literary tourism

The phenomenon of literary tourism has been studied in a variety of ways and researchers often utilise interviews with tourists at the destination. This was what happened in the research conducted by Herbert at Chawton and Laugharne (Herbert, 2001), by Tetley and Bramwell at Haworth (Hoppen, Brown and Fall, 2014), and by Squire at the Beatrix Potter farm, Hill Top, in Cumbria (Squire, 1991). Dung and Reijnders (2013) conducted interviews with Chinese tourists, charmed with the image of Paris emerging from the media (literature, films and serials), in three stages: before arrival (pre-visit stage), during the visit (on-site stage), and after returning home (post-visit stage). The second most popular method of studying literary tourism has been the analysis of available source materials, such as Smith (2012) in South Africa, Cosma, Pop and Negrusa (2007) in Romania, Wallace (2009) in Dublin, and many others. Most of these methods have one serious drawback, which was noted by Reijnders (2015): they consider the issue only in retrospect and ignore all 'unsuccessful' cases, when after reading a book, the reader decided not to visit the places it refers to.

Other studies have been concerned with the workers and organisers of literary tourism: for example, McGuckin (2015) conducted his research in places connected with Shakespeare; and Fawcett and McCormack (2001), in Canadian places connected with the writings of Lucy Montgomery. An original study method was used by Gentile and Brown (2015), who analysed this phenomenon using autoethnology: for two months, they personally collected information and recorded it in their notebooks to be analysed later. Most literary tourism studies have been carried out in Europe and North America (Hoppen, Brown and Fall, 2014), but in South Korea, in the home village of the popular writer Kim Yu-jong, who set some of his novels there, a trail and a museum were created, and the village was officially renamed Kim Yu-jong's literary village (Lee and Weaver, 2012).

Reijnders (2015) conducted fifteen in-depth interviews for the purpose of investigating the relationship between fictional stories (known from films, literature and tales) and making a decision about a travel destination. In his research, however, he did not focus on specific items of culture, but rather on the general process which precedes a tourist visit. An issue to consider and an inspiration to undertake research was the question whether 'city location' in literature can be used for tourist promotion in a similar way. In the research by Ryan, Yanning, Huimin and Song (2009), conducted among tourists visiting the gardens in Beijing, it was found that the novel which describes the site was extremely important for as many as 52% of visitors. It is a fact, however, that Lampiony is not a book written 'on commission', because the city authorities did not try to convince the author to choose Łódź as the setting. Still, it would be interesting to know whether such promotion could bring the results expected.

Considering the lack of publications that focus on readers of a specific book who have not decided yet to visit its setting (potential literary tourists), it can be assumed with considerable certainty that this paper is likely to be one of the first of its type.

3. The place and the book

3.1 Łódź as the spatial context of the novel

Lampiony, Bonda's book set in the post-industrial city of Łódź, was not chosen accidentally. In contrast to most Polish cities, Łódź does not feature elements related to the medieval 'golden age' (no palaces, castles, stories about royalty, etc.), which are often the core of urban identity (Young and Kaczmarek, 2008). It struggles with many problems, such as depopulation, degraded urban fabric and many former industrial areas. It is negatively perceived by Polish people: in attractiveness rating, it often occupies low ranking positions, for example, The perception of provincial capitals (TNS OBOP, 2013) and The reputation of provincial capitals (Premium Brand, 2015). There are many stereotypes and unfair opinions, such as Łódź has been called the 'Polish Detroit' (Hall, 2014) or even *miasto meneli* (the city of 'bums') in the media and public discourse.

There are many reasons for such opinions, but they are mostly caused by the history of this city. Between 1825 and 1915 there was rapid population growth from around 1,000 to around 600,000. The city had a multi-ethnic population with German textile entrepreneurs, workers and technical staff, Polish textile operatives, Russian administrators and Jewish entrepreneurs, traders and artisans (Young and Kaczmarek, 2008). Until 1900, Poles accounted for only 10–30% of the city's population (Liszewski, 1997). The layout of the city was based on a division into plots for craftsmen and a grid of streets – hence a comparison to New York (the rapid growth observed in American cities, which also developed based on industry, was similar). The poorest workmen of the 19th century factories lived next to the wealthiest inhabitants living in their lavishly decorated palaces in this part of Europe. As Young and Kaczmarek (2008) note, Łódź's industrial development led to its image becoming that of a 'bad city' and for some people it became synonymous with the exploitation of the working class. This identity was reinforced by the publication of Władysław Reymont's novel The Promised Land.

Such a cultural mixture had an influence on the Second World War history of the city, where the second largest Jewish ghetto was created (after the one in Warsaw). Because of the war, the city lost 430,000 inhabitants and became largely mono-ethnic (Marcińczak and Sagan, 2011). In the post-war socialist era, the city authorities did not care about or invest in the heritage left behind by the industrialists, for ideological reasons (Fleming, 2012). The authorities of that time continued the pre-war direction of development, focusing on the nationalisation of 1945 textile production. At the turn of the 1990s, this caused the most serious crisis in the history of the city as the loss of eastern markets in 1989 devastated Łódź's economy. The unemployment rate reached over 20%. In addition to this economic crisis, Łódź was stereotyped as a grey, grimy, industrial city (Young and Kaczmarek, 2008). The unavoidable effect of the economic shift, manifested by the expansion of urban poverty, became a salient characteristic of the social reality of Łódź in transition (Marcińczak and Sagan, 2011). It was then that negative opinions became established; they are still present, despite the considerable changes for the better that have taken place in recent years.

For several years, Łódź authorities have been trying actively to change the negative opinions concerning all spheres of life. Initiatives attempting to enliven the city include the festivals: 'The city of colours' (painting grey urban building elevations); 'Dialogue of Four Cultures' (referring to the multicultural roots of the city); a promotional campaign 'We are inviting you to Łódź – it can also be your Promised Land', referring to the novel by Reymont; and, unfortunately unsuccessful, attempts to win the title of the European Capital of Culture 2012 (Young and Kaczmarek, 2008; Fleming, 2012). The city has the largest number of revitalisation programs in Poland: old, historical, 19th century factories have been turned into luxury hotels, museums, shopping centres and cultural institutions. A wide-ranging program of reconstructing the City Centre was launched. Spacious woonerfs[2] are appearing, and in 2016 the most modern railway station in Europe was opened. The city can boast the largest number of nineteenth century industrialists' palaces and villas in Poland (according to the Town Hall).

The difficult history of the city, the rapid changes it has undergone and the negative opinions about it held by inhabitants of other cities, make Łódź a good 'laboratory' for research on the perception, image and the confrontation of reality with what is imagined. Rapid development and 'reconstruction' improve its image year after year. This makes research even more valuable on how readers who have not visited Łódź (or only visited it a long time ago) imagine the city. The more so, considering the different problems, as the authorities are looking for an idea for promotion. While in cities such as Rome, London or Paris, the influence of books or films set there on the intensity of tourism may be insignificant, in 'non-tourist' Łódź, a novel of this kind may have a significant effect.

3.2 "Lampiony": A book about the city

The book Lampiony was chosen for other reasons as well, above all due to the popularity of the author, who is called 'the Polish queen of crime' by the media, and her books are compared to novels from the so-called 'Scandinavian school'. This makes every new novel widely known across the country and wins thousands of readers, and thus has a wide range of influence and does not remain a niche publication (unlike the majority on Łódź, apart from The Promised Land).

The book in question has received a major advertising campaign in Poland in recent years. Billboards (see Fig. 1) and large format advertisements appeared in the streets, while the promotion was visible in the press and on the Internet. For the first time in Poland, the promotion of a novel involved opening a bookstore with only one title. In Warsaw, for one day (the launch), on 27th September 2016, a Lampiony pop-up store was opened with 10,000 copies of the novel. For a whole day, the author was present, signing her books and answering questions. After the launch, walks with guides were organised in Łódź following in the footsteps

[2] A 'woonerf' is a living street, as originally implemented in the Netherlands, include shared space, traffic calming and low speed limits.

of the characters from the novel, as well as an urban game. Towards the end of 2016, a theatre spectacle was staged based on the Lampiony story (Fig. 2). Such huge promotion of a novel featuring Łódź had never taken place in the history of the city before. The large number of readers allows us to assume that the book became a very significant element in creating the city's image. Thus, the research interest to study in what ways reading the book influences opinions about the city was intensified.

