Distance, integrity, hierarchy – the issue of regionalization of Central Europe based on air transport flows

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ABSTRACT
The purpose of this study is to contribute to the general understanding of air transport organization and creation of air interactions in view of three issues – distance, integrity and hierarchy. Although these issues are generally known from literature, they were not properly studied in the case of air transport. Therefore, the article brings a new perspective on the issue of air transport evaluation, the delimitation of functional regions based on air transport interactions, and the evaluation of their hierarchical organization. We analyze the database of flights between civil airports in Central Europe. We specify hinterlands of individual airports by using the modified version of Reilly's gravity law. The main results of this study confirmed the dominance of main airports (mainly Frankfurt and Vienna), while confirming a relatively large autonomy of airports localized in the former socialist countries (Warsaw, Prague).

KEYWORDS
air transport; functional regions; distance; integrity; hierarchy

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1. Introduction

The issue of regionalization, or delimitation of functional regions, is one of the most important challenge in human geography. It is, therefore, paid great attention in the environment of both Czech (e.g. Hampl 2004; Sýkora, Mulíček 2009 or Halás et al. 2010) and foreign geography (e.g. Karlsson, Olsson 2006 or Claval 2007). Regarding the fact that human activities are distributed in space unevenly, spatial relations are established between the individual entities. Such spatial relationships (interactions) are fundamental expressions of spatial organization. Major attention is, therefore, paid to research of organization, intensity and development of such spatial relationships. A concept covering these approaches is the research of spatial organization of society (Haggett 1965 or Morill 1974). Under these approaches, the study of general rules of regionalization significantly were developed, including important applications of functional regions (such as when delimitation and criticizing administrative units, etc.). Results of the above-mentioned studies clearly confirm that the spatial interactions are the key demonstration of the spatial frame of societal systems. Spatial interactions are subject to constant development, as well. The different dynamic also relates to different hierarchical scales where, in addition, different conditioning factors and key mechanisms of establishment of such interactions become evident. We can also confirm that spatial interactions at the regional level are explored relatively the best. Daily relationships in the form of common spatial interactions of people (commuting to work, commuting to use services, etc.) usually become evident at this level. Numerous studies (e.g. Hampl, Marada 2015) indicate that these forms of movements are very good indicators of regional or interregional spatial interactions. On the other hand, relatively little attention has been paid to research of international and global spatial interactions (e.g. Hesse 2010). This is mainly connected with the difficulties in searching for universal indicators of global spatial interactions. Spatial interactions generated by air transport can serve as good indicators of these interactions (e.g. Matsumoto 2007). However, these forms of spatial interactions have been given relatively little attention.

The purpose of this paper is delimitation of functional regions in Central Europe based on passenger air transport intensity data. Air transport can be considered one of the most significant and fastest-developing transport modes during last decades. Air transport plays a key role in development of current global spatial relationships. The geographical research, therefore, pays great attention to intensity of air interactions as an indicator of interconnection of the individual macro-regions of the world, or as an indicator of cooperative relations among world metropolises (Derruder, Witlox 2008). Far less attention is, however, paid to research of spatial organization of air interactions for the purposes of delimitation of functional regions (e.g. Nel et al. 2009). But in connection with the current changes in the air transport organization system, studying of such interactions is extraordinarily important. The paper focuses on both theoretical and practical aspects of determining functional air regions with a focus on three problematic conditioning factors – distance, integrity and hierarchy of the resulting regions.

The outcome of the paper is highly relevant to a number of disciplines. The main findings can be used not only by geographers, but also by economists, political scientists, cultural anthropologists, transport planners, etc. Due to the fact that it is a rather poorly explored issue, the resulting determined functional regions based on passenger air transport flows are interesting as such. Therefore, the paper has the following structure. The introduction is followed by theoretical anchoring of the study in the form of spatial interactions and functional regions. Both of these topics are discussed in terms of the above-mentioned issues – distance, integrity and hierarchy. The next part is focused on delimitation of functional air regions in Central Europe. Attention is again paid to the above-mentioned concepts of distance, integrity and hierarchy of the resulting regions. The final part then summarizes the main results of the study, indicating the next possible directions for further research.

2. Theoretical background – spatial interactions and functional regions

Spatial interactions are an integral part of the geographical reality. They are evoked by natural heterogeneity of geographical space. Therefore, they are related to both natural and socioeconomic environment. The general principle of creation and existence of spatial interactions is the tendency to make up differences and an effort to create spatial equilibrium. Sea streams or regular wind adjusting pressure in various places of the Earth's surface can be considered to be the typical representatives of spatial interactions in physical geography. The spatial interactions obtain various forms in the socioeconomic environment. They are associated with various movements of people, goods and information. Therefore, they include a very broad and complicated range of different flows. In addition, such flows of people, goods and information occur at various hierarchy levels, from local to global level. One of the key determinants of creation and intensity of spatial interactions is distance. Distance is the key concept of the familiar "first law of geography", stating that "*everything is related to everything else, but near things are more related than distant things*", described by Tobler (1970). There, the author explains that people try to make the maximum use of near things in their spatial behavior. It means that people move in space rationally and that most interactions occur in the shortest possible distance. On the contrary, the spatial interactions tend to weaken with increasing distance. This is, *inter alia*, expressed also by the "distance decay" concept when we can demonstrate using a number of spatial interactions of various character that distance is one of the key mechanisms affecting decrease in intensity of spatial interactions depending on increasing distance. An example of the distance decay concept application at a regional level when studying daily commuting to work is the paper by Halás et al. (2014). Despite the fact that such a purely economic approach to explanation was later partly denied by post-positivist geographers (mainly time-geography, see Miller 2005 or Šifta, Chromý 2017), the distance can really be considered one of the most significant determinants of creating spatial interactions.

