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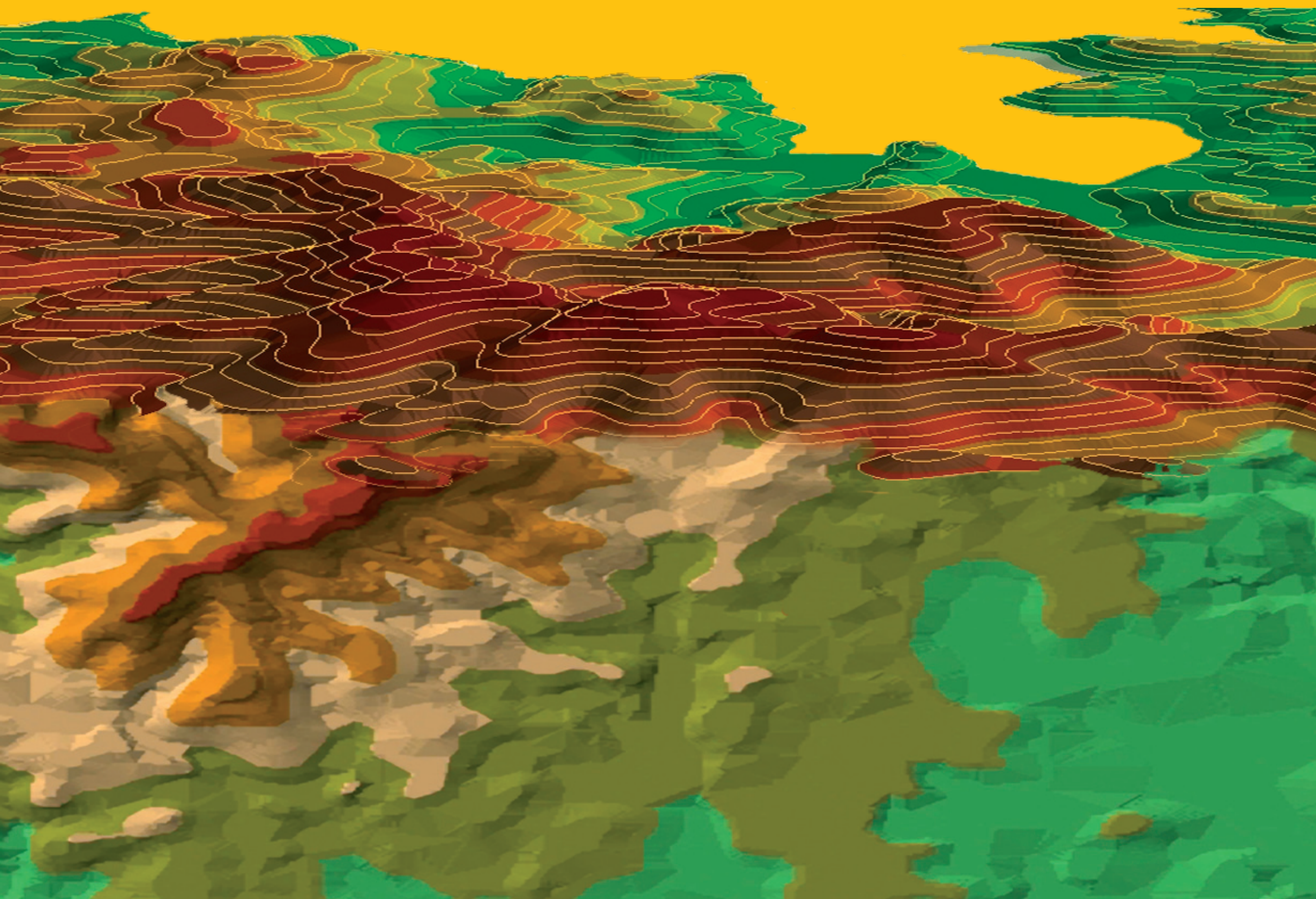

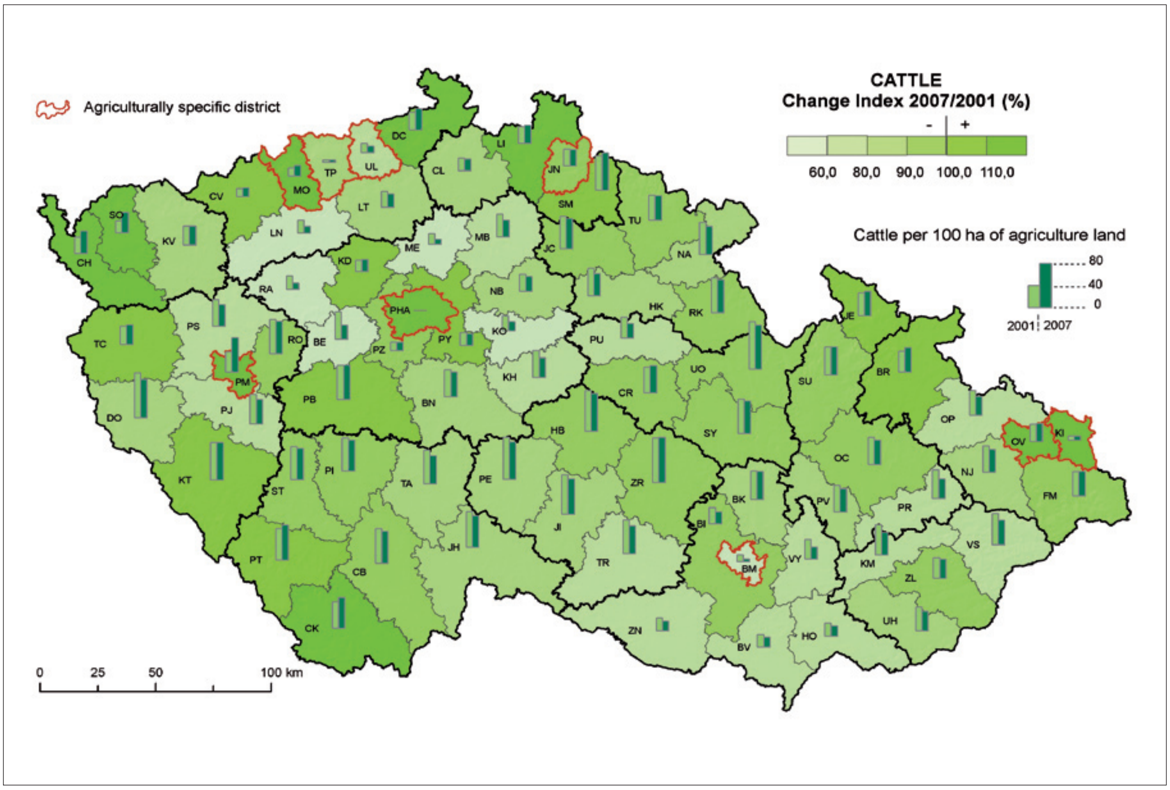

Fig. 2: Change of cattle and stock density in districts of the Czech Republic in the period 2001–2007
Source: CSO, 2001, 2008c; authors

