IDENTIFICATION OF URBANIZATION AXES IN THE SETTLEMENT SYSTEM OF THE CZECH REPUBLIC

Jiří Nerad [1]

[1] Department of Geography, University of South Bohemia in České Budějovice, Jeronýmova 10, České Budějovice, Czech Republic, nerad40@seznam.cz

Abstract

The paper submitted deals with the issue of urbanization axes in the settlement system of the Czech Republic. The empiric study of urbanization axes represents an unexplored topic in geography. In the context of this paper, urbanization axes consist of larger urban centres with intensive mutual relationships. Prior to specifying them, the theoretical part describes general development of spatial and relationship organisation in settlement systems. Further, it deals with bases of study of spatial interurban interactions emphasizing the interurban relations between commuting to work and the transport interaction. The methodological part introduces the methods of urbanization axes specification. Every urbanization axis must fulfil two basic criteria. First, it must only be created by centres with a certain minimum complex size (population plus labour market size), and the second criterion consists in their mutual intensive communication. The main analytical part of the work analyses these criteria. The result of the analysis was identification of nine comprehensively interconnected urbanization axes in the territory of the Czech Republic.

Key words: the Czech Republic, urbanization axis, synthetic graphic method, spatial interactions, interurban interactions.

INTRODUCTION

Urbanization axes represent a relatively unexplored topic in social geography. Actually, however, they represent a natural part of all settlement systems. These structures are usually perceived only intuitively in settlement systems. The only urbanization axes that are used in social geography more frequently are the blue or the yellow banana. However, significant European axes are defined rather on the basis of generalization of intensive reciprocal relations among the settlements within the axes. In case of the blue banana, for instance, its specification is usually blamed for an excessive focus on quantifiable economic standpoints. We can more often come across a general term "development axes". Their definition was dealt with by e.g. Hampl et al. (1987) or later Spurná (2008) applying the spatial correlation method. The basic development axes are defined by spatial development policy, which is a national spatial planning instrument. Spatial development policy is managed by the Ministry for Regional Development of the Czech Republic. Development axes at different hierarchical levels are defined in these principles of spatial development. There are defined overall 13 development axes with national importance (see MRD 2015). However, this is merely a generalization, empirically unfounded. These axes are defined along main road and railway communications. Development in these areas (mainly population growth of settlements) is only assumed and not scientifically substantiated.

The absence of empiric definition of some urbanization axes within the settlement system of the Czech Republic is rather surprising. In fact, the origination of urbanization axes corresponds with the principal rules (properties) of the geographic

space. This is proved by the first geographic law by Tobler (1970), who says that everything is connected with everything, but closer geographic space units adjoin one another (interact with one another) more than the more distant ones. This statement implies that towns are in continuous mutual interaction and the shorter the distance between them, the more intensive their interaction. The origination of urbanization axes is also supported by another basic property of the geographic space – its heterogeneity. The geographic space heterogeneity determines unequal arrangement of higher hierarchic order centres, and, as a result, also the necessity of interurban interactions. This property (especially in terms of general society arrangement) is probably most handled by Hampl (e.g. Hampl et al. 1987, Hampl 2005, 2010).

As a result, the principal aim of this paper is to empirically define urbanization axes in the settlement system of the Czech Republic. An urbanization axis is understood a set of comprehensively interconnected centres of a higher hierarchic order. Comprehensive interconnection is determined by various social-geographic interurban relationships showing a reciprocal character. In the paper submitted, higher order centres are perceived as towns with a certain minimum complex size ensuring their sufficient "urbanization" (urban character). Other partial objectives of the paper are standardization and hierarchization of urbanization axes. Standardization expresses differentiation of axes based on their internal structure. This evaluation reflects relationships between dominance (of one centre or more of them) and submission within an axis. Hierarchization of urbanization axes determines their importance differentiation within the entire settlement system of the Czech Republic.

THEORETICAL BACKGROUND: DEVELOPMENT OF SETTLEMENT SYSTEMS AND STUDY OF SPATIAL INTERURBAN INTERACTIONS

As mentioned in the introductory part, specification of urbanization axes lacks a theoretical basis. An attempt to define them is especially related to continuous development of settlement systems and their hierarchy. This paper is based particularly on arrangement of relations in these systems. The arrangement of relations represents vertical and horizontal relationships inside the systems. Vertical relationships reflect the hierarchical organisation of settlements and horizontal relationships represent the interurban interaction (Mulíček and Seidenglanz 2011). The dynamics of development of settlement systems is described by many authors just with an emphasis on the horizontal (interurban) relations (e.g. Bura et al. 1996).

The development of settlement systems has its historical continuity. Their quantitative and qualitative development dynamics primarily reflects the development of the entire society. In this context, their development is most often demonstrated on the basis of a three-level stage theory model. However, division of the model into pre-industrial, industrial and post-industrial stages has primarily no geographic origin. Its main ideas reflect the whole-society or economic development (Rostow 1960). In Czech geography, the society organisation in relation to the geographic interpretation of the stage theory model is most often handled by Hampl – see for example Hampl et al. (1978, 1987) and Hampl (1998, 2005).

The main objective of the paper, empiric specification of urbanization axes, is especially related to transfer into the post-industrial stage of development of settlement systems. This transition was especially associated with principal political and economic changes. While during socialism hierarchic organisation of settlements was shaped and competition and polarisation mechanisms prevailed, cooperation mechanisms started to predominate after the post-industrial era had started. It is a natural consequence of an increasing rate of mutual dependence and interconnection of settlements (Herbert and Thomas 1997). The vertical (hierarchic) organisation experienced development of especially the largest settlement centres, into which increasingly more controlling functions concentrated and thus supra-nodal cores and metropolitan compounds were created (Hampl 2005). However, the hierarchic development does not comprise population growth, which experiences rather stagnation. As a

result of these development tendencies, one-sidedly oriented interurban relations are turning into reciprocally oriented ones and complex patterns of spatial interactions originate among settlements (Mulíček 2008). Reciprocal interurban interactions are especially represented by commuting to work, school or to reach a service, transport connections, movement of information contacts, etc.

Interurban interactions are represented by a subtype of spatial interactions, which comprise any form of spatial mobility not only of the inhabitants, but also of movements and relations, in which people do not participate directly but induce them somehow (Haynes and Fotheringham 1984). The geographic space heterogeneity causes continuous interaction among centres, which is induced by unequal arrangement of social-economic sources and increases the hiearchic position of the centres in the areas of their higher concentration. A higher or lower hiearchic position is determined by intensity and direction not only of the interurban relations connected with mobility of the inhabitants but also with the relations created by transfer of materials, information and energies (Halás and Klapka 2010).

