

Methods for delineation of functional regions using data on commuters

Miha Konjar, Anka Lisec and Samo Drobne
University of Ljubljana, Faculty of Civil and Geodetic Engineering

Abstract: A functional region is a territorial unit resulting from the organisation of social and economic relations that is characterised by high frequency of intra-regional interactions. This uniform territorial unit often presents an important platform for development strategies of the country or region, and should combine different functions and their interactions on different scales. For their delineation one may consider different methods and different directly or indirectly geo-referenced data, such as population flows, trade in goods and services, communications, traffic flows, service connections, newspaper circulation, financial flows, etc. From the mentioned interactions, the daily interaction in the labour market can be considered as a good approximation for the functional region, and as such is used in most European countries. The paper analyses different methodologies for delineation of functional regions using only data on commuters between Slovenian municipalities. Three methods were compared and tested: two already described in the literature, local labour market approach, and commuting zone approach and here suggested commuting aggregation approach. A case study for Slovenia was conducted.

Keywords: commuting, labour market, functional region, municipality, Slovenia

1 INTRODUCTION

The main aim of sustainable spatial development policies as one of the main priorities of development strategies of European countries, is balanced development of the whole territory of the country. European Spatial Development Perspective (ESDP, 1999) defines three fundamental goals: economic and social cohesion, conservation and management of natural resources and cultural heritage, and more balanced competitiveness of the European territory. In order to achieve these goals, the present state of regional development has to be studied for suitable economic and political decisions. Each analysed territory should be based on complex, open, dynamic, and nonlinear system that works on basis of functional connections between smaller and larger territories. Here, region is considered as a dynamic system that is very complex and difficult to manage from the administrative point of view. In consequence, a so called functional region is the most appropriate unit for economic analysis, and for interaction of political, social, and economic processes (Tomaney and Ward, 2000).

A functional region is a territorial area characterised by high frequency of intra-regional economic interaction, such as intra-regional trade in goods and services, labour commuting, and household shopping (Karlsson and Olsson, 2006). It is characterised by its agglomeration of activities, and by its intra-regional transport infrastructure, facilitating a large mobility of people, products, and inputs within its borders. There are many types of interaction, such as population flows, trade in goods and services, communications, traffic flows, goods flows, service connections, newspaper circulation, and financial flows (Vanhove and Klaassen, 1987). From the mentioned interactions, the daily interaction in the labour market can be considered as a good approximation for the functional region (Cörvers, Hensen and Bongaerts, 2009). For delineation of functional labour market regions commuting flows are used in most OECD countries (Organization for Economic Cooperation and Development) (OECD, 2002). The basic characteristic of such defined functional region is the integrated labour market, in which intra-regional commuting, as well as intra-regional job search, and search for labour demand is much more intensive than the inter-regional counterparts (Karlsson and Olsson, 2006).

Regionalizing countries into functional regions consists of two separated problems that can be regarded as modifiable areal unit problems (MAUP) (Unwin, 1996). First, there is a scale problem, which refers to the choice of the appropriate number of regions; second, there is an aggregation problem, which basically refers to the choice of an appropriate regionalization (Cörvers, Hensen and Bongaerts, 2009). For delineation of functional labour market regions, we analyzed various methods used in most OECD countries (OECD, 2002). In practise, two different concepts to delimit functional regions are used: (a) delineation around a centre, and (b) delineation using algorithms or cluster analysis based on a combination of distance, closeness, commuting thresholds, travel times, etc. Functional region is therefore a system of highly connected smaller and larger places, and consists of one or more centres, and the appurtenant hinterland (Karlsson, 2007). In centre based delineation, particular care needs to be taken in definition of the centres. While some countries identify centres according to the population or level of employment, others take account of commuting conditions. In the latter case, the centre must be “self-sufficient”, which means that the number of workers living and working there is higher than the number of workers commuting to another centre.