It is an important fact that this crime story is, in the author's words, "a novel about the city" (Bonda, 2016, p. 629). In the afterword, she writes:

> 'the setting of my books is a key issue. (…) the story narrated in Lampiony could happen only there. Nowhere else does the light shine like there, or will you find such energy, hear so much cursing, see bottles in gateways, feel such longing for the past, but at the same time meet so many unusual, open, warm and helpful people in the streets. (…) Every walk along Łódź streets is like a scene from a film. (…) Nothing is smooth or slick, as if from a postcard here. (…) Standing next to one another, in full harmony, there are glass-clad high-rise buildings, historical tenement houses, the districts of the poorest and the artists, and kebab shops. All this is saturated with the spirit of artists, from mural painters to the best rap musicians.' (Bonda, 2016, p. 630–631)

Before writing the novel, Bonda spent several months in the city discovering Łódź with the help of guides, fans, museum workers and local inhabitants. This resulted in the very realistic picture of the city presented in its pages. Whole sections resemble a guidebook, containing true descriptions of buildings, interiors and topography. The novel also contains a large number of elements specific to Łódź, starting from local vocabulary to song lyrics, references to literary works, music and films by artists and poets connected with the city. Lampiony features several dozen genuine locations, street names, tram and bus lines, and over 35 detailed descriptions. The writer touches upon the historical issues of the city, its famous inhabitants, as well as the causes of the crisis and the problems the city struggles with. This makes the novel an extraordinary crime story, here the setting is not just a background, it is one of the major protagonists. In this way, the combination of a popular fiction style with the qualities of a guidebook makes it ideal for research on the influence of reading on a reader's perception of the city. Furthermore, the date of publication (it is recent) makes it possible to observe the process of developing literary tourism, in this case, 'from the beginning'. All the factors mentioned above: popularity; promotion; a large number of readers; guidebook-like sections; and a real space as the setting, give the book the potential to build complex tourist products referring to it. The evidence that the city is strongly present in the story is the large number of specific places and sites described by the author (see Figs. 3 and 4).

The maps present 76 places, which are the basis for further analysis. Most descriptions (58) regard real places and sites and only eight are creations of the author's imagination, mostly including elements of 'underground Łódź' (shelters, tunnels, underground motorways) or the unfinished mosque. The majority (39 sites) are situated in the strict city centre (Fig. 4). The characters are found in 30 of these places, 26 are indirectly connected with the storyline while 20 ("none") have nothing to do with it. Sites included in the "none" category are those which were mentioned in the novel and have realistic location, but they are neither directly nor indirectly related to its plot (e.g. they are mentioned in a dialogue as an element of the cityscape). The analysis did not include surface areas (districts, quarters), linear areas typical of the city (e.g. rivers, sewers), nor those whose descriptions did not point to specific locations.

The level of accuracy in the descriptions of individual sites also varies. Complete and detailed descriptions concern less than a third, short for 20, while 34 are just briefly mentioned. When analysing the content, we can notice that some descriptions represent a guidebook style of narration (history,

Fig. 1: A billboard advertising Lampiony on a tenement house. Content translation: "The newest novel of queen of crime. Adventurous, unpredictable, dangerous – new Bonda". Source: authors' photograph

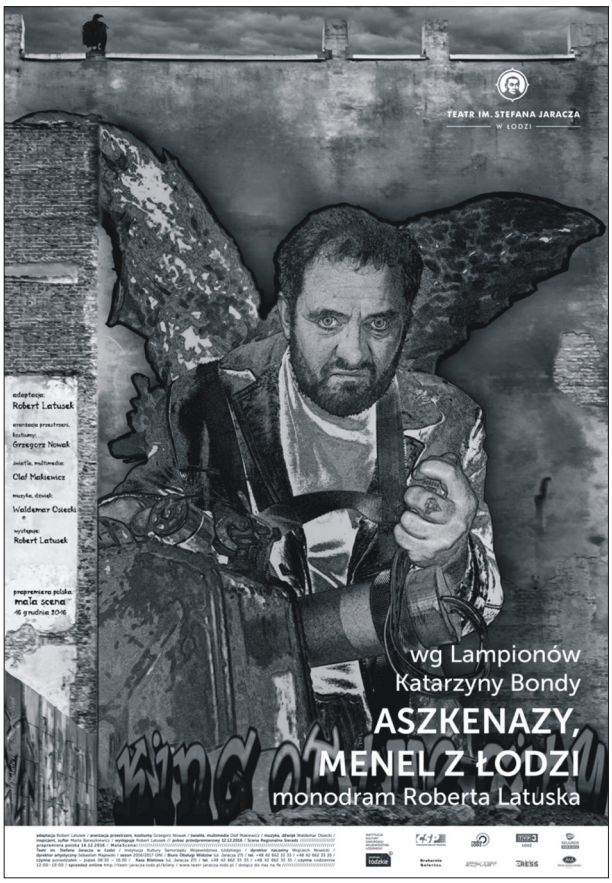

Fig. 2: A poster advertising a theatre spectacle using the motifs included in Lampiony.
Source: Grzegorz Nowak, advertising materials from Jaracz Theatre in Łódź

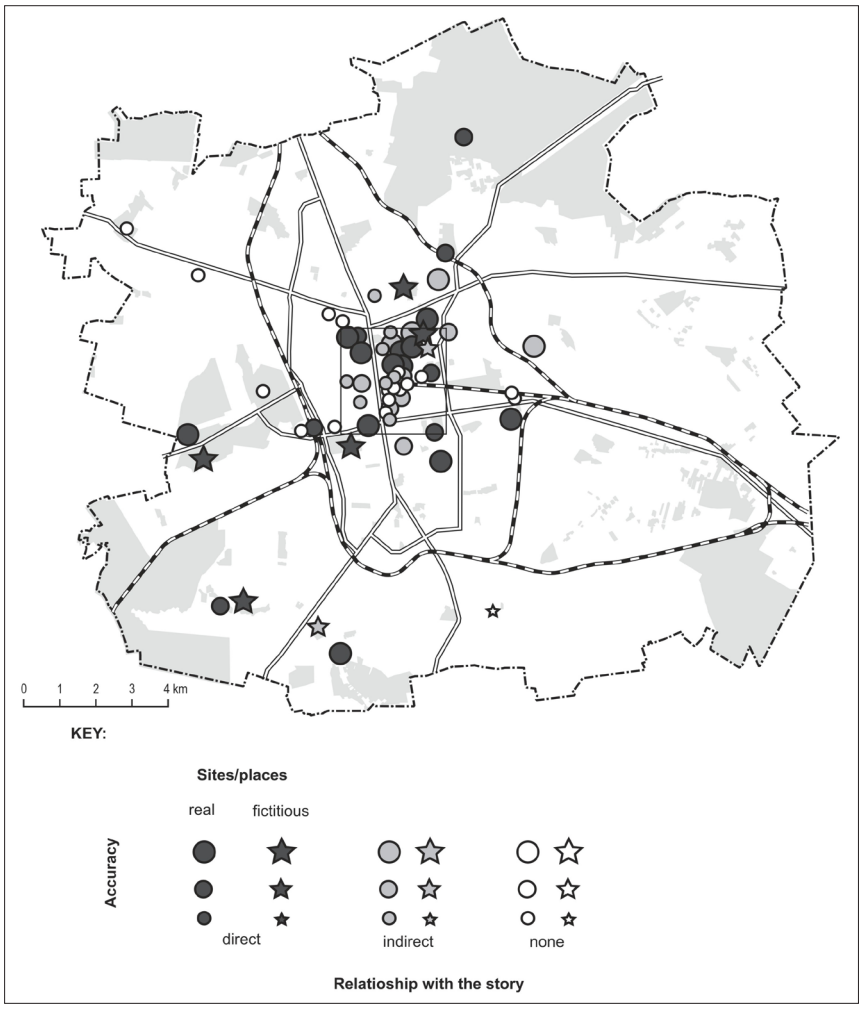

Fig. 3: Distribution of Łódź sites and places mentioned in Lampiony (Note: Grey areas = greenery (forests, parks), White areas = urban areas) . Source: authors' elaboration

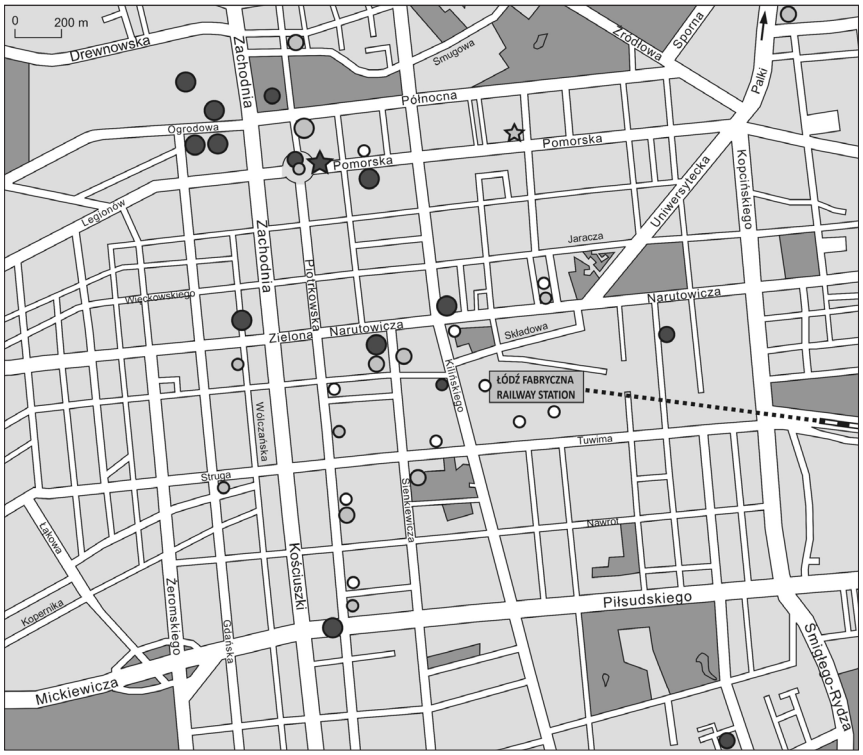

Fig. 4: Distribution of sites and places described or mentioned in Lampiony: The centre of Łódź (Key as in Fig. 1). Source: authors' compilation

dates, architectural details and interesting facts). Literary techniques like this are usually evaluated as vague. On the one hand, the book becomes a source of information and an encouragement to visit the city, but on the other, the technique slows down the action and the guidebook-like descriptions seem artificial compared to other parts of the novel.