The first stages of the study of spatial and interurban interactions were preceded by studies of spatial arrangement of settlements and their facilities. The very beginning is connected with Thünen's theory of concentric agricultural zones of the beginning of the 19th century – see von Thünen (1826). This theory laid the foundations of other significant theories concerning the arrangement of settlements. The first of them is represented by Weber (1909) and his theory of the industry localisation, within which he enriched geography with terms such as the localisation factor, localisation unit, etc. Then, Christaller (1933) and his theory of central places of 1930s represent one of the most important models of hierarchic and spatial organisation of settlements in the entire social geography. Actually, the entire study of interurban interactions is reflected by the first geographic law described in the introductory part, which implies the principal properties of inter-municipal relations. See Tobler (1970) and his proposition that everything is connected with everything, but things that are closer to each other are connected with each other more.

The first period of more intensive research into the spatial and relation organisation of settlements is connected with the launch of quantitative methods into geography in 1950s and 1960s. These methods brought an emphasis on the spatial organisation of the geographic reality (Daněk 2008). One of the most important authors dealing with the spatial organisation of settlements was Haggett (1965, 1977). The author formulated a spatial (localisation) analysis of the settlement arrangement. He intended to clearly and locally define the spatial and relation organisation of settlement systems by means of geometric models. He used as the basis formerly described localisation theories and especially Lösch's modified theory of central places. The basis of his theory is a concept of a central – nodal region. He considers a nodal region a basic spatial unit. He defined it as an area surrounding the settlement (centre), which is connected with it on the basis of spatial organisation. Haggett's model is based on interaction of nodes with its surroundings, which create communication networks. Different meaning of nodes creates their importance hierarchies – see Haggett (1965, 1977).

According to Frantál et al. (2010) it is possible to divide the current methods of monitoring the spatial organisation of geographic phenomena and their spatial interactions into two basic groups. The first method is based on quantitative methods and the second one on synthetic graphical methods. Modelling of spatial interactions on the basis of quantitative methods is primarily associated with application of the first models including gravity ones. These models are based on Newton's gravitation law and are generally used for specification of centres' spheres of influence. The most frequently used model is Reilly's one, which was originally constructed for the purpose of wholesale coverage area. In the territory of the Czech Republic, the application of the gravity model using the data of commuting to work and school was pursued by e.g. Halás et al. (2009) and Halás, Klapka (2010). The gravity model was applied to transport interaction most by Řehák (e.g. 1992)

and further by e.g. Hudeček (2008) and Bartošová (2008). According to Seidenglanz (2007), the gravity models are not in the centre of attention of geographers any longer, which also applies to modelling of transport interactions.

The frequently used methods include functional regionalization, which is most often carried out on the basis of commuting to work. Macka (1969) was the first to deal with commuting regionalization based on whole-national data. This issue was also handled by Hampl mentioned above – see his work Hampl et al. (1978, 1987, 1996) or Hampl (2005). Sýkora (e.g. Sýkora et al. 2007 or Sýkora and Mulíček 2009) also focuses on regionalization based on commuting; he defines the so-called FUT (functionally urbanized territories). Last but not least, the most important regionalization also includes e.g. an atlas by Maryáš and Řehák (1987).

Of course, the study of transport interactions is closely connected with commuting and therefore with some of the works mentioned above. This work used the methodology of Maryáš and Řehák (1987) which, besides commuting, also monitored transport interconnection of settlement centres. The first possibilities to show transport interactions among centres were pursued by e.g. Hůrský (1974). The same author later dealt with the first transport-geographic regionalization (Hůrský 1978). At present, transport-geographic regionalization is pursued, for example, by Kraft – see Kraft et al. (2014a and 2014b). He focuses his studies also on transport hierarchy of centres (Kraft et al. 2009 and Kraft 2012). Marada (e.g. 2003 and 2006) is another one to deal with transport hierarchy. This author belongs to leading personalities of Czech transport geography. Marada (2010) analysed the overall transport-geographic organisation of the society and his work also includes supra-nodal transport interactions of interest. Among more important Czech geographers is also, for example, Seidenglanz (2007), who focused on transport position and transport services of peripheral areas of the Czech Republic. Seidenglanz (2010) also researched transport interactions in Moravia as a potential for creation of local polycentricity, and some of his methods were applied in this work for modelling of transport interactions.

RESEARCH METHODS

As mentioned above, the empiric specification of urbanization axes in this work is based on two aspects. First, it was necessary to define settlement centres with a higher hierarchic position. This step ensured the necessary urban character of the individual centres and was carried out on the basis of a complex size analysis of towns – see Hampl (2005). It is a comprehensive indicator of a hierarchic level of a town, which is a synthesis of its population and labour market size. Only those towns of the Czech Republic were selected which meet the criterion of complex size of 2.5 and more. The result was 427 centres, the comprehensive interconnection of which was researched in the following stages of the analysis. Specification of hierarchically higher settlement units was followed by an analysis of their "supra-nodal" interurban relationships focussing on their reciprocal character. Identification of urbanization axes was based on two forms of interurban interactions – namely transport and commuting. These interactions were used as an integral element of urbanization axes.

In the first case, only public transport interactions were monitored and the respective data were taken from IDOS electronic timetable. The quality of traffic connection among the centres was specified by means of the method by Maryáš and Řehák (1987). In this case, the traffic connection quality is defined by representation of reciprocal lines in the individual hourly intervals of the morning peak between 5:00 a.m. and 8:59 a.m. Only direct lines were chosen. The time of arrival was monitored, and what was decisive was not the number of lines but their representation in the individual hourly intervals. The maximum connection in one direction was 4 and in both directions 8. Wednesday, 27 March 2015, was determined as the reference day, as there were no restrictions or restraints. The limit to the maximum length of travel resulted out of the size differentiation of the individual centres. We used the method by Seidenglanz (2010), who singled out 6 size categories of towns and assigned to them different maximum time spent commuting to work (see Table 1). This resulted in the total of 1,539 connected pairs of centres with the traffic

Table 1 Limitation of time accessibility of centres. Source: Seidenglanz 2010; author's calculations.

Population	Maximum time accessibility (min)
0 – 14,999	45
15,000 – 29,999	50
30,000 – 49,999	55
50,000 – 99,999	65
100,000 – Brno	80
Prague	105

connection values from 1 to 8. Maryáš and Řehák (1987) believed the minimum value of very good transport connection was representation of at least 5 lines, as values of up to 4 can only represent one-sided connection. Only pairs that achieved the minimum value of 5 were taken into consideration in this context. Thus, the result of combining both methods was the total of 987 suitable transport interactions.

Commuting to work and school was another form of the interurban interaction monitored. Like with transport connections, we used the data on daily periodicity and the criterion of intensive reciprocal connection had to be fulfilled. Therefore, the minimum value of 100 commuters in both directions was determined. Thus, the minimum volume of commuting between two centres was represented by 200 daily commuters. Such relations that involved centres not achieving the complex size described above were removed from the resulting ones. The result totalled 193 pairs the commuting relationships of which met all the criteria specified above. These interactions formed a basis for other stages of the analysis of urbanization axes identification.