The effect of distance in geographical space is more or less associated also with all basic theoretical models of human geography. As an example, we can mention models known from location theory – von Thünen model of agricultural/land use location, Weber's theory of location of Industries or the well-known Christaller's Central Place Theory. There, the distance is expressed mostly in the form of transport costs when the transport costs became the key determinant of allocation of the above-mentioned phenomena (Hall 2012). Distance and transport costs expressed by it, therefore, have the main task in the geographical space when creating the territorial integrity, or in existence of natural relations between cores and their hinterlands (see below). This is, *inter alia*, expressed in most gravity models used primarily for approximation, modeling and prediction of spatial interactions of various character (migration flows, commuting flows, transport flows, etc.). The general principle of gravity models states that gravitational force between two geographical locations is directly proportional to the size of masses of such locations (points) and indirectly proportional to their mutual distance (Kraft, Blažek 2012; Chmelík, Marada 2014). Regional integrity is, therefore, conditioned by mutual distance of the given objects in geographical space and intensity of their mutual interconnection in many cases. The regional integrity principle is embodied, for instance, in general theory of regions, or in the concept of functional regions. Functional regions are specified by region types which are organized by functional relations (Brown, Holmes 1971). Functional relations are established by the above-mentioned spatial interactions.

With respect to the aim of the paper, it is crucial to deal with the concept of spatial interactions generated by transport. Transport interactions are specific examples of spatial interactions. We can consider them rather very complex indicators of spatial interactions, as transport currently establishes significant social, economic or cultural contacts. Therefore, we argue the high predicative power of transport interactions in study of settlement and regional systems (e.g. Ullman 1980; Kraft, Marada 2017, etc.). It is also necessary to clearly emphasize differences, as hierarchy level change is associated with change of utilization of the individual transport modes. Rodrigue et al. (2017) states that at the local level the most significantly applied modes are walking, public and car transport, which perform most of the day-to-day spatial interactions satisfying citizens' commuting to work, schools and services. The key nodes at the regional level are, in particular, metropolitan areas which are usually connected by high speed railways, motorways, etc. The global level is then integrated by air and shipping routes. Here, the key nodes are gateways and various hubs (airports and ports).

The global air transport system has noted significant organizational changes in the past decades, with major impacts on changes in their spatial organization. Besides general increase in air transport intensity (supported mainly by external factors), (internal) changes also occurred in the air transport organization as such. These were mainly generated by deregulation and liberalization of air transport (Dobruszkes 2009). The deregulation of air transport represents a number of measures that permit airlines to offer flights to any destination, in any country and at any price (Seidenglanz 2010). The air transport liberalization (Europe) and deregulation (America) occurred in different parts of the world with different intensity and in different stages. At present, we can argue the air market is liberalized in North America, Western and Central Europe, while liberalization did not occur in some parts of the world at all. A general observation can be made that a direct effect of deregulation was the concentration of air transport in *hub-and-spoke* networks. The principle of hub-and-spoke networks use large airports as the hubs which act like points where passengers change planes on long-range international flights. This resulted in creation of a relatively clear hierarchy of airline hubs. This strengthened internal integrity of air regions where airline hubs ensuring interconnection of their hinterlands with other global airline hubs currently significantly dominate in the hub-and-spoke systems in deregulated parts of the world.

3. Data and methods

We are dealing with analysis of internal flights in the territory of Central Europe. However, this region can be defined in different ways (discussion, e.g. in Bláha, Nováček 2016). For the purposes of this study, we work with Central Europe specified as consisting of Germany, Austria, Switzerland, the Czech Republic, Slovakia, Poland, Hungary and Slovenia. We are monitoring the intensity of air transport among particular civil airports in these countries. The data was obtained from the open database of historical flights on the server www.flightstats.com. We monitored the number of internal flights (i.e. flights within the area of Central Europe) among all airports in the territory of Central Europe. The data was monitored for one day – Wednesday 18 January 2012. Although it is only one day, the data is sufficiently representative, in our opinion. It is indisputable there are quite important fluctuations in air traffic (from year to year or from month to month), but we consider the chosen day as representative "common" day (i.e. without seasonal flights etc.). The data is representative in this case, as well, although data of the number of passengers among particular airports would be more precise. However, such data was not available in such detail in these territories. The database contains all realized flights (scheduled, LCCs, charters etc.). Although there are some specific airports (mainly in the eastern part of Central Europe) with dominant share of LCCs (see below). In total, we analyzed 54 airports in the subject territory (airports which had flight connections with another airport in Central Europe). The position and connectivity of monitored airports are thus limited by internal flights within Central Europe. 768 flights were analyzed among all civil airports. The total number of internal flights was used to identify the level of interconnection of the individual parts of Central Europe, as well as to identify the individual hierarchy levels.