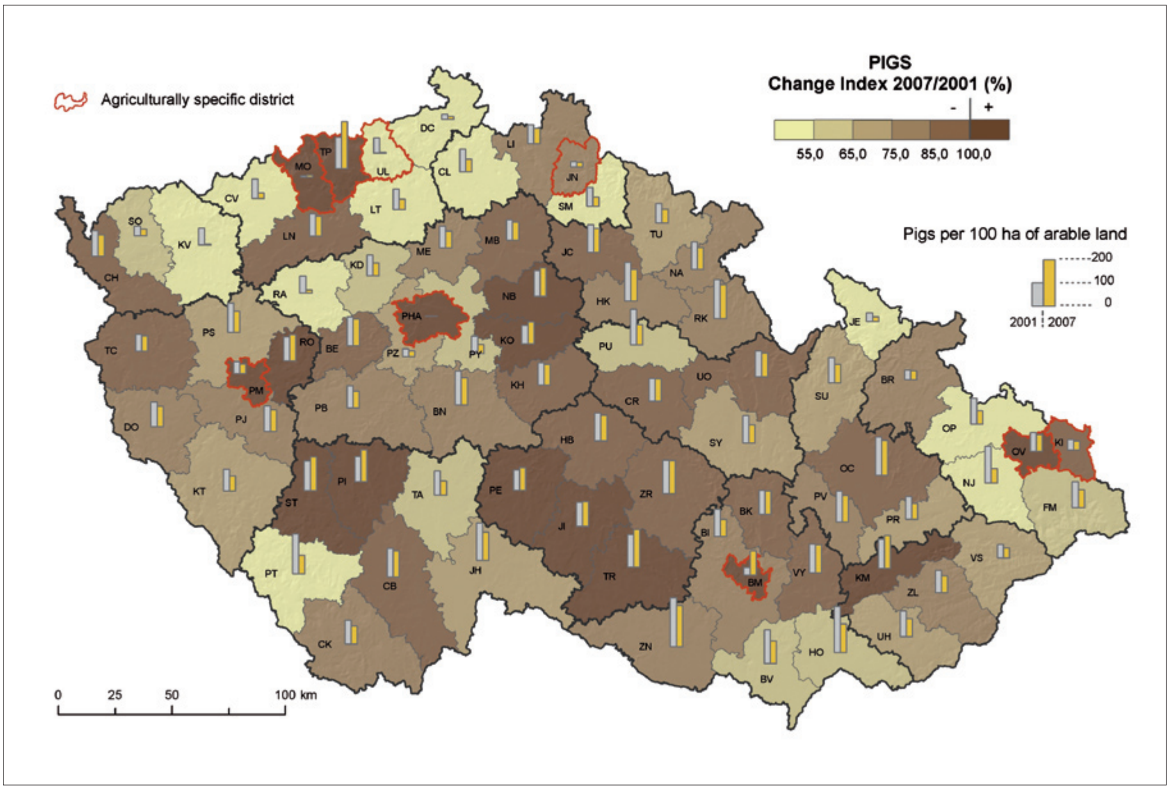

Fig. 6: Change of pigs rates and stock density in the districts of the Czech Republic in the period 2001–2007
Source: CSO, 2001, 2008c; authors

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Articles:

INTERREGIONAL DIFFERENCES IN THE CZECH REPUBLIC, 2000–2008

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Abstract

The paper evaluates interregional differences among Czech regions in the period 2000–2008 by three statistical measures of variability applied to selected indicators. Specifically, the analysis uses regular statistical measures of regional differentiation as the coefficient of variation, Gini coefficient of concentration as well as Theil index. Regional disparities were studied for selected socioeconomic indicators such as GDP per capita, registered unemployment rate, average monthly gross wage and entrepreneurial activity. The results of this paper show that interregional differences at the level of NUTS 3 regions are very small in the selected years and exhibit no significant change over the period 2000–2008.

Shrnutí

Meziregionální rozdíly v České republice v období 2000–2008

Příspěvek se zabývá hodnocením meziregionálních rozdílů mezi kraji ČR v letech 2000–2008 pomocí tří různých metod hodnocení aplikovaných na vybrané indikátory. Konkrétně se jedná o použití standardních postupů pomocí variačního koeficientu a Giniho koeficientu koncentrace, ale i netradičních metod jako je Theilův index. Mezi vybrané socioekonomické indikátory, jejichž regionální rozdílnost byla zkoumána, patří HDP na obyvatele, míra registrované nezaměstnanosti, průměrná hrubá měsíční mzda a podnikatelská aktivita. Výsledky nám umožnily zaznamenat regionální rozdíly v referenčních letech.

Key words: *regional disparities, socioeconomic indicators, coefficient of variation, Gini coefficient of concentration, Theil index*

1. Introduction

Regional disparities are the result of various socioeconomic developments at different territorial levels. Although, to some extent, these disparities are the driving force for regional development, on a larger scale they may cause the accumulation of social problems and socioeconomic instability. This concept was developed for example in the theory of unbalanced growth whose main representative is A. Hirschman (1958). The issue of balanced regional development is often discussed by national governments and is dealt with in the EU Cohesion policy (CEC, 2007). From a long-term perspective, the convergence processes occur at the level of EU Member States, while the divergent processes can be observed at the regional level, especially within the new EU Member States (CEC, 2004; Halmai, Vasary, 2010; Ezcurra et al., 2007).

The Czech Republic as well as other Central and Eastern European countries is still in transition, which brings significant changes that are subsequently reflected in various degrees and ways in regions (Blažek, 1999; Blažek, Csank, 2007; Hampl et al., 1996). The transformation period 1991–2001 was characterized by the prevailing tendency of divergence, which is expressed by the deepening regional differentiation, particularly in socioeconomic characteristics of regions (Hampl, 2005). According to Blažek and Csank (2007), divergent trends slowed down and regional disparities achieved more or less stable levels since the beginning of the 21st century. The variability of the socio-geographical system creates a continuous need for research and leads to a series of analysis addressing this issue. Since the second half of 2008, the focus of research has been on the development of regional differentiation in the context of the global economic crisis and its comparison with the previous years of trade boom.