The starting point for specification of urbanization axes consisted in a synthesis of principal commuting and transport criteria for the pairs of towns, which were made even stricter. This concerned an increase in the minimum number of commuters in both directions from 100 to 200 in case of daily commuting. As far as the transport interconnection quality is concerned (see Maryáš and Řehák 1987), all centres had to show mutually intensive connection (value 8). In addition, another criterion was used for transport connections, which included the minimum mutual sum of 100 or more direct links of public transport per day. Resulting urbanization axes were considered centres with this so-called comperehensive interconnection, while isolated pairs of centres were removed and at least 3 towns had to participate in the interaction.

The total of nine urbanization axes were identified in the final stage taking these steps. In addition, their internal structure or hierarchization of the centres within the axis based on the prevailing direction of commuting was analysed. It was just commuting as the most important current process of the spatial mobility of inhabitants that was deliberately taken into consideration. Moreover, transport relations usually show almost a balanced reciprocal character. The prevailing direction of commuting was derived from a simple ratio of those departing from centre A to centre B and vice versa. What was also hierarchized was the individual urbanization axes among one another. This was carried out using a ratio of monitored daily interactions falling upon each urbanization axis:

$$P_{DI} = \frac{I_{UA}}{I_{BSC}} = \frac{I_{UA_{COM}} + I_{UA_{TRA}}}{I_{BSC_{COM}} + I_{BSC_{TRA}}} \cdot 1000\ [‰]$$

where:
P_{DI} – proportion of daily interactions;
I_{UA} – total number of daily interurban interactions integrated in urbanization axis;
I_{BSC} – total number of daily interurban interactions in a basic set of centres;
$I_{UA_{COM}}$ – number of daily commuting interactions integrated in urbanization axis;
$I_{UA_{TRA}}$ – number of daily transport interactions integrated in urbanization axis;
$I_{BSC_{COM}}$ – number of daily commuting interactions integrated in a basic set of centres;
$I_{BSC_{TRA}}$ – number of daily transport interactions integrated in a basic set of centres.

The ratio of daily interactions expresses what share of transport and commuting interactions is integrated in the individual urbanization axes. This share is based on the total number of interurban interactions in the basic file of centres. A file of 193 pairs of centres complying with the principal commuting criteria was marked as the basic file of centres.

IDENTIFICATION OF URBANIZATION AXES

The starting point for definition of the urbanization axes was specification of the total of 427 towns that complied with the methodical criteria mentioned above. Centres with the highest complex size value are shown in Table 2. This concerns 11 strongest mesoregional centres, which are represented by nearly all regional centres. Only Karlovy Vary and Jihlava are an exception. Enormous (population and work) importance of Prague exceeding other centres in a remarkable way manifests itself in the strongest category. In contrary, regional centres at 5th (Olomouc) to 11th (Ústí nad Labem) positions have rather a balanced complex size. The number of centres in the individual complex size categories is shown in Table 3. It is obvious here that the number of centres in the individual categories is very asymmetric. This is a proof of strict hierarchic arrangement in the settlement system of the Czech Republic, especially of a limited number of strong centres. The size differentiation of centres according to their complex size, however, is not decisive for this work. Other parts of the analysis are based on picking 427 centres. Interurban interactions among them are monitored; their intensity is a decisive factor for specification of comprehensively interconnected urbanization axes.

Table 2 Centres with complex size 100 and more in the Czech Republic in 2001. Source: Hampl (2005).

Centre	Relativized size (CZ = 10,000)
	Complex size
Prague	1,414.5
Brno	444.0
Ostrava	404.5
Pilsen	192.8
Olomouc	126.1
České Budějovice	125.2
Zlín	120.9
Hradec Králové	117.8
Liberec	111.0
Pardubice	107.3
Ústí nad Labem	101.8

Table 3 Categorization of centres by complex size in the Czech Republic in 2001. Source: Hampl (2005).

Relativized size (CZ=10,000)	Number of centres
Category of complex size	
100 and more	11
50.0 – 99.9	13
30.0 – 49.9	21
20.0 – 29.9	26
10.0 – 19.9	64
5.0 – 9.9	105
2.5 – 4.9	187

Based on combination of the methods by Maryáš and Řehák (1987) and Seidenglanz (2010) the total of 987 pairs of centres with very good mutually intensive transport connection by public transport was identified. Only Vejprty, Zbiroh, Železná Ruda, Vyšší Brod and Strání did not meet the transport criteria out of the basic number of towns. Except for Zbiroh, they are peripheral centres situated near the state border. More than a half of the total number of 987 suitable transport interactions is formed by mutually intensively interconnected pairs of centres. Intensive transport interconnection of the centres selected corresponds to their higher hierarchic position. This is logically associated with the number of links ending in them or departing from them.

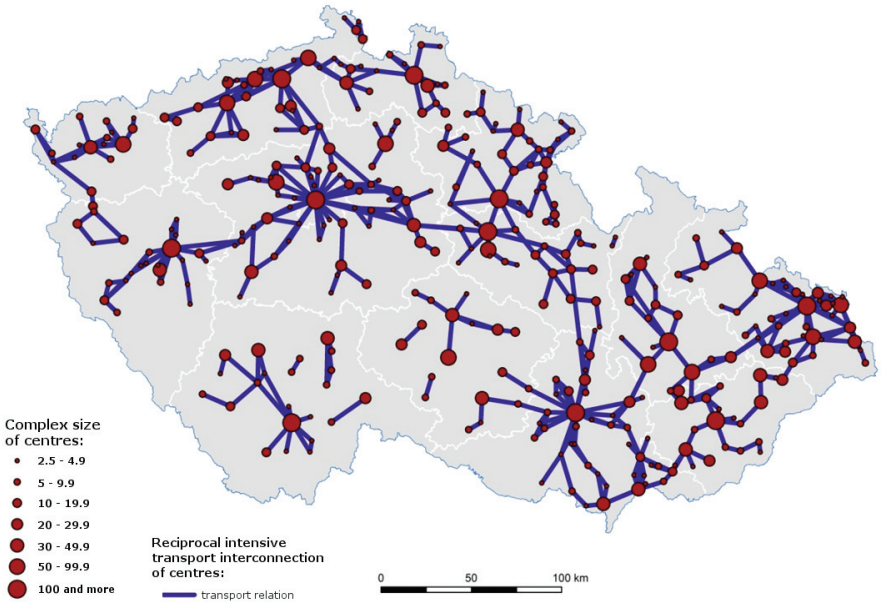

Figure 1 Transport interconnection of selected centres in the Czech Republic in 2015. Source: IDOS, Hampl 2005; author's calculations.