The theoretical models of delineating commuting regions propose that we understand the commuting patterns of working population. Here, different factors determine where persons with a fixed place of residence choose to work. It is supposed that all workers have information about jobs, wages and travel costs, that all jobs are concentrated in two centres i and j , and that all wages are the same in i and j , but in general a bit higher in j ($w_j > w_i$). Another assumption is that all the jobs are equal in terms of skills they demand, and that all workers have the same skills. In theoretical model, all workers live on a linear strip between i and j . Travelling from any point between i and j is associated with travel costs, c_i and c_j , that increase with the distance to i and j , respectively. Given that, it is now assumed that the objective of the workers is to maximise the real wage (w) net of the generalised travel cost (c). This net wage we refer to as ω . The net wage at any location between the two centres is $\max\{\omega_i, \omega_j\}$. The two functional regions consist of the locations (x), which satisfy either $FR_i\{x: \omega_i(x) > \omega_j(x)\}$ or $FR_j\{x: \omega_j(x) > \omega_i(x)\}$ (Karlsson and Olsson, 2006).

Some of the most used methodologies for delineation of functional regions are the three approaches described by Karlsson and Olsson (2006): the local labour market based on one way commuter flows, commuting zone approach based on calculated mutual dependence between municipalities, and accessibility approach. The last one is based on the accessibility concept and investigates both the employers’ access to workers, and the workers access to jobs. Another methodology is the one used by the Statistical Office of United Kingdom, which defines Travel-To-Work-Area based on commuting of working population. Moreover, up-to-date GIS tools also have a major impact on the delineations of functional regions. GIS tools offer new approaches, use new and different methodologies. One of those is also software FlowMap¹, which allows different analysis and modelling of commuting flows (OECD, 2002).

The main purpose of this paper is a comparison of different methodologies to delineate functional regions using only commuting data which are based on the application of the selected methodologies for the case of Slovenia. In the practical part, we selected and tested three different methods: the local labour market approach, commuting zone approach, and commuting aggregation approach. In the third methodology, which is suggested by authors of this paper, the functional regions are formed without predefined central municipalities, by aggregating municipalities one by one, using only commuting data. The aim is to aggregate territorial units into highly connected systems with high economic interaction.

¹ FlowMap is a Utrecht Universities’ program, accessible on <http://flowmap.geog.uu.nl/Index.html>. It is used for GIS analysis and presentation of interactions and flows in analysed areas.

2 METHODS

In our study, three methods to delimitate the commuting (functional) regions were chosen: local labour market approach, commuting zone approach, and, here developed, commuting aggregation approach. The selected approaches gave us an inside look in two different concepts: delineation of functional regions around the predefined centre municipality, and another one that do not use predefined centre municipality as a starting point for aggregation of spatial units (in our case municipalities). Application of these three methods for the study case requires adjustment of the methods to characteristics of Slovenian commuters, and characteristics of Slovenian labour market.

2.1 The local labour market approach

There are three different levels of interaction that may be used in delineation of a functional region using labour market approach (Karlsson and Olsson, 2006). Let suppose two (regional) centres indexed i and j , that are connected by a line, and x , denotes an intermediate point between the endpoints i and j . At a location x , the commuting frequency to the centre i is $f_i(x)$. The functional region consists of all geographic locations that satisfy one of the following three conditions. The first condition is to include all locations with any commuting to the centre i . The extension of the functional region i , FR_i is defined by $FR_i = \{x: f_i(x) > 0\}$. A second alternative condition would be to use a cut-off frequency \bar{f} for inclusion.

$$FR_i = \{x: f_i(x) \geq \bar{f} > 0\} \quad (1)$$

The cut-off frequency in condition (1) gets rid of the very few long distance commuters. This rule does not allow extremely low interaction. With the second condition, one obtains a smaller functional region than when using the first condition. The third criterion for defining a functional region is to consider neighbouring central places, and to calculate the breakpoint between the different central places. The border is found where the attraction is equal to both of the closest cores. This is formally described by:

$$FR_i = \{x: f_i(x) \geq f_j(x)\} \quad (2)$$

In theory, the borders of functional regions are exactly defined. In practice, the functional region consists of smaller areas (spatial units) that have been aggregated based on commuting flow. This means that the smallest spatial unit, for which there exist commuting data, influences how close the estimated functional region will be to the theoretical functional region.