In the next step, we dealt with delimitation of hinterlands of these airports. Regarding the fact that we studied territory of the above-mentioned Central Europe, we used NUTS3 as the basic regionalization units. These have a different size in all countries, but they are determined at least partly at similar hierarchy level. Exceptions are NUTS3 regions in Germany where these regions are usually smaller. 593 NUTS3 regions were used for the regionalization algorithm. The regionalization algorithm identified the strongest theoretical relations from particular regions to the most important airport based on Reilly's gravity law, i.e. according to their attractiveness and proximity. The reason for selecting this procedure was that the Reilly's gravity law respects "natural" attractiveness of the individual airports, measured by number of flights offered (e.g. Nystuen, Dacey 1961). We used the topographic version of Reilly's law (see e.g. Řehák et al. 2009), due to its advantage of allocating the individual regions to airports. The calculation formula was as follows:

$$n = \frac{d_{AB}}{1 + \sqrt{\frac{M_A}{M_B}}}$$

where n expresses a distance to a larger airport, d_{AB} is the total distance between two airports and M_A and M_B determine the total size of airports A and B. Distances between regions (centers of regions) and airports were measured along roads by car calculated by Network Analyst in GIS. Sizes of airports equaled the total size of airport (number of all arrivals + number of all departures). This approach is more general because of calculating all flight, not only the internal flights in Central Europe. Regarding the fact that the subject territory was sufficiently large, we used the Reilly's law formula in its basic form. Due to proximity of a major airport, two airports were merged into one in some cases, whereas only the major one continued to be taken into account. This situation concerns airports Berlin Schönefeld (to Berlin Tegel), St. Gallen – Altenrhein to Friedrichshafen, Warsaw Modlin to Warsaw Chopin.

In the last stage, we monitored the hierarchical structure of the airports and their hinterlands. It is evident that major airports captured a larger territory than less significant airports. There were also significant differences in their regional autonomy, or closeness. This is the reason why we defined 4 levels of functional air regions in the Central European territory on the basis of hierarchical clustering. Level 4 regions correspond to the specified hinterlands of the subject airports, however, they had to fulfill additional conditions. They had to integrate at least two other NUTS3 regions and at least 500,000 citizens had to live in the entire region. Application of this condition eliminated small airports, or airports which potentially affect small territories and a low number of citizens. Level 3 regions are only regions, the airports of which reported at least 20 departures and arrivals a day. The regions not meeting this condition were clustered under the respective airports which they had the most intensive flight connection with. Level 2 regions had to meet the condition of presence of airport with at least 50 departures and arrivals a day. Level 1 regions are regions of the most significant airports in Central Europe with at least 100 flights a day.

4. Results

4.1 Analysis of offered flights in Central Europe

Intensity of internal air transport interactions in Central Europe is illustrated in Figure 1. Based on the method selected, 54 airports in Central Europe were analyzed with 768 internal flights realized among them. It is evident that the number of flights from the individual airports is significantly affected by their position in the system of global, continental and regional air transport. Concentration of the flights in the western part of Central Europe (mainly Germany and Austria) is obvious. This is given by several factors – higher population density, better economic situation (measured by GDP), more extensive air transport network and with substantial share of domestic transport in case of Germany. This was even higher than the share of international flights. On the contrary, we can observe smaller concentration of flights in the eastern part of the region. This is the consequence of low population density, lower GDP, as well as relatively recent development of air transport in these former socialist countries (e.g. Marada et al. 2010; Ďurček, Horňák 2016; Komornicki 2008 and others). A role is also played here by a relative geographical location within the Central European region. Small airports in the eastern part of Central Europe often focus more significantly on specific segments of air transport market (such as focus on seasonal flights or unilateral focus of flights with selected regions – see, e.g. Kraft, Havlíková 2016). However, we can confirm in general that the Central European airports are interconnected by rather very intensive flights, which intensifies integrity of the Central European space.

Structuring of airports in Central Europe according to the total number of departures corresponds in human geography to normal asymmetric differentiation (many minimums – few maximums, described e.g. by Hampl 2012). Frankfurt (FRA), Vienna (VIE), Munich (MUC), Berlin-Tegel (TXL) and Zurich (ZRH) airports had the biggest share in the total number of flights (Figure 2). Their dominance would be even more evident by counting of all offered (i.e. not only internal) flights. Their dominant position is first of all supported by their position in the air transport system. Most of these airports are used as airline hubs for a number of airlines. A typical example is Frankfurt International Airport, used as an airline hub for AeroLogic, Condor, Lufthansa, Lufthansa CityLine and Lufthansa Cargo airlines (www.frankfurt-airport.com). The medium-sized airports are represented here by airports of the former socialist countries (Prague, Warsaw and Budapest) which noted a fast development of air transport in connection with accession of these countries to the European Union. These are the main airports of these countries, the existence of which is, in addition, supported by the presence of national airline operators (an exception is Budapest where the low-cost airline Wizz Air is based). In this respect, Dobruszkes (Dobruszkes 2009) states that it is the accession to the European Union that caused expansion of a liberalized and deregulated free air market for all countries of the former socialist block. A secondary effect of the air transport deregulation and liberalization was expansion of low-cost airlines which currently play an important role in the European air market. One of the major spatial consequences of their expansion is establishment and development of secondary airports (Taylor