Figure 1 demonstrates even more detailed specification of quality of supranodal transport relationships. It concerns transport interconnection of centres showing a mutually intensive character (see the method by Maryáš and Řehák 1987). The total of 549 pairs of centres created the most intensive transport interactions. In this respect the region of Vysočina obviously stands out as an internally peripheral territory. First, there is a very low number of intensive transport relations with the regional centre, and second, there is no distinct interconnection with neighbouring regions. This does not apply only to the south-east centres (Třebíč and Velké Meziříčí), which, in contrary, have transport connection to Brno and not to its regional centre. Like in Vysočina, in South Bohemia the supra-nodal transport connections are closed in the region's territory itself. This is related to the fact that the whole territory of the region of South Bohemia is actually bordered with almost a continuous strip of a peripheral area with no distinct centre. Another interesting territory is the area of Tachov, which is much more connected with the region of Karlovy Vary (Mariánské Lázně) in terms of transport than with its regional centre. Another characteristic feature is intensive connection of the regions of Pardubice and Hradec Králové, which reflects the interconnection of the area of East Bohemia.

The analysis of mutual transport interactions is followed by specification of interconnection of the centres based on daily commuting to work and school. The total of 193 relationships with 200 centres participating meets the methodical criteria. All interactions selected are shown in Figure 2. Commuting to work and school represents one of the most important forms of people's spatial mobility at present. In the Czech Republic, it still has a very nodal character, which determines the relatively lower number of supra-nodal commuting relations (Hampl and Marada 2015). In the settlement system of the Czech Republic, there are considerably fewer supra-nodal centres connected by commuting than connected by transport as analysed above. To a certain extent, this might be caused by problems occurring during statistical determination of these relations within the census, counting of houses and flats.

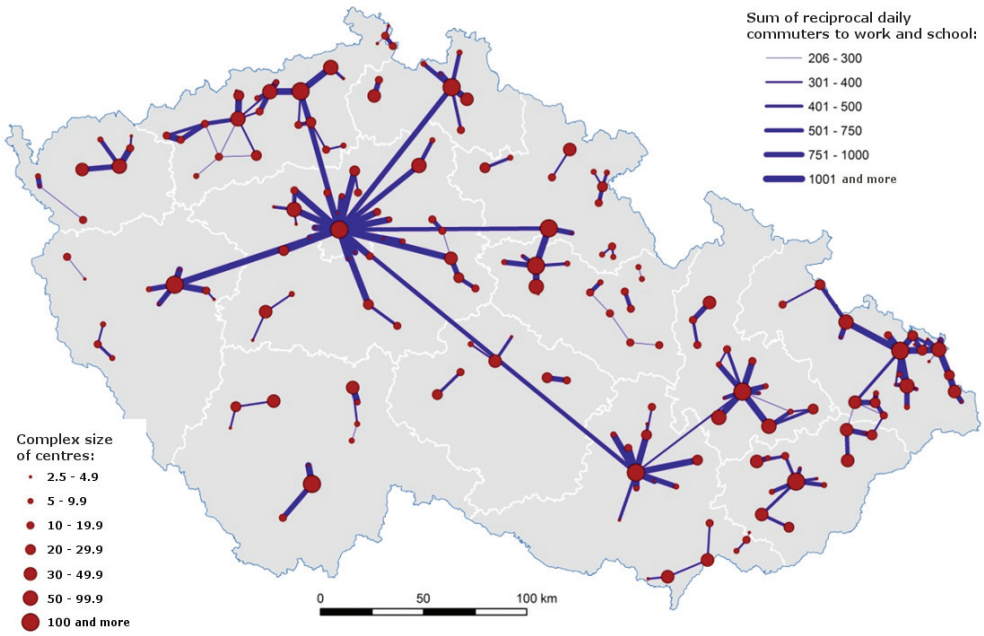

Figure 2 Reciprocal commuting relations of selected centres in the Czech Republic in 2011. Source: Population and Housing Census 2011, Hampl 2005; author's calculations..

The relation organisation of supra-nodal commuting demonstrated especially enormous importance of Prague, which is connected even with very distant mesoregional centres, such as Plzeň, Ústí nad Labem, Liberec, Hradec Králové and Brno. These commuting interactions for very long distances indicate the main importance of high-quality roads (highways), because at present, people are using a passenger car for commuting increasingly more (Kraft and Prener 2014). Strong connection can be monitored also in traditionally polycentric areas of the territory of Ostrava and northwestern Bohemia. Bicentric structures of Liberec–Jablonec nad Nisou and Pardubice–Hradec Králové show strong relations, too. We can generally say that the more distant the interacting centres are the weaker the intensity of the relations of commuting is (more information e.g. Halás et al. 2014). Especially radial structures of relations around some big settlement centres where the cores interact with bigger centres in their hinterland stand out in this context. Besides Prague having already been mentioned, this especially concerns structures around Brno, Olomouc and, in a more complex form, around Ostrava.

Supra-nodal commuting relations are much more differentiated in terms of territory and concentrated than in case of transport relations. The "peripheral character" of the area of Vysočina stands out even more here. Again, this area shows the lowest number of interactions. What is very specific here is especially the absence of Jihlava, which is the only regional centre not participating in any supra-nodal relation. This situation indicates particularly the nodal orientation of relations heading for Jihlava and the absence of another superior centre with which it could cooperate. A lower number of relationships is also located in the area of South Bohemia and in the traditional monocentric structure of the region of Plzeň, where especially the peripheral areas in the north or south of Plzeň stand out. When looking at the previous Figure 1, it is obvious that the region of Hradec Králové shows the biggest differences as far as the territorial concentration and intensity of interconnection of centres are concerned. The commuting interconnection of the centres is remarkably smaller than the transport interconnection. Especially important here is very excentric position of

the regional centre which forms the strongest relation with Pardubice, and a limited number of more important centres.

The total of 200 centres and 184 interurban interactions were shaped by synthesizing the criteria of transport and commuting. Then, commuting interactions of the biggest centres for very long distances were removed as they were associated with more intensive mutual commuting but, on the other hand, were not connected properly due to the time restriction. Such relations especially include Prague and its relation to Plzeň, Ústí nad Labem, Liberec, Hradec Králové and Brno. Then also connection of Brno with Olomouc and Ostrava with Nový Jičín and Staříč. In order to ensure sufficient complexity of interurban interactions their current number (184) was reduced applying the following criteria:

- The minimum of 200 daily commuters to work and school to the other centre in each direction;
- The minimum number of mutual-direction public transport links 100 per day and more;
- Full representation of direct public transport links in four hourly intervals of the morning peak (5 a.m. to 8.59 a.m.) in both directions (value 8).