The first step at this approach is to identify municipalities that are strongly self-sufficient. A list of strong self-sufficient municipalities was created for the Slovenian case (Drobne, Konjar and Liseč, 2009). A municipality was considered strong self-sufficient and was higher on the list if it fulfilled two conditions. The first condition was based on the sum of commuting frequencies of working population from the municipality i to municipality j , and was calculated as:

$$f^{(i)}(\%) = \sum_j f_j / (\sum_i f_i + \sum_j f_j) \leq \bar{f}^{(i)}(\%) \quad (3)$$

In (3), $f^{(i)}(\%)$ is the percentage of workers who lived in the municipality i and commute to other municipalities j ; $\sum_j f_j$ is total number of workers who live and work (stay) in the municipality i ; $\sum_i f_i$ is a total number of commuters who leave to other municipalities j from the municipality i , and $\bar{f}^{(i)}(\%)$ is a cut-off relative frequency. The second condition for self-sufficient municipality was based on number of working places in the municipality i , w_i . These criteria placed the municipality higher or lower in the list, relatively to the number of working places that the municipality offered.

When self-sufficient (central) municipalities were defined, chains of municipalities were created from non self-sufficient municipalities until condition (2) was satisfied. This condition defines the border of functional region, which is the break line, where the attraction is equal to both of the closest self-sufficient municipalities. The chains were calculated automatically, using our own software based on Java platform². The chains are formed from (a) municipalities that are directly connected with their maximum commuting flow of working population to the predefined centre – these municipalities were automatically connected to that centre; (b) municipalities that are not directly connected with their maximum commuting flow to the predefined centre, but are connected with their maximum commuting flow to non self-sufficient municipality, which is then further connected with its maximum commuting flow of working population to one of the predefined centres and (c) the pairs of municipalities, which present each other the destination of the maximum flows, have been connected to the centre, to which the direction of the second maximum flow is oriented.

2.2 The commuting zone approach

The second approach for delineation of functional regions based on commuting flow is less focused on centres than the first method. The commuting zones are built from the existing mutual dependence between municipalities rather than from one-way dependence. The first step is the same as in the previous case (determination of self-sufficient centres). The second step is calculation of the mutual dependence that serves to aggregate municipalities into functional regions around the selected central municipality. The number of commuters from the municipality i (j) to the municipality j (i) is measured by C_{ij} (C_{ji}). P_i (P_j) is the number of working population in the municipality i (j). The strength of two-way commuting ties, mutual dependence, is calculated by (4).

$$(C_{ij} + C_{ji}) / \min\{P_i, P_j\} \quad (4)$$

With inclusion of such a measure, we can see that two municipalities with a large one-way commuter-flow do not necessarily qualify as a region (Karlsson and Olsson, 2006). The method favours local connections between municipalities and their mutual dependence to a regional centre.

2.3 Commuting aggregation approach

The main difference between the first two methods and the commuting aggregation approach is that the last one is not based on predefined centres of the functional regions. The starting points are the municipalities by itself, and the functional connections between them, which in our case are defined by data on commuting flow of working population. The suggested methodology is partly based on both previously described approaches. The first step is calculation of the share of people commuting from the municipality i to any other municipality. The maximum share (commuting flow) is used to aggregate the municipality i to the municipality j , which is the provider of working places for the maximum flow of commuters from i . By formation of new relatively small local labour systems, it is possible to identify some of the centres by the number of municipalities that were aggregated to the centre (central municipality). The formation of local labour systems goes from small labour market sub-systems of several centres to the complex systems with limited number of centres. In the first step, defined local labour market (sub-) systems are then included in the second step, where mutual dependence between the local labour (sub-) systems is calculated:

$$(C_{ab} + C_{ba}) / \min\{P_a, P_b\} \quad (5)$$

² Java is a trademark of Sun Microsystems, Inc.

In (5), C_{ab} (C_{ba}) represents the number of commuters from local labour system a (b) to local labour system b (a), and P_a (P_b) is the number of the working population in the local labour system a (b). Mutual dependence can be used for the second aggregation and formation of new functional regions on a higher level. In this way, delineated functional regions include all municipalities that are connected by maximum flows, and all municipalities that are strongly dependent.

3 CASE STUDY

The study of functional regions in Slovenia is partly connected with the introduction of administrative regions with regional administration. Because it has already been more than twenty five years since the introduction of local self-government, it seems that this problem is a never ending story of Slovene Geography (Piry, 2005). The majority of regionalization proposals have been already in a way functionally oriented, since they were based on dominant gravitation of rural surroundings, appurtenant hinterland to one or more centres (Perko, 1998). Today, there are few main goals of future regionalization of Slovenia. Decentralization of state functions, and transfer of important part of public affairs from the state to regional level, harmonious regional development, and inter-national cooperation (FGG, IPP-UL-PF and SJN, 2009).