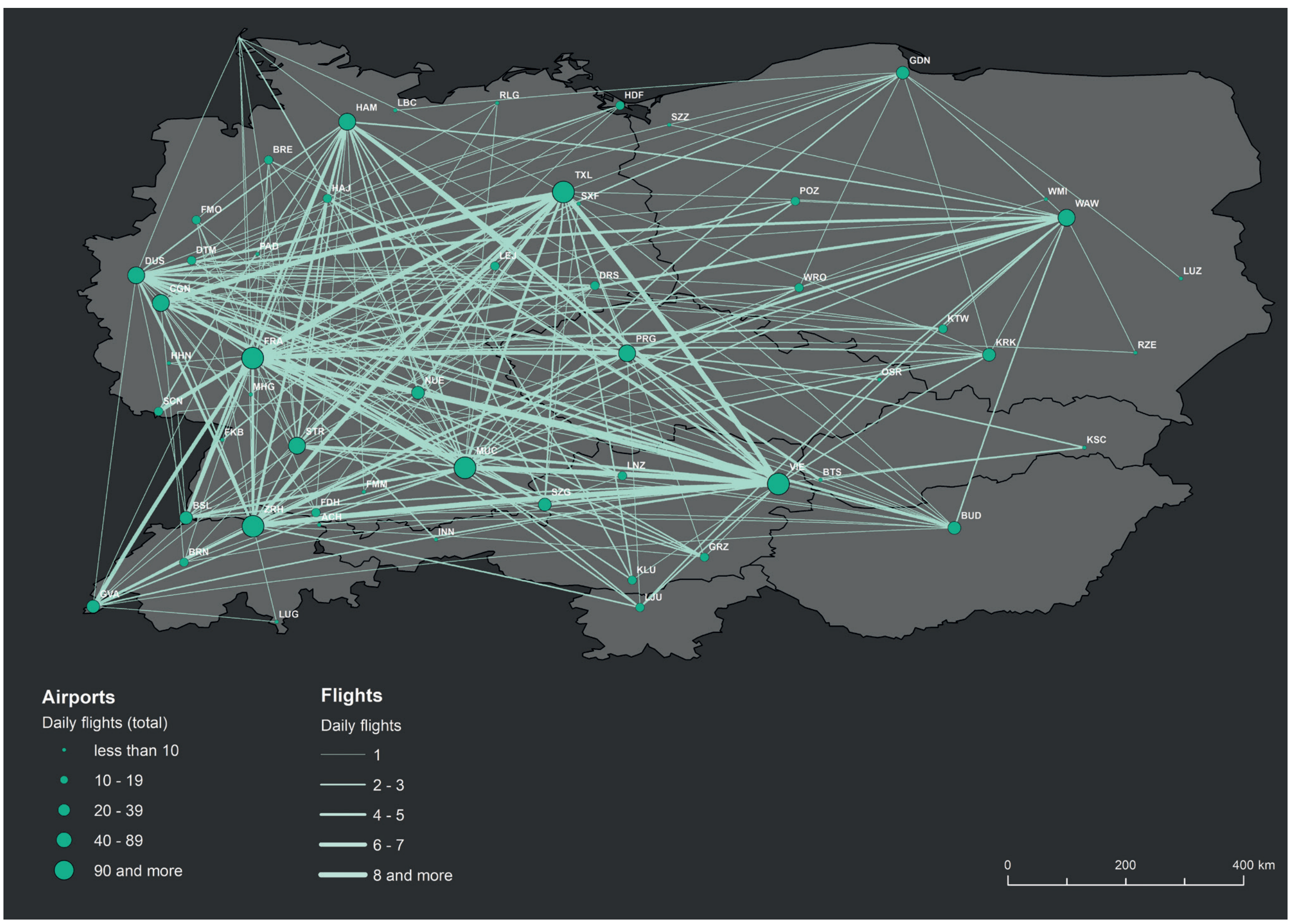

Fig. 1 Intensity of internal air transport interactions in Central Europe (2012).
Source: flightstats.com, own calculations