Thus, there was a considerable decrease in the total number of comprehensively interconnected centres. There were 52 comprehensive supra-nodal relations created by the total of 72 centres. Term "urbanization axis" has not been used in the current empiric parts of the work deliberately so far. To maintain the main idea of the work we have spoken only about pairs of centres with intensive relations or comprehensive interconnection. Urbanization axes must be comprehensively connected by at least three supra-nodal centres. In this context, such interurban interactions that created spatially isolated pairs of centres were removed. The total number of 52 interurban relations thus went down to 36 and the number of centres involved from 72 to 46.

As expected, no urbanization axis was created in the region of Vysočina having been mentioned several times already. Due to a very limited number of more important centres and the dispersed character of the settlement system, we also removed the last comprehensively connected pairs of centres in the region (Žďár nad Sázavou and Nové Město na Moravě). The circumstances in the region of Plzeň are similar. There is not a sufficient number of larger centres around Plzeň with which Plzeň could communicate. A considerably monocentric settlement structure created only one comprehensively interconnected pair of towns – Plzeň and Rokycany. The region of South Bohemia lacks a urbanization axis, too. Like in the cases above, it is a reflection of the settlement structure of South Bohemia. Only Tábor with Planá nad Lužnicí and Hluboká nad Vltavou with České Budějovice fulfilled the comprehensive parameters of the interurban interactions. On the other hand, the absence of an urbanization axis is somehow surprising in rather a polycentric settlement system of the region of Karlovy Vary. There are only two spatially separated pairs of centres with appropriate interconnection in the region territory (Františkovy Lázně–Cheb and Karlovy Vary–Ostrov). Thus, four regions of the Czech Republic lack urbanization axes.

As a result, nine comprehensively interconnected urbanization axes were identified in the territory of the Czech Republic. For the purpose of good-quality cartographic interpretation, urbanization axes in Bohemia and Moravia (or Moravia and Silesia) are depicted separately (see Figures 3 and 4). This differentiation corresponds with different properties of these settlement macrosystems, particularly a more polycentric character of Moravia and Silesia. A comparable number of urbanization axes was identified in these territories in spite of their big territorial disproportions (and, of course, a lower number of centres). Four urbanization axes were identified in the territory of Moravia and Silesia and only one more, *i.e.* five urbanization axes, in the territory of Bohemia. As far as the number of supra-nodal centres is concerned, an identical number of 23 centres is integrated in the urbanization axes in both the territory of Bohemia and Moravia.

Urbanization axes in the territory of Bohemia are demonstrated by Figure 3. As expected, one of Bohemian urbanization axes was identified in the polycentric area of northwestern Bohemia. This

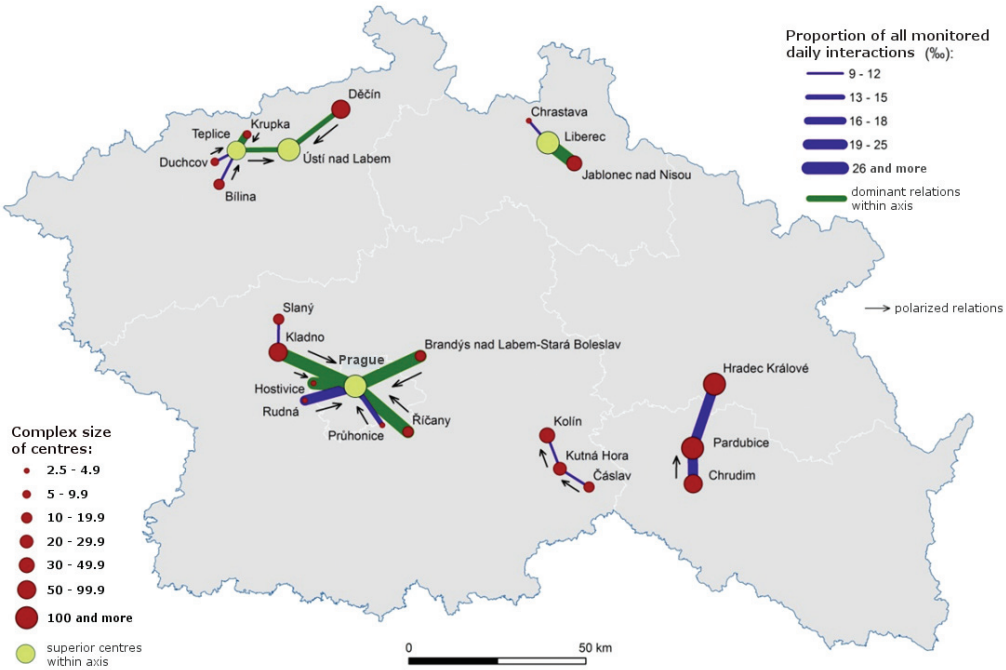

Figure 3 Urbanization axes in the Czech settlement system.
Source: Population and Housing census 2011, IDOS, Hampl 2005; author's calculations.

urbanization axis is formed by Děčín, Ústí nad Labem and Teplice, where it branches off in the directions of Krupka, Duchcov and Bílina. Thus, this axis consists of six centres. The most intensive interactions can be found in the partial axis of Děčín–Ústí nad Labem–Teplice–Krupka (Kraft et al. 2014a). Bílina and Duchcov create rather below-average intensive relations with Teplice. Higher intensity of relations between Teplice and Krupka is determined by the industrial estate in Krupka. Generally, however, the relations among the towns along this axis do not achieve very high values. The total share of the daily interactions monitored within the urbanization axis is average comparing to other axes monitored (see Table 4). The internal structure can be classified as polycentric or rather bicentric with two main centres – Teplice and Ústí nad Labem.

The core urbanization axis of the region of Central Bohemia consists of Slaný–Kladno–Prague, where it ramifies in the direction of Hostivice, Rudná, Průhonice, Říčany and Brandýs nad Labem-Stará Boleslav. As far as the number of centres involved is concerned, Prague axis represents the second most important structure, and in terms of a share of integrated interurban interactions, it has the highest position hierarchically (see Table 4). However, the intensity of the individual interconnections is very variable. The strongest comprehensive interconnection of all pairs of centres monitored is created by Kladno and Prague. Also Brandýs nad Labem-Stará Boleslav, Říčany and Hostivice form intensive relations with Prague. These centres or rather their relations form the core area of the urbanization axis. All commuting interactions (except for the relation between Slaný and Kladno) can be characterized by their strong polarization and dominant flow leading to Prague. In this context, it is obviously a monocentric urbanization axis.

The region of Central Bohemia is the only region involving two major town axes with comprehensive interconnection. The other comprehensively interconnected file of centres situated close to one another is Kolín–Kutná Hora–Čáslav. The

Table 4 Selected characteristics of urbanization axes in the the Czech Republic. Source: Population and Housing census 2011, IDOS; author's calculations.