4. Research methodology

The research was conducted using a questionnaire distributed online. People who had read Lampiony were contacted through the portal entitled lubimyczytac.pl ('we like read', the largest Polish website presenting book reviews, enabling readers to have discussions, evaluate and express their opinions. It is also a social media platform for literature lovers. Currently, it has over 670,000 registered and active users (nearly 2% of Poland's population). The survey questionnaire was sent to a sample of selected users: the basic criterion of choice was indicating Lampiony as a book that had been read and then evaluating it in some way. Out of this group, the researchers selected those who had expressed an opinion and presented it as text. In this way, they chose people who were more likely to complete the questionnaire and more willing to provide answers to the open questions included. Overall, an invitation to take part was sent to 322 people, and 130 (40%) respondents returned correctly filled-in questionnaires, which is a good result. This response rate may indicate some level of self-selection bias, but it cannot be controlled for in such a design. It is likely that the benefits outweigh the costs in such a case.

The research was limited to a study conducted via the Internet mostly due to the fact that the greatest difficulty was reaching people who might become potential literary tourists. Unfortunately, it is not physically possible to conduct interviews with those who have bought the book, neither the shops nor the publisher record their customers' data, nor are willing to pass it on. Buying a book does not necessarily mean reading it, either, especially in the period before Christmas when it was promoted and was often bought as a gift.

Respondents varied with respect to sex: 100 women and 30 men. This may have resulted from disproportionate reading habits in Poland [according to a report *´Stan czytelnictwa w Polsce w 2015 roku´* (in English: Polish readership in 2015) prepared by the National Library, 46% of women and only 27% of men read at least one book in a year]. Almost nine out of ten respondents (86%) had university education, 10% secondary education and 4% only elementary or basic vocational. According to the report, this does not deviate from the norm in which the higher the level of education, the higher the percentage who read books. The most numerous group of respondents consisted of those aged 20–40 years. The respondents (over 62%) came mainly from large cities with over 500,000 inhabitants, and smaller towns (23%), while another 15% lived in the countryside. These response patterns were probably due to the larger popularity of writing posts on Internet forums among city inhabitants, a higher rate of reading in urbanised areas, as well as the fact that the advertising campaign was run mostly on the streets of large cities.

The survey was conducted in November and December, 2016, i.e. slightly over one month after the book's launch (28th September 2016). As a result, it was fresh in the respondents' minds, but some time had already passed since reading the book, which eliminated the element of 'heated' emotions present right after finishing it, possibly influencing its reception. Out of the 130 who participated in the study, only 14 had read the book just a few days before filling in the questionnaire, 47 people had read Lampiony a week or so before, and 69 claimed that they had read it more than one month before. A very large majority (92%) of the respondents came from outside Łódź, the city where the book is set. This is very important in the study because the respondents are potential tourists. What is more: 43% of them had never been to Łódź; and 24% had visited the city more than three years earlier, so their current image was not strengthened by personal experience. The inhabitants, or those who had visited the city in the previous year, made up 26% of the respondents, while 7% did not indicate any specific date of visit. Considering the aims of the research, the most important responses are those that were collected from people living outside the city and barely knowing it.

5. Results

5.1 General impression of the city

The first issue approached in the questionnaire was the respondents' general impression and feelings towards the city described in the book. They were asked to define their impressions and say whether they changed after reading, and if so, how the book can influence the opinions of other readers. The answers to the second question were to specify the general perception and the kinds of emotion which the novel evokes. The distribution of responses to these questions is presented in Figure 5.

The most important information which can be inferred from the responses is the influence of the book on the perception of the city. For 53%, reading Lampiony changed their opinion (25% – for the better, 28% – for the worse). The respondents' thoughts on its influence on other people are interesting. Here, the statements are less critical, only 19% perceive a negative tone to the text which, will have a negative influence on other readers. In this case, more people expect a lack of influence of the book on the image of the city (39%).

This may point to the fact that Łódź is presented unfavourably in the novel. We must not forget about its genre: it is a crime story, a novel full of wrongdoing, violence and other pathologies. The setting itself could not be presented in an idealised way, so that the reader would not detect the lack of authenticity. From the point of view of tourism organisers or city authorities, however, it is worth discussing the promotion of this type of literature. Whether it is for marketing reasons ('The only thing worse than being talked about is not being talked about.') or for

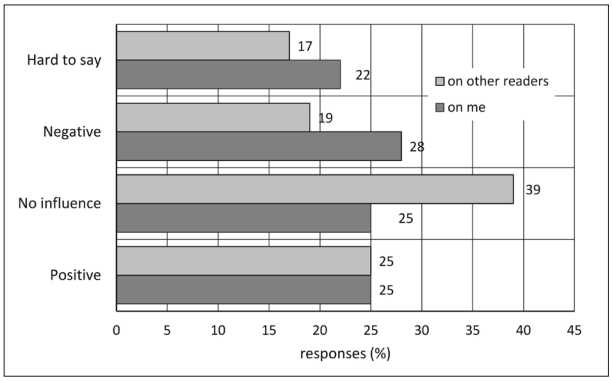

Fig. 5: The influence of reading Lampiony on the image of Łódź. Source: authors' compilation from survey

tourism, it is not advisable to promote negative associations among potential tourists. A similar situation is found in the case of the crime story entitled *Ziarno prawdy* (A Grain of Truth) (Miłoszewski, 2014), which presented the setting (Sandomierz) as a provincial town, full of people with complexes. For a substantial period of time, the author was treated as *persona non grata* and ignored by the town authorities (Pudelko, 2015). The situation changed, however, when it turned out that despite the negative overtones, the book attracted tourists to Sandomierz, and its film adaptation contributed to the promotion.

In order to examine this phenomenon in more detail, respondents were asked to present their opinions about individual elements and aspects of city life before and after reading the novel. It forced them to think more deeply and focus on individual elements, not on the city as a whole. In addition, a question of 'changing opinions' was concealed here, as the respondents evaluated individual components using a 1– scale (from 'definitely negative' to 'definitely positive'). The element of change or lack of opinion was defined *ex post*, by comparing the respondents' opinions declared 'before' and 'after' reading the book (see Tab. 1).

Before reading Lampiony, the categories rated highest included the development prospects for the city and the number of historical monuments, and those rated lowest were cleanliness and affluence. After reading the novel, the respondents evaluated the number of historical monuments and tourist attractions most positively, and safety and cleanliness most negatively.

Therefore after reading, the average rating for 6 out of 8 evaluated elements decreased, opinions became more critical as regards the city's general appearance, safety (the largest decrease), cleanliness, inhabitants, affluence and development prospects. Reading the book improved opinions regarding only two elements: the number of tourist attractions and historical monuments.

From the point of view of the study, the change of opinions as a result of reading is quite significant, 41% of the respondents changed their opinion either more positive or more negative, the difference between them being similar. The opinions which changed the most regarded appearance, safety and development prospects (respectively, 68, 62 and 59 respondents changed their opinion, comprising 45–52%) of the responses. The smallest number changed with respect to the number of historical monuments and the affluence of the city. Looking at the total number of answers, the largest increase was recorded among negative opinions. While before reading the book those responses constituted 27% of all answers, after reading, it was 37%. This means that reading the book had an influence on changing opinions about the city in nearly half of the respondents and in this case it was a change for the worse.