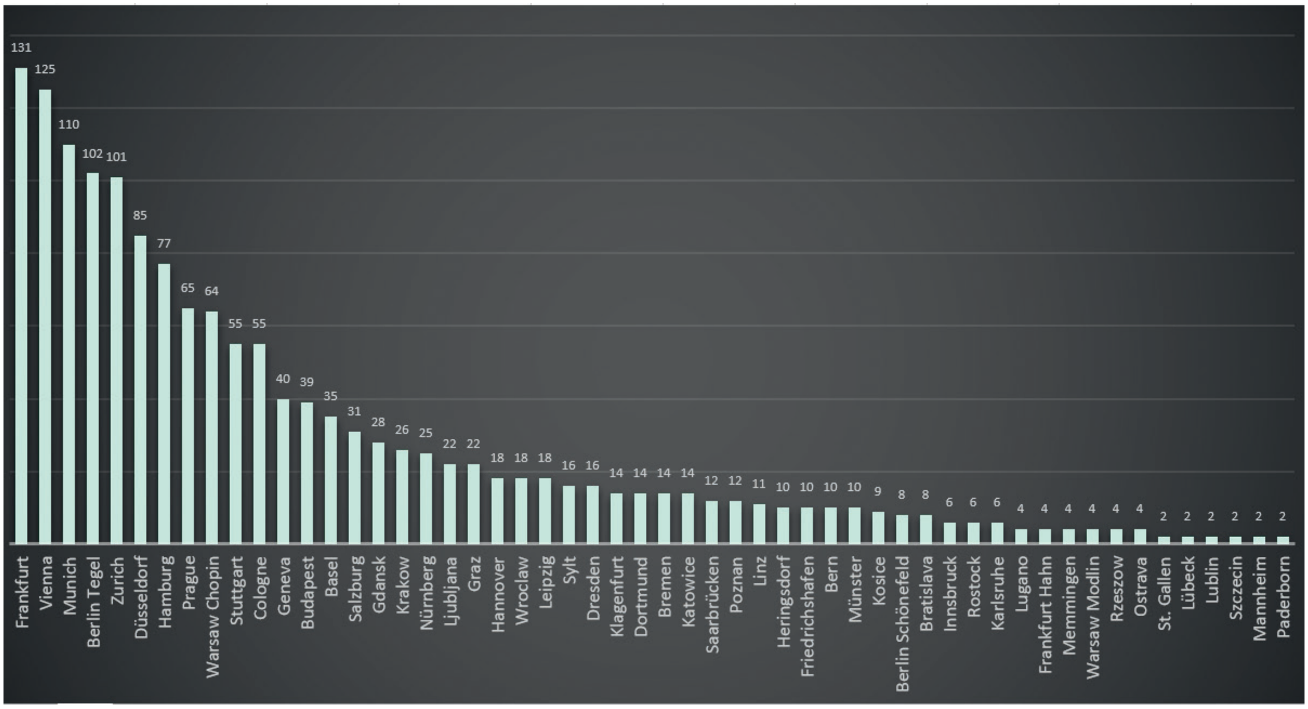

Fig. 2 Number of flights according to particular airports in Central Europe (2012).
Source: flightstats.com, own calculations

2016). There are a number of them in the Central European space. They are established either near major international airports (such as Bratislava near Vienna, or Warsaw-Modlin near Warsaw Chopin Airport) or as airports "filling" the space, thus satisfying the demand and supply in regions with poor availability of air transport (such as Košice, Lublin or Rostock). The size of airports from the eastern part of Central Europe is usually strongly influenced by LCCs and charter flights (Kraft, Havlíková 2016). These types of carriers are important segments of air transport market in fast developing economies of former socialist block.

With respect to the intent of this paper, we further deal with study of distance when generating transport interactions. Figure 3 shows that the function of distance becomes evident even at higher hierarchy levels, but with different development. Regarding the fact that the average air transport distance is about 1,000 km, the curve does not have a maximum in the nearest distances and a decreasing trend since the beginning. On the contrary, it has a slowly increasing trend in the first categories (approximately up to 300 km). This is logical, because the competitive advantages of road and railway transport usually affect the short distances. The biggest distribution of flights is noted in the category of 600–750 kilometers. This is the distance that roughly corresponds to the mutual distance of the major airports or metropolitan regions in the Central European space (e.g. Ženka et al. 2017). The curve has a falling trend in the other intervals. Such development roughly corresponds to

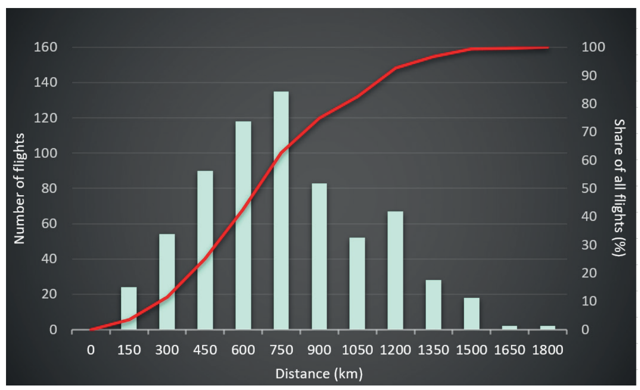

Fig. 3 Absolute and cumulative distribution of internal flights according to distance in Central Europe (2012).
Source: flightstats.com, own calculations

the theoretical determination of distance decay for the air transport, published, e.g. by Russon and Hollingshead (Hollingshead 1989).

4.2 Delimitation of hinterlands of airports in Central Europe

Hinterland of the individual airports in the subject area was specified with the use of the Reilly's gravity law. Its indisputable advantage is that it basically combines distance of the individual airports from the subject region, weighed by its attractive force (measured by the number of offered flights). Good et al. (2011) used the Thiessen polygon method for specifying the hinterland on the assumption that people use the nearest airport to travel. In our opinion, the