Urbanization axis	Number of integrated centres	Proportion of daily urban interactions (‰)			Internal structure
		Commuting	Transport	Total	
Prague axis	8	109.1	87.2	196.3	Monocentric
Ostrava axis	11	91.0	81.3	172.3	Polycentric
Brno axis	6	64.5	76.9	141.4	Monocentric
Northwestern Bohemia axis	6	33.7	31.1	64.8	Polycentric
Liberec axis	3	25.2	16.7	41.9	Monocentric
East Bohemia axis	3	25.6	14.6	40.5	–
"Haná Triangle" axis	3	18.9	10.6	29.5	Monocentric
Wallachian axis	3	10.0	10.5	20.5	–
Central Bohemia axis	3	9.0	10.0	19.0	–

axis of East Bohemia is one of five urbanization axes consisting only of the basic number of three supra-nodal centres. In terms of intensity of daily interactions, this axis has the lowest comprehensive interconnection, and comparing to the shares of daily interactions of the other urbanization axes it is hierarchically the lowest (see Table 4). In this case, the internal structure cannot be clearly identified. The complex size of the individual centres is growing in the direction of Čáslav–Kutná Hora–Kolín. Interurban interactions are slightly polarized and the prevailing direction of commuting goes from Čáslav to Kutná Hora and from Kutná Hora to Kolín, where the local car making factory TPCA Kolín generates the most jobs.

In North Bohemia, the urbanization axis is located in the bicentric area of the settlement system of the region of Liberec. Besides the traditional bicentric structure it also comprises Chrastava. Again, the axis is formed by centres situated very close to one another. Dominant relations within the urbanization axis are realized daily between Liberec and Jablonec nad Nisou. Only the pairs Prague–Kladno and Prague–Říčany mentioned above achieved higher values. On the other hand, the relation between Liberec and Chrastava is among above-average ones. Table 4 shows that the urbanization axis of Liberec includes the highest share of daily interactions of all the axes consisting of three centres. Both commuting relations are polarized towards Liberec, which thus forms the core of the monocentric axis.

If we do not consider the Capital City of Prague a separate region but a natural centre of the region of Central Bohemia, the group of Hradec Králové–Pardubice–Chrudim is the only urbanization axis stretching in the territory of two regions. It is a naturally comprehensively interconnected axis of East Bohemia. The overall share of daily interactions is the second highest of all three-member urbanization axes (see Table 4). The hierarchically very balanced position of the bicentric structure of Pardubice and Hradec Králové corresponds with their very balanced reciprocal commuting to work and school. The supra-nodal relations between Chrudim and Pardubice are very intensive, too, but the main volume of commuting is heading for Pardubice.

The following characteristics of Moravian urbanization axes relates to Figure 4. A remarkably monocentric urbanization axis was identified in the territory of South-Moravian region. Like in

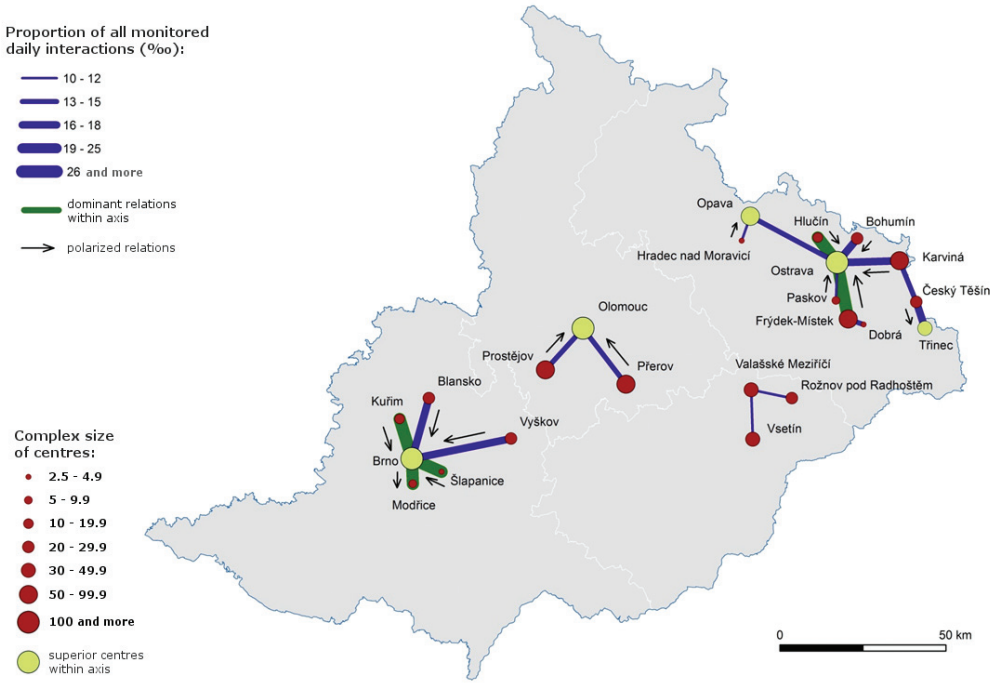

Figure 4 Urbanization axes in Moravian and Silesian settlement system.
Source: Populations and Housing census 2011, IDOS, Hampl 2005; author's calculations.

case of Prague, however, its monocentricity is the result of a high hierarchic position of Brno within the entire settlement system. The axis of Brno creates a special radial structure, where the towns of Modřice, Šlapanice, Vyškov, Blansko and Kuřim are connected with Brno very intensively. In fact, it is a file of partial urbanization axes the core of which is Brno. Table 4 demonstrates that it is the third most important urbanization axis in terms of hierarchy of the individual axes. All interurban interactions except for Brno–Modřice can be classified as strongly polarized. Modřice, however, can be considered an organic part of Brno and moreover, there is an industrial estate there. It is just Modřice with whom Brno creates dominant relations within the axis as well as with Šlapanice and Kuřim.

An urbanization axis anticipated before was identified in the core area of the region of Olomouc, namely in the area of the so-called "Haná Triangle" (Olomouc–Prostějov–Přerov). The urbanization axis of Haná creates relations with average intensity. The hierarchic position of Prostějov and Přerov is very similar because their relations to Olomouc show similar intensity. Both dominant commuting flows are aimed at Olomouc. In this context, the urbanization axis of Olomouc can be classified as rather monocentric in terms of the organisation of relationships, although the Haná Triangle is traditionally considered a polycentric structure of settlement.

The last urbanization axis created by only three centres (Vsetín–Valašské Meziříčí–Rožnov pod Radhoštěm) is situated in the territory of the region of Zlín. Comparing to the other axes, the intensity of comprehensive interconnection of the centres is low. A lower share of interurban relations is integrated only in the Central-Bohemian urbanization structure of Kolín–Kutná Hora–Čáslav (see Table 4). The main feature of the Wallachian urbanization axis is especially the balanced character of the integrated centres in terms of their hierarchy and mutual cooperation. The term cooperation is well-grounded in this case as no polarized relations were

identified here (it is the only axis lacking polarized relations). Thus, logically, no dominant centre has formed in the internal structure.