Previous researches give us a good review of the phenomenon of commuting to work in Slovenia. Bole (2004) describes basic patterns, causes, and consequences of the daily mobility of workers as well as the influence that the central municipalities have. Results of Interreg project RePUS (Pichler Milanović et al., 2008) and some other ESPON projects (ESPON 1.1.1, 2005; ESPON 1.4.3, 2007) have delineated Slovenia into 42 local labour systems (“micro-regions”), and 17 regional labour systems (“mezzo-regions”). Those systems were defined using data from Statistical Register of Employment, and some additional social and economic data to define central municipalities. The main aim of that work was to define and delineate functional urban (see also Zavodnik Lamovšek, 2005). More about functional and administrative regions was discussed in (Drobne et al., 2009).

3.1 Data, application of the methodology and results

In our case study, the data on inter-municipal commuting to work were acquired from Census 2002 (SORS, 2009). There were a total of 287,272 inter-municipality commuters between 192 municipalities in Slovenia. Most of them (more than 74%) used cars, either as a driver or passenger, and only 9% of working population commuted to work by bus, and less than 1.5% of them by train (Bole, 2004). We analysed 36,672 ($192^2 - 192$) inter-municipality connections.

In our first attempt to delineate Slovenia into functional regions, centre-based labour market approach was used. Information about one-way commuter flows of inter-municipal working population was the only data used in the model of local labour market approach. Figure 1 shows functional centres, and the appurtenant hinterland resulted from the local labour market approach, where municipalities were aggregated to the predefined central municipalities, based on chains created using the maximum flow of commuters.

The methodology was already described in the previous chapter. For more details about the methodology applied, and more results see also (Drobne, Konjar and Lisec, 2009), and (Drobne et al., 2009). The first step in this approach requires definition of self-sufficient municipalities as the centres of local labour market. Here, we used different thresholds for self-sufficiency. We propose that the municipality in Slovenia is self-sufficient if less than 35% of working population commuted from the municipality to other municipalities, and if there were more than 15,000 working places in the municipality in the case of nine functional regions.

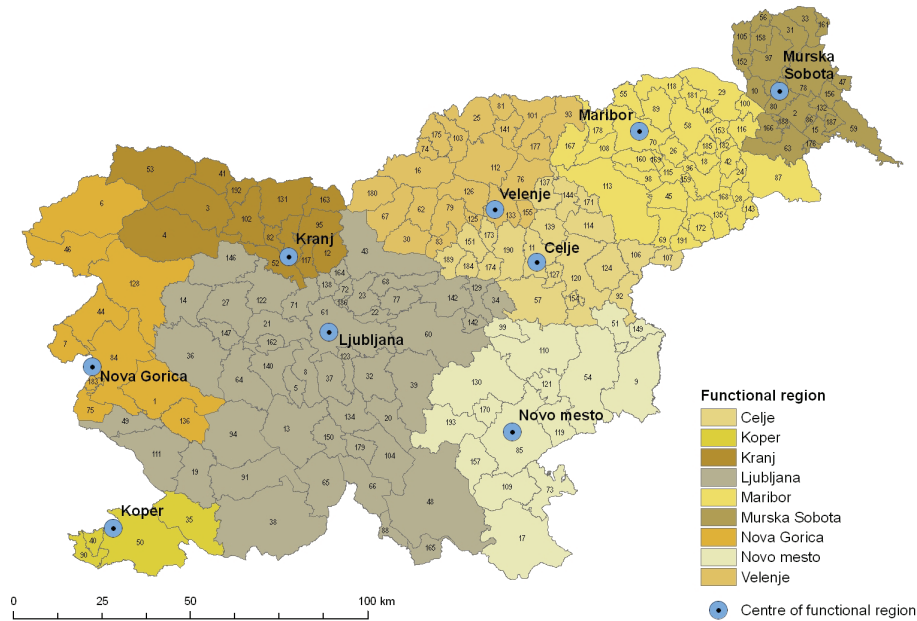


Figure 1: Nine functional regions of Slovenia defined by local labour market approach.

Different breakpoint values have been examined for different numbers of functional regions. This value has also been the most appropriate in order to test nine administrative regional centres in Slovenia (Drobne et al., 2009). Based on predefined centres, the chains of municipalities were created from non self-sufficient municipalities following the principle of maximum flows of commuters in the direction of different centres (Figure 1).