5.2 'A city remembered'

The respondents also answered an open question, they were asked to think of a few words they associated with the city of Łódź after reading the book. In this way, it was possible to learn about their first associations which had not undergone any earlier categorisation or evaluation. This freedom of expression was to guarantee 'true' and more emotional opinions. Short statements were assessed and ascribed to four categories: positive, negative, neutral, and one including contrasts. The fourth category in this case was necessary because it encompasses a relatively large group of responses. Just as the writer stressed in her statements (and in the text of the novel), contrasts exist everywhere in Łódź; in its space, people and emotions. The same could be observed for the respondents' former opinions; in a few cases, the figure evaluating a given phenomenon as positive or negative was very similar. Among the free answers, there were quite a few statements which cannot clearly be ascribed to one of the three 'classical' categories because they represented extreme elements. For such responses a new category of 'contrastive' was proposed. Examples of responses are included in Table 2.

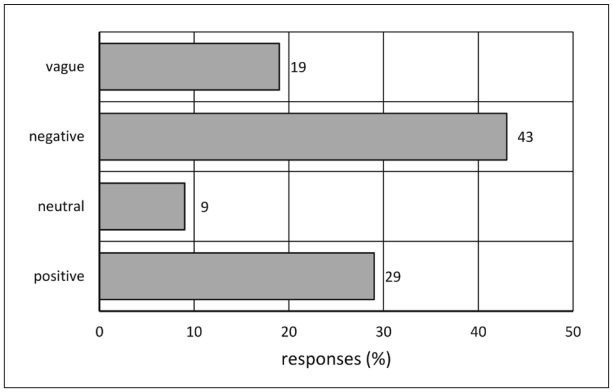

Fig. 6: Connotation of first associations with the city
Source: authors' calculations from sample survey

No.	Evaluated elements and city life aspects	Average rating		Change of opinion (considered individually)							
		before	after	improved		got worse		no change		don't know	
				number	%	number	%	number	%	number	%
1	Appearance	3.06	3.05	36	27.7	32	24.6	48	37.0	14	10.7
2	Safety	3.04	2.60	15	11.5	47	36.2	46	35.4	22	16.9
3	Number of tourist attractions	3.16	3.40	34	26.1	17	13.1	55	42.3	24	18.5
4	Number of historical monuments	3.34	3.41	22	16.9	13	10.0	72	55.4	23	17.7
5	Cleanliness	2.77	2.67	19	14.6	31	23.8	55	42.1	25	19.2
6	Inhabitants	3.14	2.97	21	16.1	32	24.6	52	40.1	25	19.2
7	Affluence	2.84	2.74	16	12.3	28	21.5	67	51.1	19	14.6
8	Development prospects	3.39	3.05	20	15.4	39	30.0	49	37.7	22	16.9
	Total	**3.09**	**2.99**	**183**	**17.6**	**239**	**23.0**	**444**	**42.7**	**174**	**16.7**

Tab. 1: Respondents' evaluation of the city. Source: authors' calculations based on the sample survey: percentage of all responses. Average rating: 1.00 = definitely negative, 3.00 = neutral, 5.00 = definitely positive.

Positive	Negative
"atmospheric, murky, interesting, enigmatic, mysterious, inspiring"	"bums, criminality, hopelessness, demise"
"interesting buildings: beautiful palaces, old tenement houses"	"filth, poverty, hopelessness"
"underrated, original, undiscovered"	"bad city with bad people"
"intriguing, captivating"	"damaged, dying, a city without perspectives"
"interesting, unique, worth visiting"	"a city of bums, infantile bums… Not very good promotion, I think…"
"modernity mixed with tradition, friendly people"	"dark, old city"
	"a ruined, dying city without perspectives"
	"a city full of psychos and criminals"
Neutral	**Contrastive**
"strange city, strange novel"	"tenement houses falling apart, canals under the city, the homeless, bohemian artists, hip hop"
"an industrial city, an industrial landscape"	"a city of contrasts, fascinating, run down, a city of many mysteries"
"a city of tenement houses and factories"	"multiculturality, uniqueness, diversity, inconspicuousness, neglect, extremes (poverty – wealth), wasted / unused potential"
"completely nothing stuck in my memory"	"a city of bums, but at the same time multicultural"

Tab. 2: Examples of readers' (respondents') statements
Source: authors' compilations based on survey research results

After applying this classification, it turned out that neutral responses made up only 9% of all answers (see Fig. 6). This proves a strong emotional involvement on the part of readers as the book hardly ever left them unaffected. It evoked strong, often ambivalent emotions (every fourth reader). This shows that it is an effective way of reaching the reader, if we treat a book about the city as an advertisement, because the time spent in the imagined space (in this case largely corresponding to the real one) is much longer than with other forms of promotion. It seems that the reader becomes 'immersed' in the story and completely gives herself/himself to it. She/he is more susceptible to the writer's suggestions and the messages coming from literature. The reader remembers more and, what is important, believes in it more strongly than in the case of traditional forms of tourist site promotion.

5.3 Literary fiction versus reality

As indicated above, the book presents several dozen real sites, often with descriptions, and that is why respondents were asked to list places which they remembered from the novel. We can speak of a promotional success of Lampiony here because as many as 80 out of 130 respondents mentioned at least one place, and the 'record breaker' mentioned eight. The average was 2.6. The most popular included Piotrkowska St, the district of Bałuty, underground tunnels and canals (it is interesting as the tunnels exist only in the writer's imagination, while the large network of sewers is by all means real), the central tram terminal, historic hotels where the characters from the book were staying (burnt down by the psychopath from the story), and actually existing tenement houses and factories. It is not surprising that the readers remembered places which were important for the plot, those where the action took place and those which were most deeply described by the writer. It is strange, however, that some places described in much detail were mentioned by only a few. This means that it is not the length of the description that makes the reader remember a given place, or that the places described by the writer in so much detail were not significant from the reader's point of view.

The readers rated the descriptions of place included in the book as realistic, while the realism of the plot and situations in the novel were rated a little lower (see Fig. 7).

Readers' high evaluations of the level of realism in the descriptions has an influence on how much they trust the writer. The readers feel that despite the fact that the novel

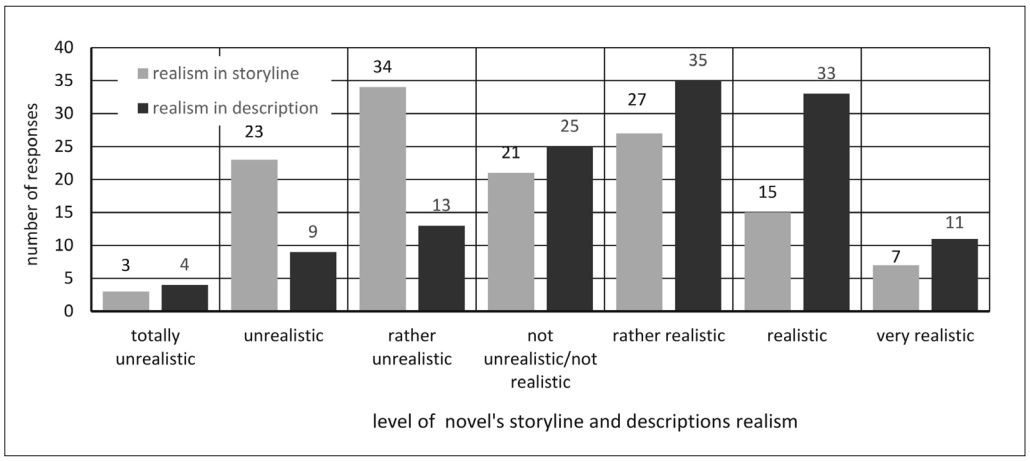

Fig. 7: Evaluating the realism of the descriptions of the city and storyline in the novel
Source: authors' compilations from sample survey

is fictitious, many of its elements (mainly the setting) look exactly the same in reality as on the pages of Lampiony. Such faithful descriptions allow the writer to 'smuggle' fiction, unnoticeable for a reader unfamiliar with the city, into the truth. In this case, the fiction included the underground tunnels which do not exist in reality. Some readers believed they were real and even mentioned them as places which they would like to visit in the city. The stronger the readers' belief that a description is realistic, the stronger its promotional effect (intentional or not) becomes, or quite to the contrary, the stronger the depreciation of the real place. Thus, the credibility of the story and the content is very important as regards the perception of the real place by the readers.

It is worth noting that respondents living in Łódź expressed a clearly different opinion. It was the only difference between them and other readers. A low evaluation, for instance, of the realism of descriptions or holding the opinion that the book had a negative influence on the promotion of the city, can be the starting point for interesting future research on the perception of the city. The author's writing skills are probably evaluated differently when someone knows the described places from their own experience than when they only imagine them based on literature. Perhaps, it is also related to the observations made by Reijnders (2015), in which readers 'see' the story not through the writer's descriptions, but through their strongly rooted associations with, or memories of places from, childhood, which had strongly impressed them. In this case, the inhabitants 'read the book through images' which they see every day, and those who do not know the city read it through their imagination, to a lesser or greater extent giving in to the writer's intentions.