And finally, the last and, at the same time, largest and most complicated urbanization structure has been generated by the polycentric settlement system in Moravian-Silesian region. Here, a special "complex" of urbanization axes is being formed, which integrates the highest number of centres (11 altogether). We can basically identify three partial axes here, which converge in Ostrava. The first axis consists of Hradec nad Moravicí–Opava–Ostrava, the second one of Dobrá–Frýdek-Místek–Ostrava and the third one of Třinec–Český Těšín–Karviná–Ostrava. However, this specification is very subjective, and therefore it is more suitable to use the previous term a complex of urbanization axes. The core area is formed by an axis consisting of Hlučín–Ostrava–Frýdek-Místek, within which the most intensive interactions take place. Almost all relations with Ostrava are more or less polarized. This does not apply only to Opava, which creates relatively balanced commuting relations with Ostrava. In addition, the prevailing commuting flow from Hradec nad Moravicí is heading for Opava, too, and therefore this town can be considered a secondary significant centre of the urbanization axis. The overall share of daily interactions monitored shows slightly lower values than in the case of Prague urbanization axis (see Table 4).

CONCLUSIONS

Urbanization axes are a part of every settlement system. However, there are big disparities when approaching their definition. An urbanization axis can be viewed not only as an axis of bigger settlement centres situated close to one another. Another possibility is to regard urbanization axes as comprehensively interconnected systems of centres with higher hierarchic position which are not important just because of their population size. This second view served as an inspiration for the paper. The main intention was to define urbanization axes in the settlement system of the Czech Republic on the basis of an empiric (relation) context.

The total of nine urbanization axes were defined in the territory of the Czech Republic based on the methods applied. Their arrangement within the settlement systems of Bohemia and Moravia (Moravia-Silesia) is interesting at first sight. When not taking into consideration the region of Vysočina and the region of Pardubice (Bohemian-Moravian regions), there are eight regions in the territory of Bohemia and another four of them in the territory of Moravia and Silesia. In spite of this territorial and numerical disproportion, the total of five urbanization axes were identified in the territory of Bohemia and only one less in the territory of Moravia. Moreover, no comprehensively interconnected axes of centres were found in the regions of Karlovy Vary, Plzeň and South Bohemia. On the contrary, urbanization axes were identified in every Moravian region. This situation generally reflects bigger polycentricity of Moravian settlement system. Traditional monocentric structures of the regions of Plzeň and South Bohemia manifested themselves in the territory of Bohemia; no town axes with comprehensive interconnection have been formed in these structures. The absence of an urbanization axis in the region of Karlovy Vary might be a subject of discussion, because some comprehensive connections might be found in this polycentric settlement structure. To some extent, this might be caused by discussed problems with data concerning daily commuting to work and school.

A question whether or not it is possible to omit such significant centres as České Budějovice and Plzeň from an analysis of urbanization axes is well-grounded, indeed. Here it is necessary to refer to the relation interconnection and sufficient number of cooperating centres. The aim of the work was not to specify urbanization structures with the biggest centres, but urbanization axes with comprehensive interconnection showing a reciprocal character between the towns within the particular axis. In spite of that, it is rather a matter of nodal than mutual supra-nodal relations in several cases. It is especially a result of strict hierarchy ruling the entire settlement system of the Czech Republic. Particularly the relations of the biggest centres – Prague and Brno – with their hinterland stand out

in this context. There is a question if it is possible to classify the relations of dominant units of a settlement system with centres positioned much lower within the hierarchy as supra-nodal. However, it is a matter of definition of supra-nodal relations in the context of the paper, *i.e.* relations among centres with certain complex size. The natural hierarchy of centres in the individual axes helped identify their internal structure.

The internal structure was identified on the basis of the fact for which centre or centres within the urbanization axis the dominant daily flows of commuting were heading. In this respect we can agree with the research by Sýkora et al. (2007), which proved a larger potential for creation of polycentric systems in Moravia. In fact, only two polycentric systems were identified in our research, namely the urbanization axes in the territory of northwestern Bohemia and in the region of Ostrava. Nevertheless, the region of Ostrava generally includes more intensive supra-nodal relations and the polycentricity is more distinct there. In terms of the entire country, polycentric systems are created in a very limited manner, which is, on one hand, a consequence of the strict hierarchy in the settlement system and, on the other hand, a consequence of the still prevailing nodal character of commuting. Enormous coverage of commuting by Prague in the territory of Bohemia manifests itself in the second case. Besides the internal structure, also the external hierarchy of the urbanization axes was monitored; it was based on the share of daily interactions falling upon a particular urbanization axis. Prague urbanization axis confirmed its dominant position. Ostrava urbanization axis came second due to the largest number of integrated centres.

It is also interesting to compare the achieved urbanization axes with development axes defined in spatial development policy of the Czech Republic. Its intuitive and general definition was criticized in the introduction. Defined development axes are only strips consisting of major cities situated on or nearby motorways and railway corridors (see MRD 2015). Urbanization axes identified in our research are not so elongated and particularly based on their real functional daily interconnections. Furthermore, each region has defined at least one development axis, whereas in this study were not identified in four regions. In conclusion, it is necessary to emphasize that this comparison and own specification of urbanization axes will never be completely objective. The rate of subjectivity is especially based on different manners of perceiving them and on individually determined methods, as no established methods are described in geography of settlements. This situation is particularly a result of the absence of empiric study of urbanization axes. At the same time, there will always be a threat of application of more or less doubtful methods. On the other hand, the fact that the topic has not been researched much created an opportunity to bring a certain empiric view of the real urbanization axes in the settlement system of the Czech Republic. This issue would definitely deserve further and more detailed empiric study anyway.

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Résumé

Identifikace urbanizovaných os v sídelním systému České republiky

Urbanizované osy reprezentují v sociální geografii relativně neprobádané téma. Tyto struktury bývají velmi často v sídelních systémech vnímány pouze intuitivně. Předkládaná práce má intenci definovat urbanizované osy v sídelním systému České republiky (dále jen ČR) empirickým způsobem. Urbanizovaná osa je zde chápána jako soubor komplexně propojených středisek vyššího hierarchického řádu. Komplexní propojení je determinováno různými sociogeografickými mezisídelními vztahy vykazujícími reciproční charakter. Střediska vyššího řádu jsou v práci chápana jako města o určité minimální komplexní velikosti, která zajišťuje jejich dostatečnou „urbanizovanost" (městskost). Pokus o jejich vymezení souvisí především s pokračujícím vývojem sídelních systémů a jejich hierarchie. Identifikace urbanizovaných os je založena především na relačním uspořádání v těchto systémech. Relační uspořádání reprezentuje vertikální a horizontální vztahy uvnitř systémů. Vertikální vztahy jsou reflexí hierarchické organizace sídelní struktury a horizontální vztahy představují mezisídelní interakce.