This paper charts the development of regional disparities in the Czech Republic after 2000 through an analysis of the socioeconomic characteristics of Czech regions in 2000, 2004, and 2008. Three different statistical methods are used to quantify the regional differentiation and their results are compared.

2. Approaches to the study of regional disparities

The concept of disparities is based on the Latin word disparitas, which means inequality, diversity or differentiation. Study of regional disparities, causes of their emergence, their development and influencing factors is an important geographical issue. The basic question is whether the natural tendency of regional development is divergence or convergence. There are many empirical studies dealing with this question (Giannetti, 2002; Ezcurra et al., 2007; Tondl, 2001; Rodriguez-Pose, 1999; Blažek, Csank, 2007), however their results vary and do not provide explicit answers. The findings mainly depend on the chosen territorial level, methodology, utilized data, and sample periods. According to several studies, divergence and convergence in economic performance can alternate in different periods (e.g. Dunford, Perrons, 1994) as well as proceed simultaneously at different territorial levels (e.g. Giannetti, 2002).

Regional disparities have become the central issue of geographical research in the Czech Republic since the early 1990s, primarily due to the post-communist transformation process. During this period many valuable studies dealing with the measurement of the size, significance and trends of regional disparities were undertaken. Regional inequality and general questions of the geographical organization of society in a transformation period were examined in particular by M. Hampl et al. (1996, 2001) and M. Hampl (2005). Further, the question of development of regional disparities in the Czech Republic focusing on methods and indicators for assessing the size and significance of regional disparities was explored for example by Blažek (1996) and Štika (2004). A number of studies after 2000 also addressed statistical methods for measuring the size and development of regional disparities as well as the causes of these disparities in general (Netrdová, Nosek, 2009; Hučka et al., 2008a, 2008b; Fachinelli et al., 2008; Galvasová, Binek, 2008) or in the case of the Czech eventually Slovak Republic (Hampl, 2007; Blažek, Csank, 2007; Kutscherauer, 2007; Matlovič et al., 2008; Sucháček, 2005).

When studying regional disparities, differences between regions are based on the values of selected quantifiable indicators. Many empirical studies of regional disparities have used a single economic indicator such as per capita income; however, this approach is not quite objective, because results are dependent on the selected indicator (Quadrado et al., 2001). According to Goschin et al. (2008), "the territorial inequalities are the results of an uneven distribution of natural and human resources, the effect of many different economic, social, politic and demographic variables and of the way they spatially interconnect and are also marked by the historic evolution of the regions". Thus, it is necessary to combine various indicators to express overall socioeconomic regional inequality.

There are different approaches in the selection of variables in measuring regional inequality. For example the EU uses major indicators reflecting economic and social development such as GDP per capita and its sectoral distribution, demographic structure, population density, unemployment rate, etc. (Özaslan et al., 2006). The United Nations (UN) evaluates, using the human development index (HDI), mainly the level of development in observed regions, which includes GDP per capita and the level of education and health (average life expectancy). The Czech Statistical Office (CSO) follows another path for the multi-criteria evaluation of regional differences at the level of administrative territories of municipalities with extended powers (ATMEP) and uses a total of fifty-two different individual indicators divided into four sections – demographic milieu and residential structure; social milieu; economics; and infrastructure, location, accessibility, and environment (Baštová et al., 2008).

There are also many multi-dimensional studies, which use various indicators and combine them into a composite index. For example, Quadrado et al. (2001) use the whole range of available indicators which reflect an individual's living conditions. Goschin et al. (2008) select just three main economic variables – GDP per capita, unemployment rate, and average monthly net earnings. On the other hand, Özaslan et al. (2006) evaluate the regional disparities in Turkey by creating a socio-economic development index, which uses 58 variables from social and economic spheres. Generally, three groups of indicators can be defined to cover the main forms of disparities, namely geographical, economic and social (Goschin et al., 2008). It is important to mention, that it is not always possible to collect selected data for certain periods or territorial units.

For evaluating the size of regional disparities, various statistical measures of variability are applied. These measures allow for a comparison of the degree of differentiation in a variety of indicators with different values and in different units of measurement. The statistical methods commonly used are the mean logarithmic deviation and the coefficient of variation. Although the mean logarithmic deviation is not suitable for the comparison of regional differences for various indicators, it enables a determination of the significance of these differences and their increasing or decreasing trends (Štika, 2004). In terms of the relative size of regional differences, it is preferable to use the coefficient of variation, which is relative to the average value of an indicator. These basic statistical methods are often supplemented with other measures of variability. The most often used measures are the Gini coefficient of concentration, the Theil index, the Robin Hood index, Atkinson index and the rate of heterogeneity H (Štika, 2004; Netrdová, Nosek, 2009; Matlovič et al., 2008; Novotný, Nosek, 2009; Lambert, 2001; Ezcurra, Rapun, 2006; Cowell, Jenkins, 1995; Shorrocks, Wan, 2005). However, it is also necessary to take into account the fact that there are several methods of calculation of these statistical measures, so even the same measurements can lead to different results. A typical distinction of these rates is their usage either in weighted or in unweighted forms (as a weighting criterion the population of a region is often used).

The important aspect in terms of a study of regional differences is the level of the territorial unit. According to Ezcurra et al. (2007), the research results "can be sensitive to the adopted level of territorial disaggregation". There are different approaches applied from the municipal level (LAU 2) to the level of regions (NUTS 3). The choice of the territorial level is also highly influenced by the availability of the required statistical data set. This can be a major limiting factor from the statistical perspective.

3. Methods

The main objective of this paper is to monitor interregional differences in the Czech Republic in the period 2000–2008. For the purpose of this analysis, years 2000, 2004, and 2008 were selected as reference years, which involved significant socioeconomic changes in the Czech society, the result of the accession of the Czech Republic to the EU and the beginning of the global economic crisis. The authors try to determine whether these events affected the size of regional disparities in the Czech Republic. Due to the highly limited availability of data for smaller administrative units (in terms of their existence, structure and timeliness), NUTS 3 regions were chosen as territorial units for this analysis. The Czech Republic consists of fourteen NUTS 3 administrative regions. The authors are aware of the small sample size, which can limit the explanatory value of the results of statistical analysis. Despite this fact, it is possible to capture the basic level of regional disparities in selected years, although our findings do not disclose the size of interregional differences at the lower territorial level, which can be profoundly different.