The second approach, the commuting zone approach, is also a centre-based labour market approach with a major consideration of dependency between municipalities on lower scale. The centres of functional regions are selected on the same principle as in the first method. The commuting zones (functional regions) are delineated from the mutual dependence between municipalities which is calculated from the commuters' flows in both ways. For this purpose, the dependence between all the municipalities was calculated on mutual flows of commuting flow of working population.

The appurtenance to the predefined centres was established following the directions of four higher dependencies (the highest commuting flow of working population). 45% of all municipalities show direct major dependence with one of nine self-sufficient centres. When considering the first two highest dependences, almost 70% of municipalities have been connected to one of the predefined centres. When considering the highest four dependences, 90% of the municipalities have been assigned to the centres. For the remaining 10%, as well as for the municipalities at the border of so formed regions, the manual rechecking of the directions of major dependencies has been done. In this way, we confirmed the appurtenance to one or another centre. Figure 2 show the delineation using commuting zone approach.

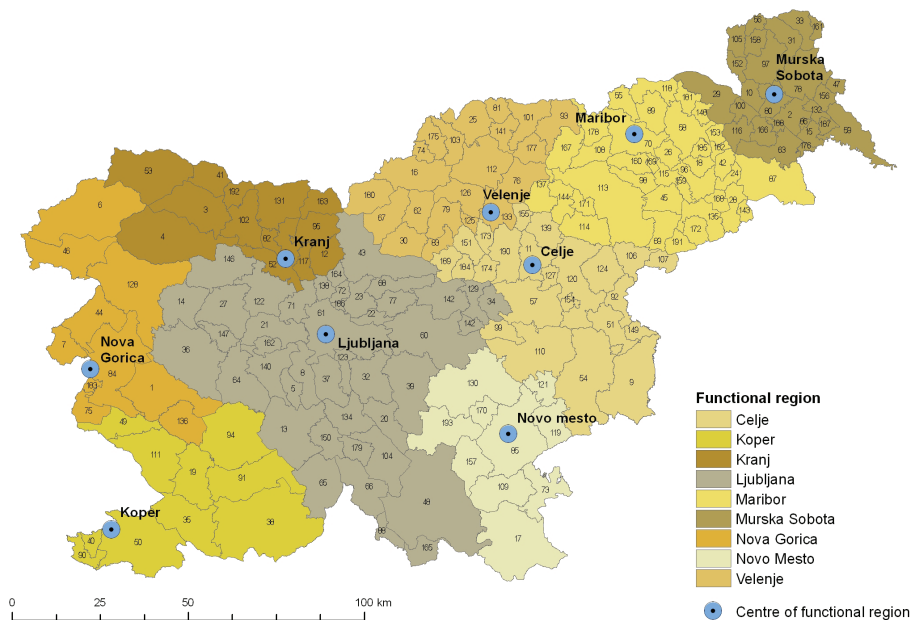


Figure 2: Nine functional regions of Slovenia defined by commuting zone approach.

The idea for the third methodology originates from the question how to use data on commuting at a lower level where regional centres are not predefined. Having used maximal commuters flows, we first formed small local labour markets at the lowest scale that consisted, for example, also only of two municipalities. The result of this first step was delineation of Slovenia into 31 local labour markets that were reutilised, and again aggregated using the idea of mutual dependences between so defined labour market areas as typical for the commuting zone approach. Here, some final modifications of the method were used from the same reasons as at the commuting zone approach. As an example, the local labour market of Kranj showed maximum dependence with Ljubljana, but all the other dependences show that Kranj is connected with the functional region in the Nord-West of Slovenia, where local labour markets of Radovljica (102), Jesenice (41), and conditionally Škofja Loka (122) municipalities are strongly connected with the labour market in the municipality of Kranj. A similar situation is in the case of local labour market system of Postojna (94) which, when considering all dependencies, also shows a very strong dependence of the costal functional region. This should be taken into consideration when deciding about appurtenance of the Postojna municipality (94) to Ljubljana functional region.

As the result of here suggested methodology, commuting aggregation approach is showed in Figure 3, where the number of the functional regions deserves a special attention. Since the methodology is interactive where progressive aggregation of predefined local labour market systems (areas) is considered, the number of regions is dependent on this interactive aggregation of the local labour systems. For our case, the optimal number which can be compared with the results of the first two approaches is ten functional regions.