The respondents were also asked to specifically on two issues, most important from the point of view of literary tourists. They were asked whether they were planning to visit Łódź under the influence of the book (Fig. 8), and if so, what they would like to see there.

Here, the respondents' opinions differed again. The number who wanted to visit the city was similar to those who did not. More than one-third of respondents (nearly 36%) who answered this question declared an intention to visit Łódź. Considering the rather negative image of the city emerging from the respondents' statements, this could be regarded as a good result. A similar percentage of respondents declared 'neutrality' and did not think that Lampiony had changed anything in their attitude to Łódź. Perhaps the factor responsible for this opinion was an increasing awareness of the historical monuments and tourist attractions presented

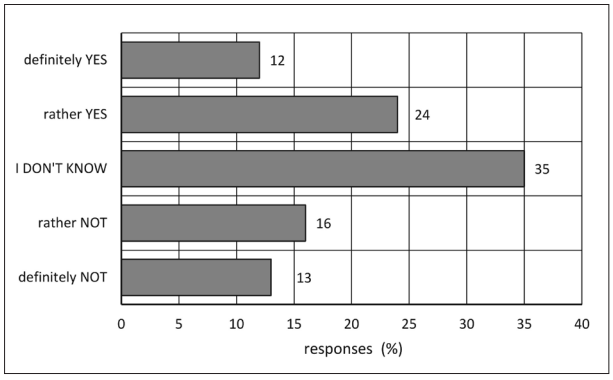

Fig. 8: The choice of Łódź as the destination of a planned tourist trip after reading the book
Source: authors' compilations from sample survey

in the analyses of individual elements of the city's image. It is possible that readers could be persuaded to visit Łódź by the 'contrastive' and, consequently, original atmosphere of the city, presented in the novel. This hypothesis may be confirmed by an analysis of the places indicated by the respondents as those which they would like to visit. Common answers included 'the whole city', 'to feel this atmosphere', 'you should visit the whole city, not only some parts'. The most commonly mentioned specific place is the main street, Piotrkowska, (the readers had probably heard about it before reading the novel), historical tenement houses and the underground canals, where a large part of the action takes place and which are not open for visiting (apart from the museum, where some of the action also takes place).

5.4 Major determinants of visiting Łódź

For more detailed analysis concerning the probability of readers visiting Łódź, a general linear modelling approach was used. Regression analysis included only the responses of participants living outside Łódź (n = 120). A large set of independent variables were analysed: whether the respondent had ever been to the city (yes/no); the first association after reading the book (positive/negative); familiarity (any knowledge/no knowledge); change of attitude (the book changed/did not change opinions about the city: respondent's declaration); direction of change (for better/ for worse); living in a large city (over 300,000 inhabitants: yes/ no); remembered places (the respondent mentioned/ did not mention places remembered from the novel); evaluating the realism of the descriptions in the book (realistic/unrealistic); evaluation of the storyline (positive/negative); whether the reader is the writer's fan (yes/no); and sex (female/male).

From the set of 11 independent variables, four were found to be statistically significant: 'large city', 'first association', 'change of opinion' and 'direction of change'. Due to the strong correlation between the latter two, the less explanatory variable ('direction of change') was subsequently excluded from the model. Due to the binary character of the variables (values 0 or 1), a logistic regression model was specified.

The dependent variable was 'planned trip to Łódź'. It was the reader's declaration whether they were planning to visit the city in the near future (implicitly after reading Lampiony). Value '1' was ascribed to 'YES' and '0' to 'NO'.

As regards the significant independent variables, the codes '0' and '1' were as follows:

- 'large city': '1' = the respondent lives in a large city (over 300,000 inhabitants), '0' = the respondent lives in a small town or the countryside;
- 'first association': '1' = positive association, '0' = negative association;
- 'change of opinion': '1' = the respondent declares that after reading the book, she/ he changed opinions on Łódź (to positive or negative), '0' = the respondent did not change opinions after reading the novel.

When this reduced set of independent variables is used in the analysis, the logistic regression model is significant (see Table 3).

The interpretation of the results leads to the following conclusions:

- Respondents living in 'Large cities' declared their willingness to visit Łódź more rarely. The value for the Exp(B) = 0.271 coefficient means that approximately in

Change of opinion	B	Std. deviation	Wald test	df	Sig.	Exp(B)
Association	2.489	0.487	26.085	1	0.000	12.051
Large city	– 1.307	0.492	7.067	1	0.008	0.271
Change of opinion	1.214	0.491	6.105	1	0.013	3.367
Constant	– 1.560	0.510	9.349	1	0.002	0.210

Tab. 3: Logistic regression for the dependent variable: 'a planned visit in the city'
Source: authors' calculations using SPSS software

the case of every third person, the place of residence has a significant influence on taking a decision concerning a potential visit to the city;

- A positive 'Association' has the most positive influence on the decision to visit the city (the value of Exp(B) is over 12, which means that a positive association results in a decision to visit the city over 12 times more often than a decision not to); and
- The declared 'Change of opinion' about the city has a positive influence on the declaration to visit. The value of the Exp(B) coefficient higher than '3' means that the decision to visit was made three times more often among those who admitted that the book had changed their opinion about the city. This change is particularly significant from the point of view of the discussion about the role of the book in shaping the decision concerning the choice of the tourist destination. It shows that such a relationship does exist and the role of the novel in shaping opinions about the city to a certain extent influences the plans for a trip.

For this model, the results (Chi-square = 52,025 and significance > 0.0001) confirm its significance. The coefficients of fitting the model to Cox and Snell's R-square data and to maximally corrected R2 – Nagelkerke, at the level of 0.352 and 0.477, indicate a good fit. Expressed relatively, these results show that the decision to visit Łódź will probably be taken by those from smaller places (small towns and villages), who might have changed their opinion about the city under the influence of the book, and that likely their first association with Łódź after reading was positive. This means that if Łódź authorities want to use Lampiony for promotion, it would be reasonable to run an advertising campaign in smaller towns rather than in large cities (different from before when the publisher's advertising campaign was run in cities). From the point of view of attracting tourists to the city, it would probably be better to buy a copy of the book for village and town libraries than to run an expensive billboard campaign in the capital.

6. Conclusions and recommendations

Literary tourism is growing in popularity. There are more and more academic publications on this form of tourism, but only a few concern research on the influence of reading a literary work on the motivation to choose specific destinations.

Many studies have demonstrated that novels whose action is set in real, specific places have a considerable influence on shaping the image of these places, but it is not always a desired (positive) image, which might result in readers visiting the city. The following factors are important in this process: the reader's place of residence; earlier stereotypes concerning the city (and whether they have been confirmed or changed by the descriptions included in the novel); as well as attractive, unknown places and facts presented in the book. We must not forget, however, any reader's individual approach to the work, visible in their extreme feelings, emotions and opinions.

From the point of view of the objectives set for this paper, it is important to note that reading the novel has had a positive influence on making the decision to visit the city (in this case Łódź) by people living in small towns, who had changed their opinion after reading the novel. This conclusion is confirmed by both the detailed qualitative analyses of the responses, and by the statistical methods used. It would be interesting to check whether this relationship also applies to the inhabitants of large cities who read such novels set in smaller places.

It should be remembered, however, that depending on the author's intentions and vision, as well as the character of the content included in the descriptions (authenticity, naturalness, emotionality), the final effect may vary from delight to extreme disgust. Therefore, city promotion taking advantage of 'grim' novels (such as Lampiony) is risky and may bring results quite different from expected.

Considering the originality of these analyses based on research conducted among readers, potential tourists, as well as any effects of the actual influence of literature on the choice of destination, it is worth recommending similar comparative studies concerning other novels set in specific locations. The variables in such future research should be not only the locations (their size, character and brand), but also different literary genres. This will make it possible to compare the results, both in spatial and problem-related aspects. It is important for any such study to be conducted among readers who are not directly familiar with the place described in the book, as in this case of "Lampiony". One of the results might be an investigation of to what extent a literary work can be the basis for creating not only a new, attractive tourist product, but also a whole image of a city as an interesting tourist destination.

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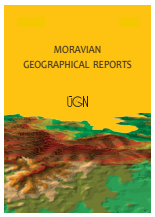

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SCIENTIFIC COMMUNICATION

Prestigious honour for the discipline of Geography: The Karel Engliš Honorary Medal presentation to Professor Bryn Greer-Wootten

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Abstract

This communication concerns the prestigious award - the Karel Engliš Honorary Medal for Merit in the Social and Economic Sciences - that Bryn Greer-Wootten, Professor Emeritus at York University in Toronto and the Editor-in-Chief of the Moravian Geographical Reports (MGR), received from the Czech Academy of Sciences in 2018. The article contains the most important and interesting points from the Laudation by Professor Radim Blaheta (Chair of the Institute of Geonics' Institutional Board and the previous Director of the Institute), the Response by Professor Greer-Wootten, and the Closing Speech by Bohumil Frantál (Executive Editor of MGR), which were presented during the award ceremony on August 28, 2018 at the historic Löw-Beer Villa in Brno, Czech Republic.