Because of the specific position of the capital Prague, the regional differences will be analyzed twice: firstly in fourteen administrative regions including Prague, and secondly in thirteen administrative regions excluding Prague. This process eliminates the distortions that are caused by extreme values of selected indicators of Prague. It finally allows more objective evaluation of regional differences in the other administrative regions.

One of the main tasks was the selection of appropriate indicators that comprehensively characterize the economic and social situations within and between the regions. Based on the literature review and data availability, four indicators were selected – registered unemployment rate, average gross monthly wage, GDP per capita, and entrepreneurial activity. For the sake of full disclosure, the limitations of the values of these indicators resulting from the method of data collection and calculation are also discussed.

Unemployment rate is a traditional comprehensive indicator reflecting a region's economic situation as well as the quality of life of the population (Blažek, Csank, 2007). It is expressed as a percentage of the unemployed people in the total labour force and is used, for example, to delineate assisted regions for national regional policy. There are two methods of calculating the unemployment rate in the Czech Republic that differ in the method of the input data survey: a general unemployment rate measured according to ILO methodology (ILO = International Labour Organization) and a registered unemployment rate measured according to the methodology of the Ministry of Labour and Social Affairs. This paper utilizes the registered unemployment rate, which is calculated from job applicants out of work, who are registered at labour offices. The methodology of calculating the registered unemployment rate changed in 2004. For this reason, data from the year 2000 are methodologically different compared to data from 2004 and 2008; however, the change of methodology has no impact on the explanatory value of the indicator as well as on the comparison of the size of regional differences.

Besides the unemployment rate, GDP per capita is another widely used comprehensive indicator mainly characterizing the economic performance of the region. GDP is the sum of gross value added for all sectors of the national economy plus net taxes on products minus grants on products (CSO, 2009). Data for the calculation of GDP are determined in accordance with the Eurostat methodology of ESA 95 (European System of Integrated Economic Accounts) by a workplace method, i.e. enterprises' data are allocated to regions according to the localization of the local unit. One of the shortcomings of this indicator is that it involves the production of people commuting to work into the region and thus contributing to GDP and vice versa (Ježdík, Chlad, 2009). Thus, commuting centers (especially Prague) reach a higher level of GDP. This is however a generally accepted way of calculating GDP. The methodology of calculation of this indicator changed with the EU entry in 2004, thus, data for the period 2000–2004 have been retrospectively adjusted to the new methodology.

According to Blažek (1996), average monthly gross wage can be seen as a complementary indicator to GDP. It represents the share of wages per employee per month, excluding other personnel expenses (CSO, 2009). Wage is calculated based on the businesses with twenty or more employees (in the financial sector irrespective of the number of employees) and all non-business organizations.

Average monthly gross wage was calculated by the workplace method up to the district level, but only until 2001. From 2001, the indicator was calculated using the company headquarters method up to the district level. Since 2006, both methods have been applied (workplace method and company headquarters method) but only up to the level of NUTS 3 regions. Although the values of average gross monthly wage calculated using the workplace method are more correct, the data used in this paper are based on the company headquarters method due to the lack of available data based on the workplace method in the selected years. Wages calculated according to the company's headquarters (plants and establishments located in another region than the headquarters are also included) can partly affect the regionally structured data. This case however applies only to large-sized enterprises with local affiliations across the country. The volume of these companies is limited, thus the indicator of average gross monthly wage only slightly distorts the regional data. Despite of its shortcomings, this indicator is frequently used for comparing the socioeconomic level of regions. In 2009, another modification in methodology was implemented, but this is outside the scope of this study.

The last selected indicator represents the rate of entrepreneurial activity, which also reflects a region's economic environment and is often used by regional authorities to define problematic areas (Chabičovská, 2008). For this study, the calculation of entrepreneurial activity is based on data of the number of corporate businesses per 1,000 inhabitants. Entrepreneurial activity was calculated from records of the number of corporate businesses listed in the Business Register. These include public companies, limited partnerships, joint-stock companies and limited liability companies with over twenty employees.

It was also necessary to choose appropriate methods of assessment that can be used for evaluating the size of regional disparities of individual indicators in the selected years. The authors chose three statistical measures of regional differentiation – the coefficient of variation, Gini coefficient of concentration, and Theil index. The usage of these measurements can provide an image about the variability measured by selected statistical indicators and it also allows for greater comparability with other studies. All of these inequality measures can be monitored over time, which indicates whether there is a reduction or increase in inequalities of the phenomenon.

The coefficient of variation (V_x) is probably the most widely used measure of inequality, which reflects the relative size of data diffusion with regard to the average. It is based on mean logarithmic deviation, which is related to its average and is set in a percentage as expressed in Eq. (1).

$$Vx = \frac{\sigma}{\bar{x}} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} \cdot \frac{1}{\bar{x}}, \qquad (1)$$

where n is the number of observational units, x_i is the value of indicator x for the i^{th} region and is the arithmetic mean of values of indicator x. The higher the value is, the greater the inequality of the distribution of the phenomenon.

The advantage of this inequality measure is its non-dimensionality, through which it is possible to compare the variables in different measurement units. By contrast, the dependence of this measure on the average of the distribution can be considered a disadvantage, because this distribution is inappropriate within the scope of reality of very asymmetrical distribution of socioeconomic phenomena (Netrdová, Nosek, 2009). From this perspective, the analysis of regional disparities within a set of regions excluding Prague, which have more symmetrical distribution of selected indicators, will refine the results.

A widely used measure of inequality, especially in the measurement of income inequality, is the Gini coefficient of concentration (G_i), which is "twice the area between the ideal curve (the line of absolute inequality) and the actual Lorenz Curve" (Matlovič et al., 2008). As compared with the coefficient of variation, its main advantage is its independence of the average distribution. One method of calculation is expressed in Eq. (2):

$$Gi = \frac{1}{2n^2\bar{x}}\sum_{i=1}^{n}\sum_{j=1}^{n}\left(x_i - x_j\right) \qquad (2)$$

where n is the number of observational units, x_i is the value of the indicator x for the i^{th} region, x_j is the value of the indicator x for j^{th} region and is the arithmetic mean of the indicator x values. The values range from $0 \leq Gi \leq 1$, where 0 represents absolute equality and 1 represents an absolute inequality of the distribution of the phenomenon.