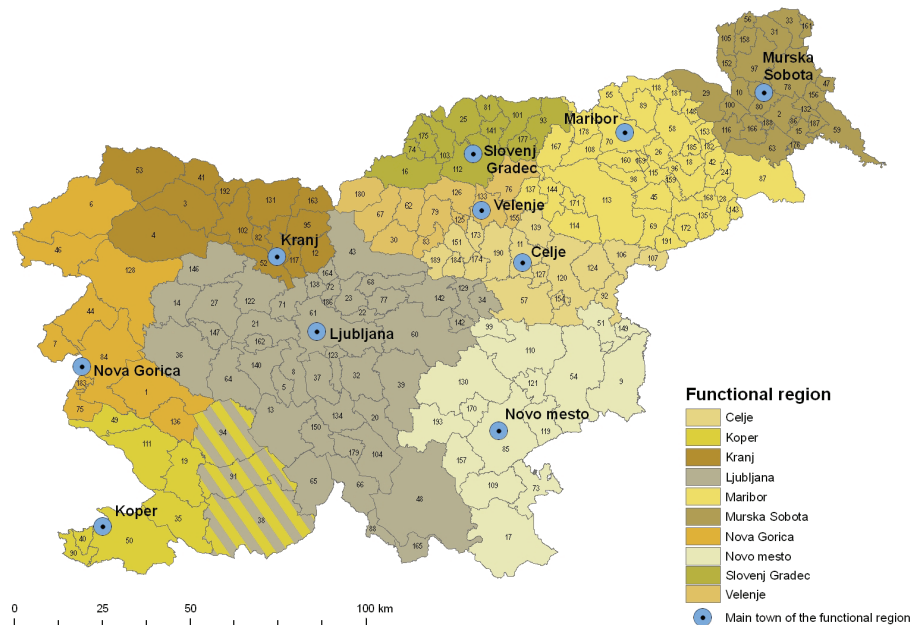


Figure 3: Ten functional regions of Slovenia defined by commuting aggregation approach.

The introduced methodologies show different kinds and levels of dependence between the spatial units (municipalities). All the presented approaches for delineation functional regions considered aggregation of these spatial units by maximum flows of commuters between municipalities. When comparing results of three approaches for modelling functional regions, it can be concluded that predefined centres manifestly influence delineation of the country. Even without predefined regional centres, the results are comparable with analysed two centre-based approaches, in particular centres of the labour market zones. There are also some differences in the results of the first two methodologies; the mutual commuting flow of working population between the municipalities (the commuting zone approach) brought more reliable results. Furthermore, some distinctions are noticed for municipalities close to the border of the functional regions. Those small municipalities are often problematic when discussing administrative regionalisation. It can be assumed that the “problematic, border” municipalities are functionally connected to different centres and neighbouring municipalities.

4 CONCLUSIONS AND FURTHER RESEARCH

In the paper, we suggested different methods for delineation of functional regions using only data on working inter-municipal commuters. The selected approaches gave us an inside look in two different concepts: delineation of functional regions around the predefined centre municipality, and here suggested and tested approach that do not use predefined centres of municipalities as a starting point for aggregation of spatial units (municipalities). The third methodology offered a new approach of forming local labour systems (functional regions) without predefined centres (which are necessary input for the other two approaches retrieved from the literature: the local labour market approach, and commuting zone approach). We extended previous work of delineation of Slovenia into functional regions using methodologies based only on commuters’ data.

As showed from many authors before, the daily interaction in the labour market can be considered as a good approximation for the functional region. But also the decision about the appropriate methodology is important. According to different scales of the regionalization, and different purpose, an appropriate methodology should be considered. In this way, delineation functional regions can be used as a good starting point and framework for further analyses and research.