Keywords: *Karel Engliš Honorary Medal, award ceremony, Bryn Greer-Wootten, Czech Academy of Sciences*

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1. Introduction

On August 28, 2018, Bryn Greer-Wootten, Professor Emeritus at York University in Toronto and the Editor-in-Chief of the Moravian Geographical Reports, was presented with the prestigious Karel Engliš Honorary Medal for Merit in the Social and Economic Sciences by Professor Eva Zažímalová, President of the Czech Academy of Sciences.

The Karel Engliš Honorary Medal for Merit in the Social and Economic Sciences was established by the Academic Council of the Czech Academy of Sciences on February 14, 1995, for outstanding contributions of Czech and foreign scholars in the social and economic sciences. The medal was named after Karel Engliš (1880–1961), a famous Czech economist and politician, Professor at Masaryk University in Brno and at Charles University in Prague, and a member of the Czech Academy of Sciences and Arts in the field of national economics. For further details about the award and political economist Karel Engliš, see the website of the Czech Academy of Sciences (2018).

Some 75 persons, approximately 2/3rds professional geographers from various Czech universities and research institutes, attended the ceremony at the historic Löw-Beer Villa in Brno, Czech Republic.

2. Laudation by Professor Radim Blaheta

Professor Bryn Greer-Wootten was born in West Ham, London, UK in 1938. He completed his M.A. in Geography at Durham University in 1962, after moving to Canada. In 1968 he obtained a double Ph.D. (Geography and Planning) at McGill University in Montreal. He taught at McGill and at the University of California, Berkeley, before his appointment in Geography and Environmental Studies

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Fig. 1: Professor Bryn Greer-Wootten has his speech during the award ceremony (Photo: Z. Říha)

at York University in Toronto in 1970. At York, he was promoted to Full Professor in 1983 and became Professor Emeritus and Senior Scholar in 2003. Currently, he is Professor Emeritus in the Faculty of Environmental Studies and the Department of Geography, an Associate Director of the Institute for Social Research (ISR), and an Associate Coordinator of the Statistical Consulting Service (ISR).

Dr. Greer-Wootten's first contact with the Institute of Geonics was with the Department of Environmental Geography in 1998, in connection with his sabbatical research on the ecological and social impacts of nuclear power developments. He has been a consistent contributor to the CONGEO Conferences since 2001. In 2003 he was appointed a member of the Editorial Board of the Moravian Geographical Reports, and in 2012 he became the Editor-in-Chief of the journal, a position he retains until today.

For the Institute of Geonics (IGN), he has been a member of its International Advisory Board since 2006 and has made some valuable contributions. For the Academy, Dr. Greer-Wootten has served as a visiting International Expert for the Review of the Institute of Geonics in 2011, and in 2014–2015 he was a member of the CAS Review Committee: External Evaluator, International Expert for the Review of the Institute of Geonics. His comparative analyses with Canadian experience have been invaluable.

From the perspectives of the Institute of Geonics and the Academy of Sciences, the contributions of Bryn Greer-Wootten to Geography reflect several important elements:

- his broad range of interests, from deep (philosophical) thoughts and investigation of basic problems and principles in Geography, to applications of modern statistical analysis;
- he has been a consultant and enthusiastic advisor for the (young) researchers from the Department of Environmental Geography, including assistance with publications;
- his important participation in the development of research concepts in the Institute of Geonics and the Department of Environmental Geography; and
- his very important contributions and selfless hard work in increasing the quality of our journal, the Moravian Geographical Reports.

As an acknowledgement of his exceptional and generous work for the Institute of Geonics, we proposed awarding Professor Greer-Wootten the Karel Engliš Honorary Medal for Merit in the Social and Economic Sciences.

Many thanks to Bryn Greer-Wootten for his friendship, and the work he has devoted in favour of the Institute of Geonics, the Academy of Sciences and the Czech Republic. Cordial wishes to Bryn for continuing his fruitful, valuable work, to have good health, to be as usual full of positive energy and the joy of life.

3. Response by Professor Bryn Greer-Wootten

I thank Professor Radim Blaheta for his remarks, all the while wondering if he was actually talking about me! Some of my expressions of gratitude are as follows:

- First, to The Academy – to Madame President Professor Eva Zažímalová for coming to Brno from Prague to make this presentation on behalf of the Academy Council;
- Second, to the Institute of Geonics – to former Director Radim Blaheta, my perhaps "unconscious mentor" for all matters 'Academy' in nature, and to current Director Josef Foldyna, for many logistical and other solutions behind the scenes for today's meeting;
- Third, to members of my family for making this journey with me – especially to my wife Mirka, without whom, quite literally, I would not be here today, and to my sister Annemarie from England, accomplished historian of religion and (now retired) actress of renown, so I will be trying my best to 'perform' well today!;
- Fourth, to my colleagues in the Department of Environmental Geography: I owe a special debt to former Heads of the Department who have helped me in many ways, academic and otherwise, during my visiting appointments: Doc. Antonín Vaishar, Doc. Karel Kirchner, and currently Dr. Petr Klusáček. Principally,

I am most indebted to my colleagues on the Editorial Board of the Moravian Geographical Reports, on which body I have been proud to serve as Editor-in-Chief for the last ten years: Bohumil Frantál (the best Executive Editor of any geographical journal anywhere!), Stanislav Martinát, Tomáš Krejčí, Jana Zapletalová – and even some members of the Board from "away" – greetings to Dan van der Horst from Edinburgh!; and to all of you who have honoured me by your presence today!

Now, I have a few moments to share some thoughts with you about my journey to this place and at this time – thoughts that perhaps constitute some elements of 'merit', as indicated by the Medal itself – as clearly decided by the Academy, for which I am truly humbled. I do not want to make a big point of it but when one reaches a certain age, much water has passed under the bridge. In this case, the 'water' is the continually flowing currents of geographical thought over the last fifty-plus years, and the 'bridges' are certain landmark points characterising those currents, captured at specific points in time.

In many ways I have been fortunate to witness and, to some extent, to be a part of some rather dramatic changes that have "ravaged" or "saved" the discipline of Geography, depending on 'from where' and 'when' one looks at it! Please note: 'from where' and 'when' – the essence of a "Geographical Perspective" – today encapsulated in the driving motif of current Geographical research as "space-time" – a conceptual umbrella for all that geographers aspire to do – but difficult to realise as one's basic Euclid does not work! Unabashedly, I am also following in the steps of my friend, Kevin Cox, in his magisterial account of the evolution of Human Geography (Cox, 2014).

My own journey begins more than sixty years ago as an Honours undergraduate at Durham University in the UK. The prevailing motif of the day and for decades before then was "The Region": a concept as real or imagined as one wished, but one that was supposed to unite Physical and Human Geography. My dissatisfaction with the constraints of this concept was realised in my Masters thesis (Greer-Wootten, 1962), which demonstrated that a former regional entity – the Darent Valley in North West Kent – had been 'destroyed' by the metropolitanisation of the countryside. To my surprise, I was not required to defend my thesis.[1]

Perhaps emboldened by this turn of events, I ventured even further into the theoretical framing of regional problems in my doctoral work (in Geography and Planning) at McGill University in Montreal, Canada. The 1960s were the exciting times of the so-called Quantitative Revolution in Geography – and I was swept up into this cyclone of ideas.

While I strongly believe that these early academic experiences have had a strong influence on my development as a Geographer, in the interests of time I am going to use a commonly accepted framework for the development of the discipline since the late 1950s, and present some brief examples (among many such possibilities) of the work that I have carried out in line with this evolution.

The Quantitative-Theoretical Revolution: 1960s +[2]

In a sense this was a real revolution – against descriptive regional accounts, branching out to include many sister social science disciplines, especially economics with its strong emphasis on theory and model building. The geographic work was also strongly geometric, driven by William Bunge's (1962) 'Theoretical Geography'. My doctoral dissertation was completely in this mode, and the following statement gives some idea of what this work entailed, as much brazen as in its lack of humility: "One might speculate that geography, with a full development of the geometric approach, may one day be defined as that discipline that investigates the interface between two-dimensional space and multidimensional spaces. Processes occur in the latter spaces, and have some spatial elements in them …" (Greer-Wootten, 1968, p. 276).

Reactions to Theoretical Geography: 1970s +

Against the restrictive (spatial) modelling of the 1960s, researchers began to question the absence of decision-making processes. For the Behavioural Revolution, empirical research depended to such a large extent on survey research methods, such that important methodological issues as sample design, questionnaire design, fieldwork using direct interviews, etc., gained importance – but the analysis continued to be largely quantitative in nature. This methodological approach continues to inform my empirical research to the present. As part of this 'revolution', my work in this area largely concerned intra-metropolitan migrations in Montreal and Toronto: imagine my dismay when we found that most migrant paths were random in nature (Greer-Wootten, 1972; Greer-Wootten and Gilmour, 1972), relatively unaffected by spatial structural constraints.