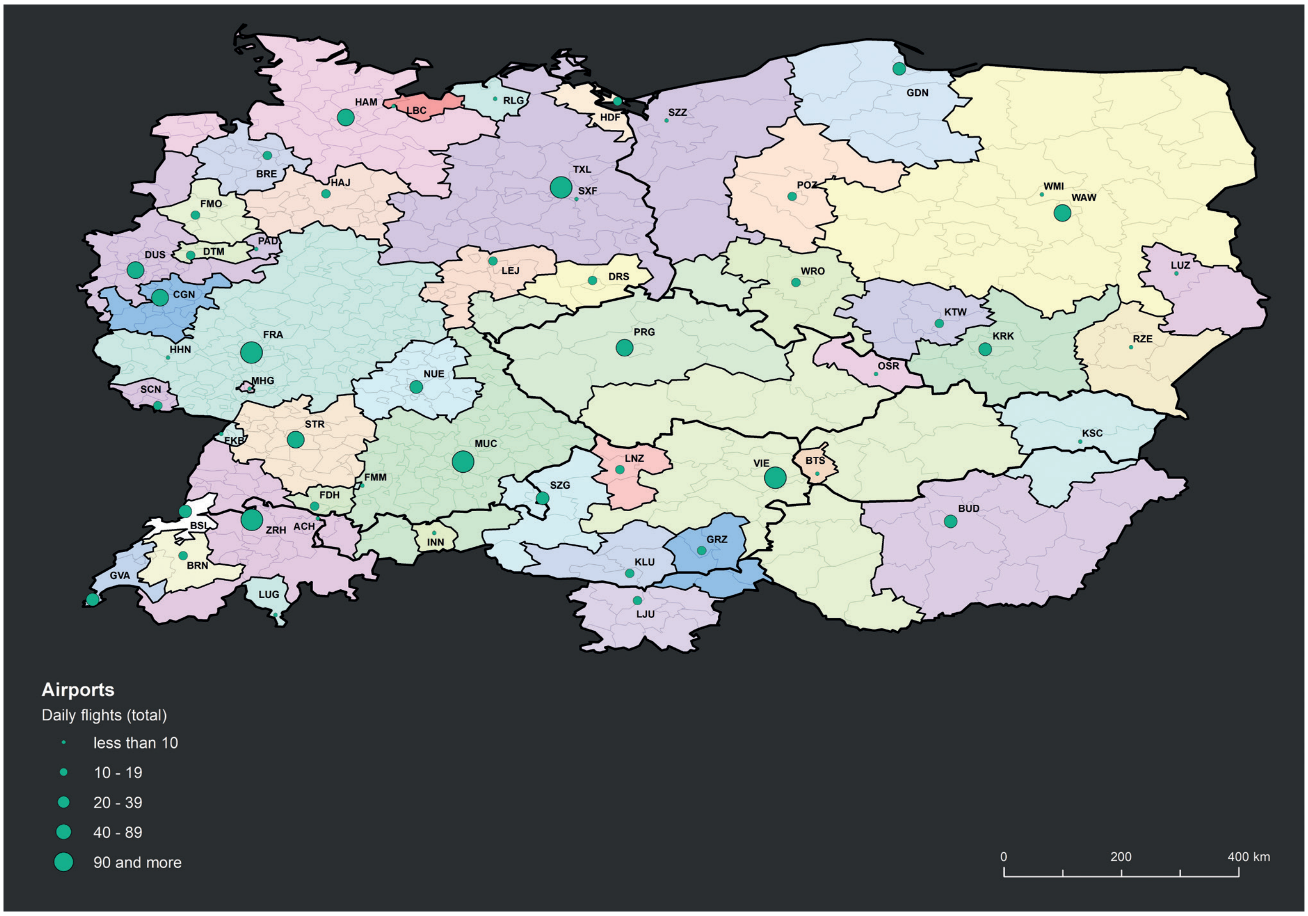

Fig. 4 Hinterlands of airports in Central Europe calculated by Reilly's law.
Source: flightstats.com, own calculations

situation is, however, more complicated and in addition to distance from the nearest airport, the factor of its attractiveness, or the number of offered flights and available destinations, is also significant here. All NUTS3 regions were chosen as the basic units. There were 593 of them in the subject area. Based on the regionalization algorithm, these regions were gradually allocated to a possible 48 airports in Central Europe on the "play-off" principle. The play off principle is based on the evaluation of stronger relationships to the pair of potential airports. The Reilly's law then determines which of the potential airport is more important for the researched region based on their proximity and attractiveness (number of offered flights).

It is evident that the total supply of each airport had a directly proportional impact on the size of its hinterland (see Figure 4). We can conclude that the hinterland size of the individual airports correlates with the number of flights they offer. Simply stated, it means that important airports create a larger hinterland, while less important airports create a smaller one. But this relationship is different in some cases. The most significant regions thus include not only regions of the most significant Central European hubs (Frankfurt, Vienna, Berlin), but also regions of big cities with airports of medium importance (Warsaw, Prague, Budapest, Hamburg, etc.). In terms of the number of integrated NUTS3 regions, there are airports with an extremely high number of subordinate regions in Central Europe (e.g. Frankfurt with 97 regions). This situation is, however, not resulting from various sizes of the NUTS3 units in the subject territory (here, major difference between the size of NUTS3 regions in Germany and other Central European countries). Even in terms of population, the Frankfurt airport serves the largest area; its hinterland has more than 14 million inhabitants. Airports with relatively largest hinterland (measured by number of inhabitants) include other major airports in the Central European space. An exception is the second largest region of Warsaw. The Warsaw airport is the centre of a region with the size of approximately 130,000 km^2 with more than 13.5 million inhabitants. This is given by absence of a near competitive airport. With its central position and large offer of flights, it affects a major part of Poland (the nearest competitive airports are in Lublin, Cracow and Gdańsk). The Düsseldorf airport also covers a relatively large hinterland, which is again given mainly by intensive concentration of inhabitants in regions of Western Germany (mainly Lower Saxony and North Rhine-Westphalia).

Linear dependence more or less applies in the relationship between the hinterland size and number of flights offered by the individual airports. However, the given situation is still "disturbed" by several differences (Figure 5). As stated above, the concentration of airports is lower in former socialist countries in the eastern part of Central Europe. This also causes hinterlands with a higher population (Warsaw, Prague, Budapest, Katowice, Cracow, Gdańsk, etc.) surrounding local airports than airports in the western part of the region. Therefore, we can confirm that there are relatively obvious differences between the level of market saturation with air transport among developed regions of Germany and Austria and relatively less developed Polish, Czech and Slovak markets. Therefore, there are intensive competitive relationships between the individual airports and their hinterland in the western part of Central Europe. Airports with a high number of offered flights and on the other hand relatively small hinterland include Munich, Zurich, Cologne, Hamburg or Geneva. All of these airports are mostly limited by vicinity of competitive airports with a similar number of offered flights, which negatively affects their competitive position in the market while limiting the possibilities of their expansion.