The Theil index (T_h), by contrast, is a relatively less used measure of inequality in the Czech scientific literature. Actually, it is defined as a weighted geometric mean of relative phenomenon and it is mainly used to measure economic inequality. In this paper, a non-weighted form of the index is used because the selected indicators have already been related to the population of the region. The Theil index is expressed in Eq. (3):

$$Th = \frac{1}{k}\sum_{j=1}^{k}\frac{y_j}{y}\ln\frac{y_j}{y} \qquad (3)$$

where k is the number of regions, y expresses the total average of the phenomenon, y_j is the average of the phenomenon in the region j. Theil index values range from 0 (absolute equality of distribution of the phenomenon), to ln *(k)*, which corresponds to absolute inequality of distribution of the phenomenon.

Many researchers use decomposition of inequality measures from the generalized entropy class when identifying the size and significance of regional disparities (Cowell, Jenkins, 1995; Litchfield, 1999; Shorrocks, Wan, 2005; Novotný, 2007; Nosek, 2010). The most commonly used is the Theil index decomposition into the within-group and between-group components, where the total inequality is equal to the sum of these groups. The Theil index decomposition provides information about the relative relevance of regional disparities for the total differentiation (Netrdová, Nosek, 2009; Novotný, 2007). It is not possible to undertake the decomposition without the knowledge of data for the lower territorial levels (districts and municipalities). As mentioned earlier, selected indicators were available only for NUTS 3 regions, thus the Theil index decomposition is not computed in this paper.

Due to the small sample size of territorial units, it was necessary to estimate the significance of calculated inequality measures statistically. Thus, the parameters of sampling distribution of inequality measures for selected indicators and their 95% confidence interval had to be determined. Because the socioeconomic indicators have generally unknown sampling distribution, the authors used the computer-based method "bootstrapping", which belongs to the broader class of resampling methods. This technique is suitable for the sample size, which is insufficient for direct statistical conclusion (Efron, Tibshirani, 1993). This technique allows estimation of the sample distribution based on the generation of random sampling, which replace the original dataset, and computing the value of selected characteristic (in our case the value of inequality measure) for each random selection. The sampling "bootstrap" distribution is thus generated from the values of many resamples (Davison, Hinkley, 1997).

The authors used the "R" language and environment for statistical computing together with two R packages 'ineq' and 'bootstrap' under R version 2.12.1 to obtain sampling distributions for selected indicators through the use of the bootstrapping method (R Development Core Team, 2010; Zeileis, 2009; S original, from StatLib and by Rob Tibshirani; R port by Friedrich Leisch, 2007). In this paper, 2000 bootstrap replication were used. Based on the computed distributions of selected indicators, the confidence intervals were derived.

4. The development of selected indicators in Czech regions and comparison of regional differentiation

A comparison of selected indicators' development in 2000, 2004, and 2008 as well as a comparison of inequality measures for selected variables are presented in this part of the paper.

Registered unemployment rate

Referring to the values of the inequality measures used, the highest interregional differences are in registered unemployment rate together with entrepreneurial activity (Tab. 1 and Tab. 3). This fact is probably the result of the opposite values of registered unemployment rate: low values in the capital Prague, Central Bohemia Region, South Bohemian Region, and Hradec Králové Region together with above-average values in the Moravian-Silesian Region and Ústí Region, which are influenced by the location

Region	Registered unemployment rate (%)			Average monthly gross wage (CZK)		
	2000	2004	2008	2000	2004	2008
Prague	3.4	3.6	2.1	16,915	23,174	30,496
Central Bohemia R.	6.8	6.8	4.5	13,609	18,225	23,735
South Bohemian R.	5.8	6.6	4.8	12,256	16,262	21,070
Plzeń R.	6.5	6.7	5.0	12,680	17,324	22,277
Karlovy Vary R.	8.0	10.7	7.6	11,699	15,891	19,967
Ústí R.	16.1	15.8	10.3	12,494	16,659	21,462
Liberec R.	6.4	8.2	7.0	12,128	16,701	21,763
Hradec Králové R.	5.9	7.7	4.8	11,947	16,254	20,877
Pardubice R.	7.9	8.9	6.0	11,656	16,079	20,713
Vysočina R.	7.5	8.8	6.3	11,326	16,025	21,098
South Moravian R.	9.3	10.7	6.8	12,062	16,815	22,337
Olomouc R.	11.9	11.7	6.9	11,566	15,898	20,619
Zlin R.	8.1	9.5	6.1	11,947	16,072	20,937
Moravian-Silesian R.	15.1	15.7	8.5	12,789	17,311	22,096
Dataset including Prague						
V_x	0.4069	0.3485	0.3072	0.1078	0.1066	0.1130
G_i	0.2128	0.1903	0.1675	0.0473	0.0437	0.0470
T_h	0.0828	0.0643	0.0543	0.0052	0.0056	0.0063
Dataset excluding Prague						
V_x	0.3685	0.3009	0.2434	0.0484	0.0404	0.0438
G_i	0.1885	0.1619	0.1328	0.0264	0.0215	0.0238
T_h	0.0611	0.0426	0.0281	0.0011	0.0008	0.0010

Tab. 1: Regional differences in registered unemployment rate and average monthly gross wage in Czech Regions
Source: Authors' chart based on data from Czech Statistical Office (2009) and Integrated Portal MLSA (2009)

of structurally affected districts within this regions (for example Most, Karviná, Chomutov, etc.). The differentiation based on the registered unemployment rate is however much higher at lower territorial levels due to the existence of significant differences within the level of regions, districts, and ATMEP[1]. For example, more than a double difference in the registered unemployment rate exists in the district Brno-city compared to the districts Hodonín or Znojmo within the South Moravian Region (Integrated Portal MLSA, 2009).

During the reference period, in terms of average registered unemployment rate, there was evident change in the values of interregional differences; however, this change was statistically insignificant. Although computed inequality measures for registered unemployment rate show a slight decrease in the monitored period, the results are not statistically significant according to the 95% confidence interval (Tab. 2).

The above-mentioned slight decline in the size of interregional differences could be affected mainly by the approximation of registered unemployment rates in the Ústí Region and the Moravian-Silesian Region (both are assisted regions) to the Czech average. This can be seen especially in 2008 when the Moravian-Silesian Region recorded the largest decrease of unemployment in the Czech Republic. One of the reasons for this decrease could have been be the creation of new jobs related to the construction of a Hyundai factory in Nošovice (district Frýdek-Místek).