Another alternative to the theoretical modelling of the 1960s is seen in research that places humans at the centre of geographical research and, importantly, humans as humans – their beliefs, values, attitudes, perceptions, life-styles, etc. This Humanistic Turn stressed identity, landscape as a visual entity but also lived, region as home, topophilia, place (not space), etc. My own work in this area – for about 15 years when I never touched a statistic and in the process missed out on exciting work on Geographical Information Systems – primarily concerned people without 'home', not only homeless but "identity-less" refugees in Toronto. A phenomenological approach revealed the ways in which refugees reconstituted their lives – interpreted as a metaphor of a broken mirror, smashed into many many pieces, which gradually became whole again, piece by piece, until they were able to see themselves whole, again, a new identity (Morris, 1994). Such a metaphor cannot be gained from 'normal' social science – it is too complex and multilayered – but place matters.

Radical Geography: Early Marxist versions: 1970s +

Another equally important critique of 1960s spatial modelling is registered in the early work in Radical Geography, a movement largely inspired by Marxist scholars, especially by another friend, David Harvey.

My particular experience in this work was in the Toronto Geographical Expedition – an offshoot of the famous Detroit expedition led by Bill Bunge (Bunge, 1971: yes, the same theoretical geographer). Today, we would say that it was an example of geographical participatory action research. Then,

[1] In the 1950s and 1960s in the U.K., it was not necessary to defend one's thesis unless there were 'problems' with it! – lucky for me, as I was a new immigrant in Canada, without financial resources!

[2] The '+' indicates that most so-called "revolutions" or "turns" continue to be represented in geographical research today

as now, in such research, the aim was to reveal the distinctive ways in which people organised their own space and why this is important in planning.

When Bill first came to Toronto (as a Visiting Professor at York for two years), I offered to show him the city, its structure and land use, following typical disciplinary norms. His first request, however, was to take him to "the ghetto": my response that such an area "did not exist in Toronto" was not well received, initially – but then, in typical dialectical response mode he said: "OK, so what makes Toronto work?"

It took another two years of intensive 'expeditionary' fieldwork to begin to answer this question, resulting in a book with the provocative title: "The Canadian Alternative" (Bunge and Bordessa, 1975), much of which related back to Bill's innovative assertion that 'as long as we take care of the children, our society will be equitable and open and...' (i.e. the things that American society is not).

Policy-oriented Geography: 1980s +

A strong implication from previous geographical research was that it did not pay enough attention to resolving practical planning and policy questions, i.e. that it was oriented to its own (academic) pursuits… basically, it was not relevant. Stronger ties to research on governance (from political science) emerged, especially oriented to important policy questions with an immediate geographical basis – such as any questions that related to environmental issues (e.g. acid rain), or natural resources (e.g. energy), or socio-political issues (e.g. discrimination, housing), etc.

My own work in this area primarily concerned energy resources: recycling and energy conservation; and nuclear power and its socio-economic and political problems (Greer-Wootten and Mitson, 1976) – largely viewed as examples of risk management issues, greatly influenced by the work of Harry Otway and his associates at IIASA in Austria (Greer-Wootten, 1980).

Modern Critical Geography: 1990s +[3]

The earlier Radical Geography gradually shed much of its Marxist clothing to incorporate many approaches with a consistent epistemological base (i.e. stressing the nature of the knowledge produced by the researchers; how do we judge what is valid and reliable information?, etc.). In this respect, I note the following:

- The researcher does not only stand inside the researched phenomena (as with the humanist approach, compared to spatial modelling); and
- Does not only incorporate understanding of human behaviours in space and time (as in the behavioural geography approach, compared to spatial modelling); and
- Does not only approach the researched phenomena from a Marxist or similar perspective (e.g. class-based analysis compared to the earlier geometric modelling);
- But demonstrates a stand-point epistemology.

What is a standpoint epistemology for critical Geography? Note: 'critical' does not necessarily equate to 'critique' – it is epistemological, not methodological. In the research process it involves several important and interdependent and often overlapping steps, but primarily it involves accepting one's own values as an input to all stages of the research process – i.e. the set of questions that relate the researcher to the researched phenomena, an epistemological decision that minimally involves the following steps:

- From… What phenomena are worthy of investigation?… {who decides on priorities? Is it the researcher (typical academic response: yes; critical response: problem to be negotiated with people, etc.};
- To... Which methods best serve the demands of this inquiry?… {concerns researcher imposition [power issue] or negotiated response?};
- To… What methods of fieldwork? {community involvement in the field}... xx ... ; and
- To… How to best communicate the results of this work? {With whom? For what purposes?} …
- ... {And then repeat the process}.

Here are some of the typical responses to these questions from critical geographers:

- Stemming from "What phenomena?": the objective of the work is to change the situation, directly political (e.g. reduce inequalities, fight for tenants in public housing, etc.);
- Stemming from "Which methods?": often qualitative in nature, but better as mixed methods (i.e. quantitative and qualitative) to serve end-user demands; the actual method choice is often co-determined with people subject to the issues;
- Stemming from fieldwork demands: participatory action research, inter alia; and
- Stemming from "How?": the importance of public presentations, especially in the public domain (e.g. hearings, social media,…).

Critical Geography therefore encompasses a distinctive approach to geographical problems, (almost) regardless of substance. Nonetheless, some of the substantive issues investigated under this banner include:

- Feminist Geography (critical of patriarchy, e.g. in employment, in social reproduction, in social movements, etc.);
- Development Geography (also called post-colonial: problems of neoliberalism, globalisation, the 'Global South', racism, etc.);
- Labour Geography (working with trades unions, participating in strikes, scalar relations in employment, etc.);
- Population Geography (critical demography; refugee studies; the geopolitics of population movements, etc.);
- Political Geography (borderlands research; security studies, etc.); and
- Critical Geography of X, Y and Z: you name it (including the bio-physical domain), we do it!

My work in this area has been to attempt to bring a critical sensibility to various substantive problem areas: such as a continuing interrogation of regionalism and the theories of regions (e.g. Greer-Wootten, 2005), scale and scalar politics (Greer-Wootten, 2007), and the problems of sustainability (e.g. Vaishar and Greer-Wootten, 2006) at various CONGEO conferences over the years since 1999; such as attempts to continually upgrade submissions to the Moravian Geographical Reports, especially in terms of argumentation

[3] The strongest 'turn', by many degrees

and methodology for the last ten years; such as contributing to renewable energy studies (e.g. Greer-Wootten, 2017), and research on brownfield redevelopment with my colleagues here at the Department of Environmental Geography (Frantal et al, 2015); and to studies at my Institute for Social Research at York University in Toronto, such as those on Canadian identities, the public health system, etc.

The Current Alternatives: Hybrid Geographies… …the Anthropocene

There are reactions (of course) to Critical Geographies, which tend to be less concerned with a pragmatic voice for Geography, less action-oriented, less political, more inward-looking (to the discipline?). Two of the current important developments are as follows:

- Hybrid Geographies/Relational Geographies/More-than-human Geographies: a grand refusal of binaries such as Nature-Society, etc. This stream of work is derived recently from work in the 'New' Cultural Geography and post-colonial studies or more commonly from Science and Technology Studies (STS) derived from Latour's (2005) Actor-Network Theory. My view is that the latter studies are most noteworthy; and
- Geographies of the Anthropocene – the new geological era – largely alarmist rather than responding to the reality of global climate change, which truly presents challenges for Human and Physical Geographers to work together. If in fact the Anthropocene serves to unite geographers in their research, I would be warmer to its call for action.

Future Interdisciplinary Human and Biophysical Sciences

Geography's traditional interdisciplinary objectives concern 'place' (originally 'region') where the natural sciences and the social sciences and the human sciences meet! Yet we know from many attempts at interdisciplinary research projects, that a key element for the success of such difficult endeavours is communication! Beside any language or translation boundaries (basically, methodological issues), we need a common set of beliefs and values to guide our research: an epistemological bond that is provided by critical sensibilities: Yes! There is a Critical Physical Geography as well as a Critical Human Geography!

The bonding comes from common standpoint epistemologies, exhibited primarily in which societal problems we choose to investigate (poverty is not prioritised over flood risks, landslides over regional inequalities, etc.) – and how we intend to "right the wrongs" in our public engagements. These two points are strongly inter-related.

(In the guise of) Conclusions

So – Geographers of the world unite!! You only have to lose your discipline! And you only have to admit that there is no longer an elephant (climate change) in the room – the elephant is the room!! So, maximise your hearts in what you do – but, please do retain your theoretical and practical interests in making this world a better place! Finally, I would like to say – "Jsem tu jako doma! Mockrát děkuji!" (in English: "I'm here at home! Thank you very much!").