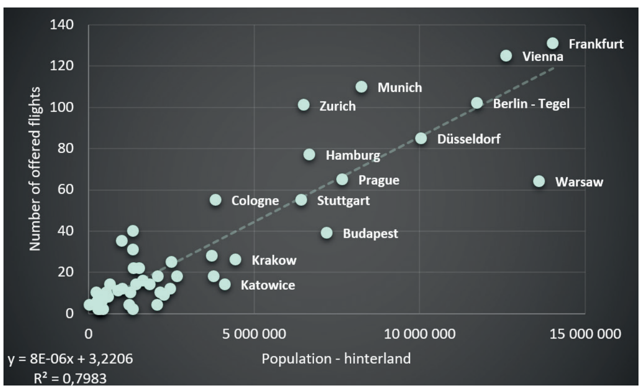

Fig. 5 Relationship between number of offered flights and hinterland population.
Source: flightstats.com, own calculations

4.3 Hierarchy of airports and their hinterlands in Central Europe

The previous analyses were focused on analyzing connectivity of airports and delimitation the airport hinterlands in Central Europe. Regarding the fact that the individual airports are interconnected by intensive internal interactions, there is the possibility to study their regional hierarchy. Therefore, this is about combining the two previous steps – hierarchical position of the airport and its hinterland. It is evident that mainly hub airports play a more important role in the air transport system in Central Europe than the regional ones. It is also a fact that they are often used as changing points for connecting small airports with more distant destinations. Based on this assumption, we studied the hierarchical structure of airports and their hinterland on the basis of hierarchical clustering. The basic condition for allocating airports to the individual clusters was their regional autonomy (expressed by number of offered flights, see Chapter 4.1) and interactions with superior airports.

According to the above-mentioned methodical procedure, four hierarchy levels of airports and their hinterlands were identified. The lowest hierarchical level includes regions of fourth level airports. At this level, the smallest airports with a low number of offered flights, potentially affecting a very small area, are eliminated. The set condition of integrating at least two subordinate NUTS3 regions and population of at least 500,000 in the first stage was not fulfilled by 13 airports (Lublin, Bern, Ostrava, Bratislava, Mannheim, Rostock, Lübeck, Lugano, Paderborn, Innsbruck, Karlsruhe, Heringsdorf, Memmingen). Their hinterlands were incorporated into airports with the most important connections. Thus 35 airports proceeded to the next analysis. That was the basis for fourth level of air transport regions. In the next stage, only third level airports were included in the analysis based on the hierarchical clustering method, i.e. airports offering at least 20 departures and arrivals per day. The level 4 airports were thus incorporated into airports of minimum third level. In this stage, the power of hub airports started to become fully evident, as significant profit was reported already here by Frankfurt, Vienna and Munich airports. This is given by their dominant position in the Central European space. In most cases, units strongly oriented on hub airports were incorporated into these airports (usually supported by the dominant position of one airline). Following elimination of the third level airports, the differences between airports became apparent even more. Regional profit was reported only by the first level airports, which demonstrates their significant position. On the contrary, the second level airports (Warsaw, Prague, Düsseldorf, Hamburg, Stuttgart, Cologne) already created a relatively independent category, not subjugating any subordinate airports. The only exception is Düsseldorf, which became the superior airport for Dresden in the previous stage. On the contrary, the airport benefiting the most from elimination of the subordinate airports is Frankfurt, the hinterland of which increased in this stage by 45 regions with 9.5 million inhabitants. The final stage is then represented only by level 1 airports. These are the five more important airports in Central Europe – Frankfurt, Vienna, Berlin, Munich and Zurich (see Figure 6). The airport benefiting the most from the hierarchical clustering was Frankfurt. Following this procedure, it became the superior airport for 11 subordinate regions. It received 100 regions and over 44 million inhabitants for its territory. A highly developed structure is also presented by the Vienna airport, which became the superior airport for 7 regions. On the