Hlavní cíl práce – zájem o empirické vymezení urbanizovaných os souvisí především s přechodem společnosti do post-industriální fáze. Tento přechod byl spojen zejména s principiálními politickými a ekonomickými změnami a následně se výrazně dotknul i sídelních systémů. Zatímco za

socialismu se vyprofilovala hierarchická organizace sídel a převládaly konkurenční a polarizační mechanismy, tak s nástupem postindustriální éry začaly převažovat mechanismy kooperační. Jedná se o přirozený důsledek rostoucí míry vzájemné závislosti a propojenosti sídel. V důsledku těchto vývojových tendencí se mění jednostranně orientované mezisídelní relace na recipročně orientované a mezi sídly se vytvářejí složité vzorce prostorových interakcí. Oboustranné mezisídelní interakce reprezentují především dojížďka za prací, do škol a za službami, dopravní vazby, pohyb informačních kontaktů apod. Dalšími dílčími cíli práce jsou typizace a hierarchizace urbanizovaných os. Typizace vyjadřuje diferenciaci os na základě jejich vnitřní struktury. V tomto hodnocení se promítají vztahy dominance (jednoho či více středisek) a submise v rámci osy. Hierarchizace urbanizovaných os udává jejich významovou diferenciaci v rámci celého sídelního systému ČR.

Vzhledem k metodické náročnosti a komplexnosti práce byla data o komplexní velikosti měst převzata od Hampla – viz Hampl (2005). V práci byly sledovány 2 typy mezisídelních interakcí – dopravní dojížďka za prací a do škol. Data o dopravním propojení středisek byla omezena pouze na veřejnou hromadnou dopravu. Jako datová základna posloužila elektronická databáze spojů IDOS. Střediska v urbanizovaných osách byla zkonfrontována s několika metodami určujícími frekvenci a reciprocitu dopravních vztahů. Data o denní dojížďce do zaměstnání byla využita ze Sčítání, lidu, domů a bytů v roce 2011. I přes veškeré nedostatky tohoto sčítání se jednalo z hlediska dojížďky o jediný a nejrelevantnější zdroj.

Na základě použité metodiky bylo na území ČR vymezeno celkem devět urbanizovaných os. Za účelem kvalitnější kartografické interpretace jsou odděleně znázorněny urbanizované osy na území Čech a Moravy, resp. Moravy + Slezska. Již na první pohled je zajímavé jejich zastoupení v českém a moravském (moravsko-slezském) sídelním systému. Při neuvažování Vysočiny a Pardubického kraje (česko-moravské kraje) je na českém území celkem 8 krajů, kdežto na moravském území pouze 4. I přes tuto územní a početní disproporci bylo na českém území identifikováno celkem pět urbanizovaných os a na moravském pouze o jednu méně. Z hlediska počtu nadnodálních středisek je dokonce na českém i moravském území v urbanizovaných osách integrován identický počet 23 středisek.

V Čechách navíc nebyly lokalizovány komplexně propojené osy středisek na území Karlovarského, Plzeňského a Jihočeského kraje. Na Moravě byly naopak identifikovány urbanizované osy v každém kraji. Tento stav v generalizované rovině reflektuje větší polycentricitu moravského sídelního systému. Naopak na českém území se projevily tradiční monocentrické struktury Plzeňského a Jihočeského kraje, na kterých se nevytvářejí městské osy s komplexním propojením. Zejména v Plzeňském kraji není okolo Plzně situován dostatečný počet větších středisek, se kterými by mohla interagovat. Podobná situace je i v práci několikrát zmiňovaném kraji Vysočina, kde se dle očekávání nevytvořila žádná urbanizovaná osa, a to z důvodu značně omezeného počtu významnějších středisek a disperzního charakteru sídelního systému. Na druhou stranu je do určité míry překvapující absence urbanizované osy v případě relativně polycentrického sídelního systému Karlovarského kraje, což může být určitým předmětem diskuse. Do určité míry to může být zapříčiněno diskutovanými problémy s daty o denní dojížďce za prací a do škol. V celorepublikovém měřítku se tedy urbanizované osy nevyskytují na území čtyř krajů.

Oprávněná je i otázka, zda lze v případě analýzy urbanizovaných os vynechat taková významná centra, jako jsou např. České Budějovice a Plzeň. Zde je ovšem nutno odkázat na vztahové propojení a dostatečný počet kooperujících středisek. Cílem práce nebylo vymezit urbanizované struktury s největšími centry, ale urbanizované osy s komplexním propojením, které vykazuje mezi městy v rámci osy určitý reciproční charakter. I přesto se v několika případech jedná spíše o nodální než o oboustranné nadnodální vazby. Je to výsledek především striktní hierarchie panující v celém sídelním systému ČR. V tomto kontextu vynikají především vztahy největších center Prahy a Brna s jejich zázemím. Přirozená hierarchie center v jednotlivých osách poté posloužila k identifikaci jejich vnitřní struktury.

Vnitřní struktura byla identifikována na základě toho, do jakého centra, resp. center v rámci urbanizované osy směřovaly dominantní denní dojížďkové proudy. V práci byl prokázán větší potenciál pro formování polycentrických soustav na Moravě. V našem výzkumu byly identifikovány v podstatě pouze dvě polycentrické soustavy, a to urbanizované osy na území severozápadních Čech a na Ostravsku. Nicméně v druhém případě se obecně vyskytují intenzivnější nadnodální vazby a polycentricita je zde výraznější. V celorepublikovém kontextu se tedy tvoří polycentrické soustavy velmi omezeně. Kromě vnitřní struktury byla sledována i vnější hierarchizace urbanizovaných os, která byla založena na podílu denních interakcí připadajících na určitou urbanizovanou osu. Dominantní pozici zde potvrdila pražská urbanizovaná osa. Na druhém místě se díky největšímu počtu integrovaných středisek umístila ostravská urbanizovaná osa.

Závěrem je třeba zdůraznit, že vymezení urbanizovaných os nebude nikdy zcela objektivní. Míra subjektivity vychází především z různých způsobů jejich percepce a zejména z individuálně určených metod, jelikož etablované metody v geografii sídel popsány nejsou. Tento stav je důsledkem především absence empirického studia urbanizovaných os. Zároveň zde bude vždy vyvstávat hrozba aplikace více či méně zpochybnitelné metodiky. Na druhou stranu neprobádanost tématu tvořila příležitost přinést určitý empirický pohled na reálné urbanizované osy v sídelním systému ČR. V každém případě by si však tato problematika zasloužila další a hlubší empirické studium.

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