The indicator of registered unemployment rate recorded minimal differences among inequality measures computed in two different ways (including and excluding data of the capital Prague). This means that the very low values of the registered unemployment rate in Prague have no impact upon overall regional differentiation. This is evident also from the histograms in Fig. 1, which depict the Gini coefficient

[1] ATMEP = The administrative territories of municipalities with extended powers.

of concentration for registered unemployment rate in 2008. The division of inequality measure's values based on the data including Prague experienced a slight increase of the most frequent values. Still the distribution was unimodal in comparison with other selected indicators where the influence of Prague is more evident.

Average monthly gross wage

Generally, average monthly gross wage constantly increased between the monitored years in the Czech Republic as a whole (Czech average increased by 38% between 2000 and 2004, and by 31 percent between 2004 and 2008). The region with the highest average monthly gross wage during this period is Prague, which has approximately by 25 percent higher average monthly gross wage than the national average. The other regions with higher average monthly gross wage are the Central Bohemia Region, Plzeň Region, and Moravian-Silesian Region. In 2008, the South Moravian Region joined these regions because of its rapid growth of wages, thus it ranked second in 2008 compared to the seventh rank in 2000. This increase in wages is likely to be associated with

Dataset including Prague		**Registered unemployment rate (%)**			**Average monthly gross wage (CZK)**		
		2000	2004	2008	2000	2004	2008
V_x	lower	0.30608	0.28266	0.22467	0.07486	0.08213	0.08340
	upper	0.75102	0.60844	0.57158	0.29603	0.34196	0.29294
G_i	lower	0.15361	0.14615	0.11462	0.02928	0.02534	0.03025
	upper	0.31531	0.29704	0.31091	0.11942	0.12255	0.12867
T_h	lower	0.04666	0.03956	0.02844	0.00295	0.00372	0.00410
	upper	0.21123	0.15242	0.17411	0.03081	0.04381	0.03974
Dataset excluding Prague							
V_x	lower	0.28491	0.23586	0.18356	0.03501	0.03186	0.03181
	upper	0.53865	0.45098	0.38379	0.08779	0.07511	0.07778
G_i	lower	0.14757	0.12391	0.10374	0.01934	0.01569	0.01764
	upper	0.27178	0.22325	0.21231	0.04210	0.03645	0.04053
T_h	lower	0.03061	0.02773	0.01639	0.00068	0.00047	0.00052
	upper	0.14311	0.10023	0.07294	0.00332	0.00264	0.00271

Tab. 2: The 95% confidence intervals for fegistered unemployment rate and average monthly gross wage in Czech Regions
Source: Authors' table based on computation in R environment (R Development Core Team, 2010)

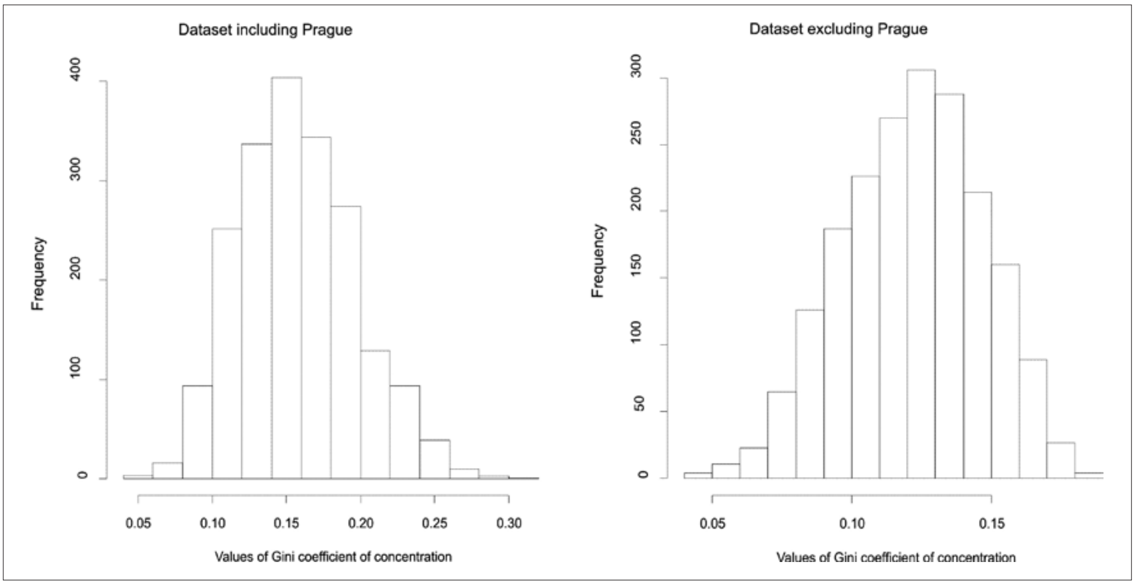

Fig. 1: Histograms of values of the Gini coefficient of concentration for registered unemployment rate in 2008
Source: Authors' chart based on computation in R environment (R Development Core Team, 2010)

the development of investment opportunities in the regional center – the city of Brno and its surroundings (high concentration of industrial zones focused on high added-value production, science and technology parks and innovation centers with close link to universities).

Beside the South Moravian Region, the Vysočina Region recorded a similar growth of wages in the monitored period (shift from the thirteenth rank in 2000 to the seventh rank in 2008). There is an evident correlation of this trend with the activity of the multinational corporation BOSCH DIESEL Ltd., which built a new plant in Jihlava in 2001. This company deals with the automotive industry and is one of the largest employers in the region (see e.g. Kunc, 2006). Conversely, the Karlovy Vary Region ranked last in the country in the level of wages and had one of the lowest growth rates of wages. An insufficiently developed economic base and small number of industrial enterprises with high added value production (even despite the construction of large industrial park in Cheb in 2003) may be the main reason for the low level of wages in the Karlovy Vary Region.