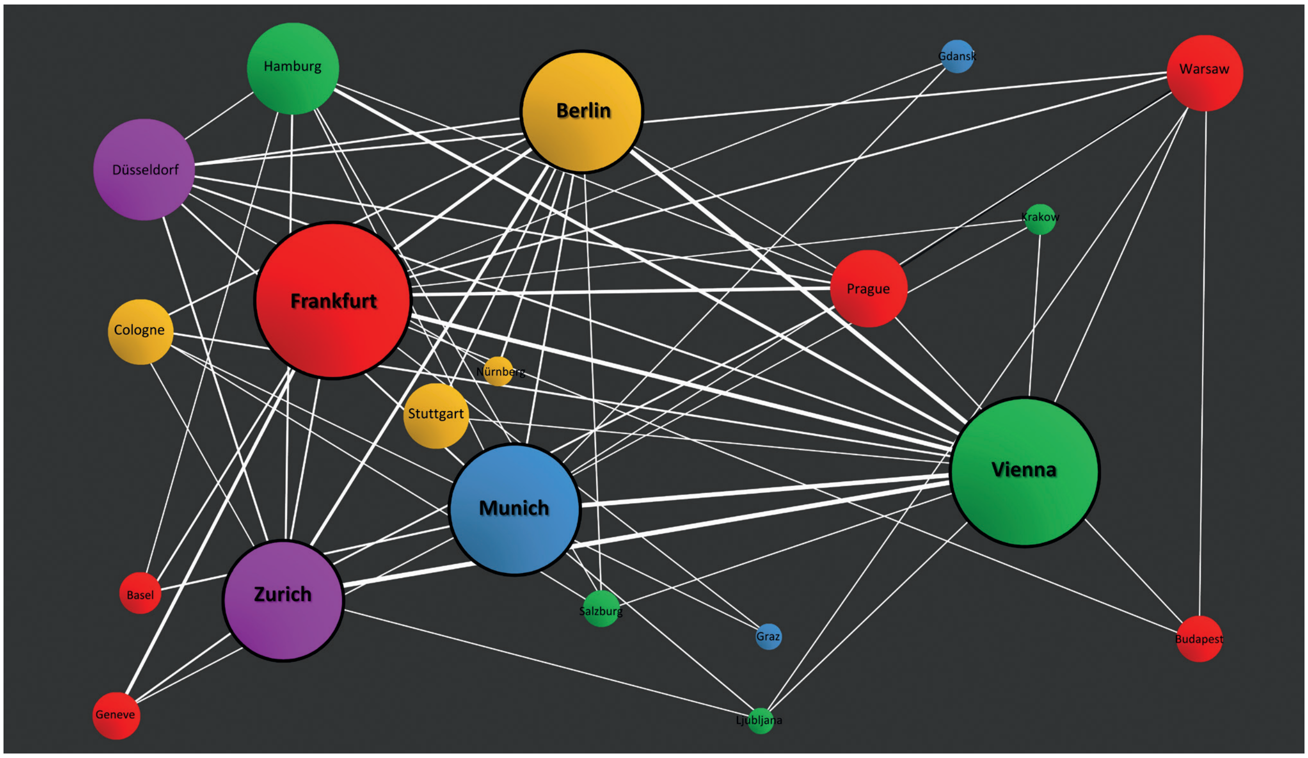

Fig. 6 Hierarchical organization of air transport in Central Europe (2012).
Source: flightstats.com, own calculations

other hand, the Zurich airport received relatively little, as its region increased only by the Düsseldorf and Dresden regions. Its role for integration of Central-European space is thus limited. It is caused namely by its marginal location in Central Europe. Most flights are oriented to western airline hubs (Heathrow, Charles de Gaulle etc.)

5. Conclusions

The analyses conducted proved a number of interesting and new findings about spatial organization of air transport in the Central Europe. First of all, we need to refer to the existing differences in intensity, organization and saturation of the air transport market between its western part where the air transport developed much earlier than in the post-socialistic countries of Central Europe. We can find evident differences mainly in spatial concentration of air transport, flight offers and other spatial aspects of air transport organization. On the contrary, the former socialist countries noted fast development of air transport rather recently in connection with transition to a market economy after 1990. A major role was also played here by accession of these countries to the European Union in 2004. Since that year, this space has been integrated into the European deregulated air space, which was associated with a number of significant organizational changes. Although air transport developed quickly here, the local market is rather a secondary market for most of the major airlines (Dobruszkes 2009). The arrival of major competing airlines and LCCs in this market did bring problems to some of the traditional national airlines. This is documented by the bankruptcy of the Hungarian flag carrier Malév, which went out of business in 2012.

The first issue was focused on the role of distance in air transport organization in line with the intent of this paper. Regarding the fact that air transport covers long-distance transport relations, a different impact of distance on forming of air interactions was demonstrated here. The effect of proximity defined by Tobler (1970) was proven, however, with different development of the distance decay function. It was also demonstrated that forming of air transport interactions was affected by settlement hierarchy, or hierarchy of the airports as such, much more. This is given by the relatively heterogeneous structure of the air transport supply and spatial selectivity of air transport as such.

Another issue analyzed was integrity and hierarchy generated by air transport. Such evaluation was identified with determination of sub-regions of particular airports in Central Europe and subsequent evaluation of their hierarchical position. Although the Central European space is characterized by a relatively high level of air transport interactions, integrity of this region is strongly affected by a number of social, economic, historical and organizational factors. It has been proven that the air transport market is more saturated in the western part of Central

Europe (measured by number of inhabitants living in the airport hinterland) than in the former socialist countries. Among other things, it becomes apparent in the different role and competitive position of particular airports. There are very intensive relationships between them. Hierarchical clustering mainly confirmed the privileged role of the Frankfurt airport. This is undoubtedly the most important airport in the Central European space (compare, for example, to Redondi et al. 2011) with the biggest flight offer, available destinations and largest hinterland. Other significant airports set in this space include Vienna, Munich, Berlin and Zurich. All of these airports are the fundamental "strategic" points of air transport in Central Europe, used as entrance gateways when travelling to Central Europe in many cases. Relatively big autonomy was proven by Warsaw, Prague and Budapest airports. These are significant airports, benefiting from their dominant role as the most significant national airports where, in addition to that, major national airlines operate (LOT Polish Airlines, Czech Airlines).

The analyses conducted also demonstrated relatively huge complexity and clear spatial differences in air transport organization in this region. Seeking other key conditioning factors should be the subject of further research. There is also a question of the spatial air transport organization development, in particular, in connection with the advancing liberalization of air transport with subsequent establishment of hub-and-spoke networks. Another interesting issue will be evaluation of the level of integration of the entire region and evaluation of its closeness (autonomy) in terms of spatial organization of global airlines.

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