BIBLIOGRAPHY

- Bole D., Daily mobility of workers in Slovenia = Dnevna mobilnost delavcev v Sloveniji. *Acta geographica Slovenica* 44, 1: 25-45, 2004.
- Cörvers F., Hensen M., Bongaerts D., Delimitation and Coherence of Functional and Administrative Regions, *Regional Studies*, 43:19-31, 2009.
- Drobne S., Konjar M., Liseč A., Delimitation of Functional Regions Using Labour Market Approach. In Zadnik Stirn L., Žerovnik J., Drobne S., Liseč A. (ed.). *Proceedings of SOR'09, 10th International Symposium on Operational Research in Slovenia, Slovenian Society Informatika (SDI), Section for Operational Research (SOR), Ljubljana, Slovenia, 417-425, 2009.*
- Drobne S., Liseč A., Konjar M., Zavodnik Lamovšek A., Pogačnik A., Functional vs. administrative regions: Case of Slovenia. In Vujošević M. (ed.). *Thematic Conference Proceedings: Vol. 1. Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia, 395-416, 2009.*
- ESPON 1.1.1, Potentials for polycentric development in Europe. Final project report, Stockholm, Nordreigo, 2005.
http://www.espon.eu/mmp/online/website/content/projects/259/648/index_EN.html
Last date accessed 12.2009.
- ESPON 1.4.3, Study on urban function. Final Report. IGEAT – Institut de Gestion de l'Environnement et d'Aménagement du Territoire. Université Libre de Bruxelles (Lead Partner), Brussels, Belgium, 2007.
http://www.espon.eu/mmp/online/website/content/projects/261/420/index_EN.html
Last date accessed 01.2010.
- ESDP 1999 - European Spatial Development Perspective, 1999. Towards Balanced and Sustainable Development of the Territory of the European Union. Agreed at the Informal Council of Ministers responsible for Spatial Planning. Potsdam, Published by the European Commission: pp 87.
- FGG, IPP-UL-PF, ILSJN, Skupno zaključno poročilo strokovnih študij v okviru projekta uvedbe pokrajin v Republiki Sloveniji, University of Ljubljana, Faculty of Civil and Geodetic Engineering, Institute for Comparative Law at the Faculty of Law in Ljubljana, Institute for Local Self-Management and Public and Public Order Maribor, Ljubljana, Slovenia, 2009.
- Karlsson C., 2007 Clusters, Functional Regions and Cluster Policies. CESIS Electronic Working Paper Series. KTH, Stockholm, Sweden.
<http://www.infra.kth.se/cesis/documents/WP84.pdf>, Last date accessed 01.2010.
- Karlsson C., Olsson M., The identification of functional regions: theory, methods, and applications. *Ann Reg Sci* 40: 1 – 18, 2006.

- OECD, 2002 Redefining Territories – The functional regions. Organisation for Economic Co-operation and Development, Paris: pp 130.
- Perko D., The Regionalization of Slovenia. *Geografski zbornik* 38: 12-57, 1998.
- Pichler Milanović N., Cigale D., Krevs M., Gostinčar P., Černe A., Zavodnik Lamovšek A., Žaucer T., Sitar M., In Drozg, Pečar J. Strategy for a Regional Polycentric Urban System in Central-Eastern Europe Economic Integrating Zone. RePUS project, Final report. University of Ljubljana, Faculty of Arts, Ljubljana, Slovenia, 2008.
- Piry I., Regionalisation of Slovenia – Never ending story of Slovene geography. *Dela* 24: 37-48, 2005.
- RePUS 2008, Strategy for a regional Polycentric Urban System in Central-Eastern Europe Economic Integration Zone, Final Report. Budimpešta, Interreg III B.
- SORS 2009, Persons in Employment - Daily Commuters by Municipality of Residence and Municipality of Place of Work, Municipalities, Slovenia, Census 2002, Statistical Office of Republic of Slovenia, Ljubljana, Slovenia
www.stat.si/pxweb/Database/Census2002/Municipalities/Population/Activity/Activity.asp,
Last date accessed 09.2009.
- Tomanej J., Ward N., England and the »New Regionalism«. *Regional studies* 34, 5: 471 – 478, 2000.
- Unwin D. J., GIS, spatial analysis and spatial statistics, *Progress in Human Geography*, 20:540–551, 1996.
- Vanhove N., Klaassen L. H., *Regional policy: A European approach*, 2nd edition. Avebury, Gower Publishing Company Limited, Aldershot: pp 398, 1987.
- Zavodnik Lamovšek, A., 2005 *Opredelevitev tipov razvojnih regij (MEGA in FUA) za Slovenijo za potrebe preveritve rezultatov projekta ESPON 1.1.1. Izdelano v okviru projekta ESPON 1.1.3.* University of Ljubljana, Faculty of Civil and Geodetic Engineering.