Table 1 illustrates the regional differentiation of average monthly gross wage in the Czech Republic. This differentiation is generally almost flat as evidenced by the low values of inequality measures. The size of interregional differences in average monthly gross wage was nearly the same in all monitored years as confirmed by nearly identical 95% confidence interval of individual inequality measures (Tab. 2). On the other hand, there is a considerable difference between the inequality measures of average monthly gross wage computed with and without the capital Prague. The high value of average monthly gross wage in Prague distorts the results, thus the inequality measures of Czech regions without Prague are actually by more than 50 percent lower. The influence of Prague's extreme values is evident also from the histograms, which depicts the bootstrap distribution of individual inequality measures. In the case of the Theil index for average monthly gross wage in 2004 calculated from the dataset including Prague, multimodal distribution was recognized. At the same time, the results of the Theil index computed from the dataset excluding Prague show the unimodal distribution with the highest value of about 0.0008, which is basically zero variability (Fig. 2).

It is also necessary to take into account a certain degree of distortion caused by the method of wage detection used when evaluating the average monthly gross wage in terms of its amount, development, and regional differentiation (see Methods). This method collects data about wages based on the registered enterprise headquarters, which are often concentrated in Prague and in other major cities (especially in the case of large and multinational enterprises).

GDP per capita

The indicator of GDP per capita increased on average by 60% in all regions during the monitored period. The growth rate of economic performance expressed by GDP per capita was higher in the period 2000 – 2004 compared with the period 2004 – 2008 in the majority of regions. The most progressive increase of GDP per capita was recorded in the capital Prague as the most advanced and fastest growing Czech region in the long term. Above average GDP per capita was also reported in the

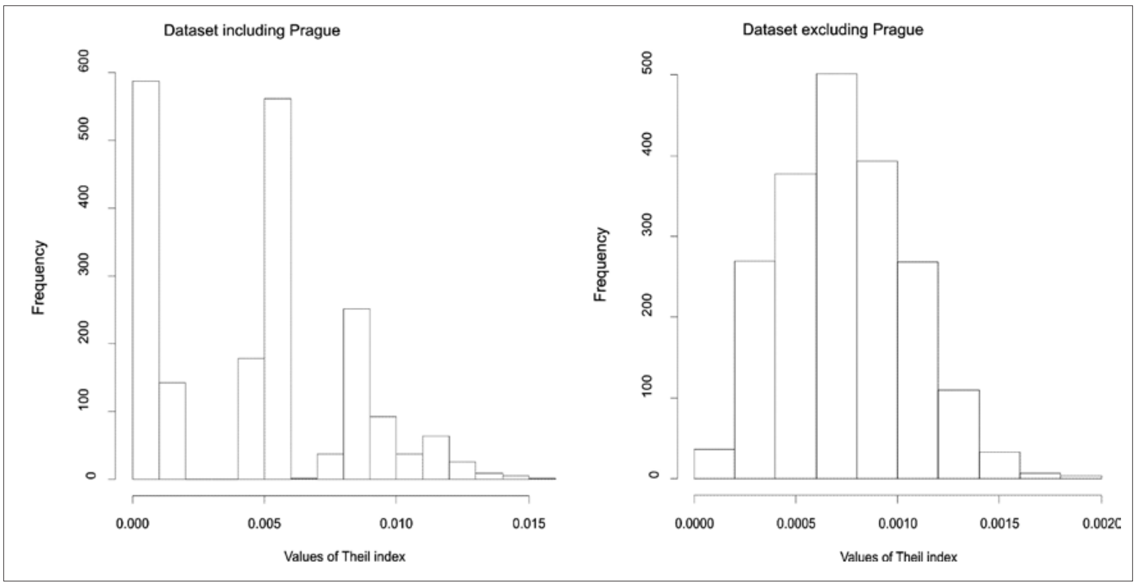

Fig. 2: Histograms of values of the Theil index for average monthly gross wage in 2004
Source: Authors' chart based on computation in R environment (R Development Core Team, 2010)