4. Closing Speech by Bohumil Frantál

I spent few weeks wondering what I should talk about when Professor Blaheta asked me to prepare a speech for this event (particularly for the guests who are not geographers), perhaps some lecture on the importance of Human Geography in the world today, and then reflecting Bryn's contribution to it. From the beginning I was little embarrassed since, first, I'm not originally a geographer but a sociologist, and second, I do not feel sufficiently experienced for such a task – especially to present it after the laureate's comprehensive presentation. Therefore, I will simply try to present my subjective views of what are the fields of research in which I see Geography can play a key role – and these areas are actually the ones where the research activities of our Department of Environmental Geography meet with the work of Bryn Greer-Wootten.

It is still not easy for me to explain to my family and friends what I actually do in my work (or what geographers do in their work). The most common laic idea is still probably that geographers are making maps. It has been often said that Geography is a "distinct" discipline, but Geography is a multi-paradigmatic, an extremely broad discipline that includes a wide variety of perspectives, approaches, and specific topical areas which span both the natural and social sciences. It is a science which may be perceived as being "a little bit about everything".

The lack of a clear public understanding of Geography as a discipline is caused also by the fact that – at least in the Czech Republic – geographers are little to be seen in the media commenting on current issues and news (in comparison with economists, sociologists or political scientists). Bryn Greer-Wootten is the first geographer to receive some honorary medal of the Czech Academy of Sciences since their foundation in 1995. It seems to reflect the fact that Geography is apparently the single traditional scientific discipline which does not have its own separate institute in the Czech Academy of Sciences. The Institute of Geography was cancelled after 30 years of its existence in June, 1993, in the process of the transformation of the Czechoslovak Academy of Sciences (Vaishar, 1993). Only one department (the 'Department of Geography of Natural Environment' then, and the 'Department of Environmental Geography' as it is called today) prevailed as part of the newly-established Institute of Geonics. Nonetheless, this situation does not mean that Czech and Moravian geography is weak and internationally non-competitive. I dare to say the opposite: Czech geographers already play an outstanding role in many fields of research in the European or even global context.

We live in an era of the so-called 'third energy transition', a transition from the fossil fuel-powered age into the post-industrial era, which is characterised by the scarcity of natural resources, energies and living spaces (Whipple, 2011). The following three words – energy, recycling, resilience – represent some of the most important challenges of our time, and the same research themes that our Department deals with, but – in my eyes – they also well illustrate the characteristics and qualities of Bryn Greer-Wootten.

Already in 1961, the Canadian geographer John D. Chapman recognised the rapid growth in demand for inanimate energy and the role geographers could be playing in explaining its patterns and importance in the growing world economy (Chapman, 1961). The last decades have shown that this prediction was true, and now geographers are studying an even wider spectrum of energy challenges than Chapman could ever have imagined. As a social science, Geography has become more critical than ever to our understanding of how inhabitants of our planet interact and how the quest for energy is affecting economic and political stability everywhere: as Pasqualetti and Brown (2014, p.1)

indicate, "If energy and society are parts of the same cloth, geography is the thread that ties them together". Czech Geographers (see for example, Frantál et al., 2018; Frantál and Malý, 2017) currently investigate issues that Bryn Greer-Wootten dealt with more than forty years ago, such as public perceptions and attitudes to nuclear power plants, the problems of nuclear waste disposal, public acceptance of different energy production and conservation systems, or the perceptions of environmental risks in general (Dobson, Greer-Wootten and Mitson, 1976; Douglin and Greer-Wootten, 1980; Greer-Wootten, 1980, etc.).

The second topic where Geography can play a key role and where the research activities of our Department meets Bryn's interests, is the recycling of landscapes or the regeneration of underused, abandoned or derelict lands (the so-called brownfields). With its integrative view of the world, Geography can provide a framework for conceptualising 'brownfields' as products of the interrelationships between places and social and ecological processes (Bjelland, 2002). Geography and GIS can play an important role in many aspects of brownfields regeneration (Frantál et al., 2013)

Last but not least, I have to (once again) emphasise Bryn's role in the Moravian Geographical Reports (MGR) journal. He has been a member of the Editorial Board since 2003, and in 2011 we started together to work on the goal to be indexed in the Web of Science database (by reconstructing the Editorial Board, setting more strict criteria for accepted papers, promoting special issues on current hot topics, etc.) – and we succeeded just one year later. The MGR has gradually become the leading geographical journal in Central Europe. The graph in Figure 2 well illustrates the qualitative development of our journal from the time when Bryn started to actively "intervene" in the journal review and editorial process.

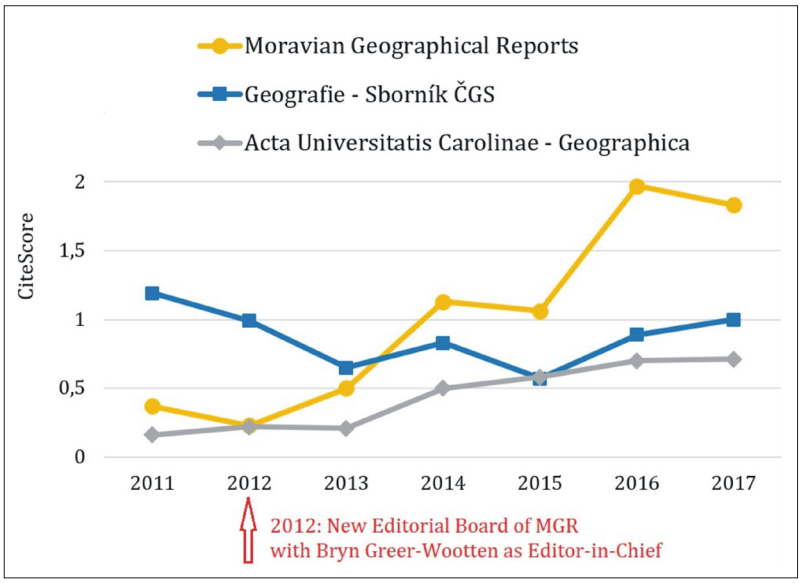

Fig. 2: Development of the CiteScore metrics of three leading Czech geographical journals
Source of data: SCOPUS, 2019; authors' elaboration

Moreover, Bryn Greer-Wootten is not just a name on the journal's pages. His active role starts with the initial review of submissions and ends with the detailed cross-check and proofreading of all accepted papers. His work is, actually, not just proofreading, but careful and detailed work that attempts to have all published papers as high quality as possible.

The 'blacksmith of words' is probably a proper term for describing one of Bryn's skills of working with words and sentences. When you look back at the titles of papers presented at the CONGEO geographical conferences (which our Institute has been organising since 1993), Bryn's papers have always been among the most attractive, appealing or even provocative ones – not only by their titles by also by their contents (see e.g. "A Politics of Scale and the Regional Trap", "The 'New Regionalism' and 'Europe of the Regions: A Geographical Oxymoron?", or "Radical Alterity and the Concept of Regional Identity").

It has always been his endeavour to present geographical research in an attractive form – be it in his own papers or the papers of other authors being published in MGR, or in the papers of myself or my colleagues with whom Bryn helped in some way (for example in consulting with respect to the statistical analysis or interpretation of data, recommending literature or proofreading English). His excellent work with words and his influence on our work is well illustrated by one story with which I would like to close my speech. Bryn Greer-Wootten is the only geographer of the people whom I know personally who has published in the 'Progress in Human Geography' journal and its predecessor 'Progress in Geography' (see Greer-Wootten, 1972; Bailly and Greer-Wootten, 1978), a famous geographical journal, which is unattainable for most Czech geographers.

So far, only one of my articles has been cited in Progress in Human Geography (Calvert, 2016). The citation includes part of a sentence from the paper on 'New Trends and Challenges for Energy Geographies', which was an introductory paper to a Special Issue of MGR (Frantál et al., 2014, p. 5). I have to admit that this one sentence has been conceived by Bryn, when he helped us with the proofreading of the paper. Let me end this speech by this sentence: "… Geography as a discipline has changed, to reflect the world as inhabited – but also the world as desired".

I hope that this award for Bryn Greer-Wootten, which can be considered also an award for Geography as a discipline, will contribute to a new revival of Geography within the Czech Academy of Sciences. At least, our Department will work hard for such a goal.

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Fig. 3. Members of the International Advisory Board of the MGR journal in front of the Institute of Geonics

Fig. 4. The Löw-Beer Villa in Brno, a place of the award ceremony

Fig. 5. Professor Eva Zažímalová, president of the Czech Academy of Sciences, presents Professor Bryn Greer-Wootten with the honorary medal

Fig. 6. Professor Bryn Greer-Wootten has his speech during the award ceremony

Illustrations related to the paper by R. Blaheta et al. (photo: T. Krejčí, E. Nováková (2×), Z. Říha)