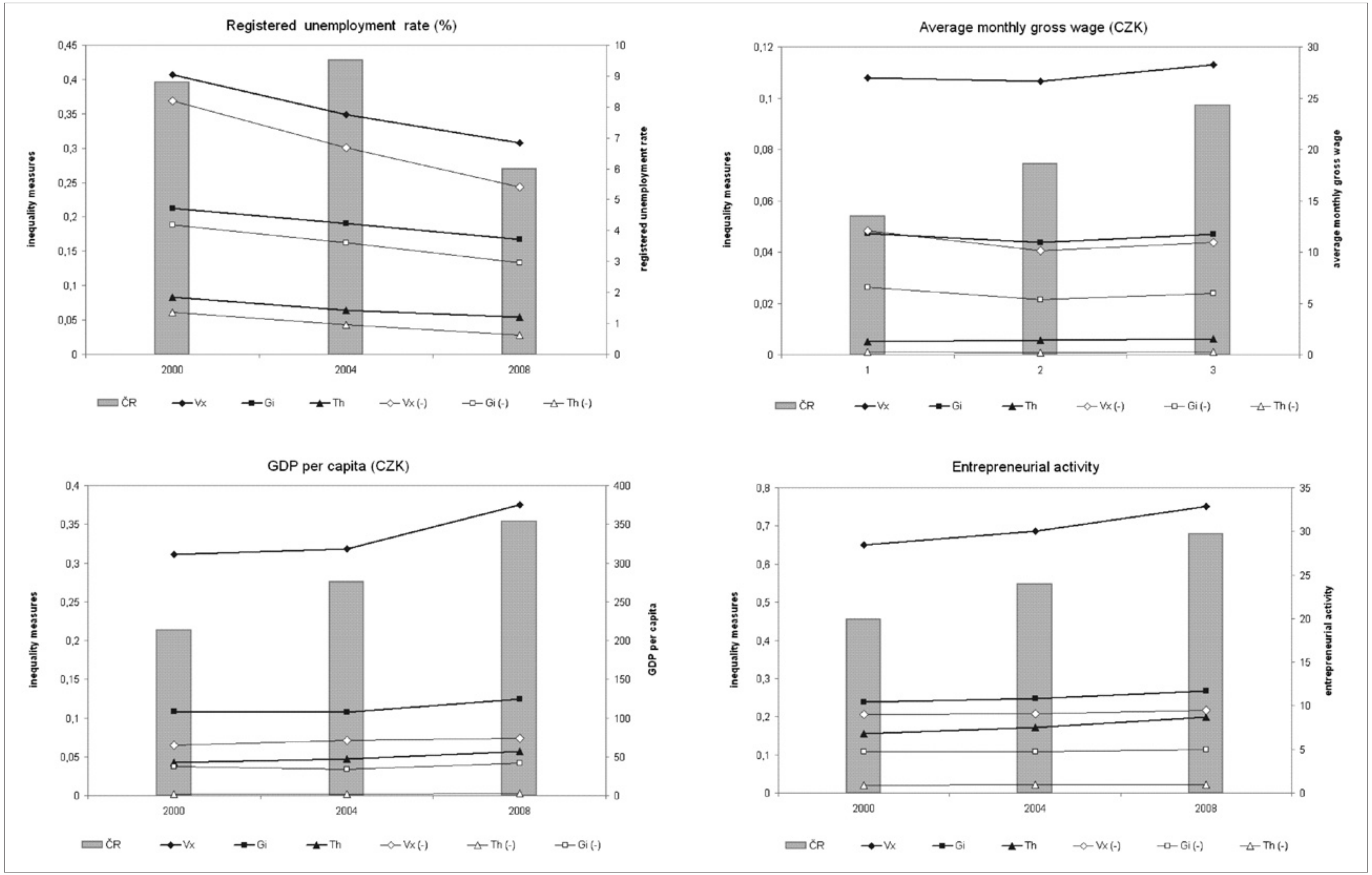

Fig. 3: Inequality measures of selected indicators in Czech Regions (including Prague and excluding Prague) in 2000, 2004, and 2008 (coefficient of variation, Gini coefficient of concentration, Theil index)

Source: Authors' chart based on data from Czech Statistical Office (2009) and Ministry of Labour and Social Affairs (2009)

Notes: CR = national average; V_x and V_x (–) = coefficient of variation calculated from the dataset including and excluding Prague; G_i and G_i (–) = Gini coefficient of concentration calculated from the dataset including and excluding Prague; T_h and T_h (–) = Theil index calculated from the dataset including and excluding Prague

South Moravia Region and Central Bohemia Region over the tracked period. On the contrary, regions with the lowest GDP per capita varied. In 2000, the Olomouc Region and the Moravian-Silesian Region achieved the lowest level of GDP per capita; however, the Moravian-Silesian Region increased its GDP per capita by 81 percent over the period. In 2008, the lowest GDP per capita was recorded in the Karlovy Vary Region and in the Liberec Region, which underwent minimal increases of the indicator over the eight year period.

There are several causes that affect the development of GDP per capita in particular regions. One of the main reasons of these inequalities is he sector structure of regional economies, especially the weight of manufacturing industry and its sectors (Ježdík, Chlad, 2009). While the economic performance of Prague is driven by commercial services, trade and finance, the Karlovy Vary Region is significantly involved in mining (compared with the rest of the country) and related manufacturing industries. An unfavorable sector structure of manufacturing might be seen as the cause of the low value of GDP per capita in the Liberec Region.

The values of individual inequality measures are really low in comparison with other monitored indicators (except the average monthly gross wage). This indicator is however strongly influenced by the extreme value of GDP per capita in Prague. The increasing economic performance of Prague can be captured by comparison of the inequality measures computed with Prague and without it. The inequality measures of GDP per capita computed with Prague recorded three times higher values of the Gini coefficient of concentration, five times higher values of the coefficient of variation, and even twenty times higher values in the case of the Theil index in comparison with values of these inequality measures based on dataset excluding Prague.

Region	GDP per capita (CZK)			Entrepreneurial activity[2]		
	2000	2004	2008	2000	2004	2008
Prague	418,425	544,780	762,352	58.06	72.37	94.59
Central Bohemia R.	204,299	252,509	325,034	13.92	17.46	21.18
South Bohemian R.	187,035	241,276	307,454	15.41	17.78	20.58
Plzeň R.	199,540	250,922	317,425	14.89	18.23	21.69
Karlovy Vary R.	173,891	216,023	253,964	13.71	17.69	25.11
Ústí R.	174,468	228,724	284,558	13.93	16.30	18.92
Liberec R.	180,137	220,905	261,872	17.56	20.24	22.57
Hradec Králové R.	191,318	244,414	293,960	15.21	17.49	19.79
Pardubice R.	178,941	230,838	295,219	13.20	15.18	17.16
Vysočina R.	188,132	237,825	295,785	10.20	11.74	13.83
South Moravian R.	187,795	252,915	326,596	22.57	27.07	32.66
Olomouc R.	161,701	210,153	269,684	11.18	13.20	16.27
Zlin R.	176,525	223,104	286,172	16.62	18.92	21.71
Moravian-Silesian R.	164,050	223,585	297,926	12.27	14.29	17.61
Dataset including Prague						
V_x	0.3113	0.3182	0.3748	0.6499	0.6856	0.7512
G_i	0.1082	0.1075	0.1242	0.239	0.2472	0.2665
T_h	0.0430	0.0475	0.0573	0.1556	0.1708	0.1985
Dataset excluding Prague						
V_x	0.0645	0.0708	0.0741	0.2050	0.2085	0.2165
G_i	0.0373	0.0339	0.0418	0.1082	0.1078	0.1132
T_h	0.0020	0.0021	0.0028	0.0197	0.0210	0.0221

Tab. 3: Regional differences in GDP per capita and entrepreneurial activity in Czech Regions
Source: Authors' chart based on data from Czech Statistical Office (2009) and Integrated Portal MLSA (2009)

[2] measured as a number of corporate businesses per 1,000 inhabitants.

This unique position of Prague is reflected also in the length of confidence intervals, which are very narrow when calculated from the set of regions excluding Prague. This is caused by the low standard deviation of the sample. According to Tab. 4, the comparison of confidence intervals uncovers the fact that there are minimal differences among the NUTS 3 regions in terms of GDP per capita. Confidence intervals constructed from the dataset including Prague have a relatively large range, especially in the Theil index (the extreme values of confidence interval for GDP per capita in 2008 were 0.04 and 1.06), thus it is hardly possible to infer the real values of inequality measures. Fig. 4 shows this bimodal distribution, which is affected by the extreme values of GDP per capita in Prague (as mentioned earlier). The first peak of the distribution approximates the variability close 0, whereas the second peak is close to 0.06.

The comparison of values of inequality measures for GDP per capita in selected years shows that there are no statistically significant trends in the development of these differences. A very slight growth was recorded between 2000 and 2008, but these differences can be

Dataset including Prague		**GDP per capita (CZK)**			**Entrepreneurial activity**		
		2000	2004	2008	2000	2004	2008
V_x	lower	0.27577	0.28874	0.33807	0.53802	0.56287	0.67779
	upper	1.39073	1.97681	2.05765	1.87800	2.10813	2.77629
G_i	lower	0.07599	0.07699	0.08654	0.16048	0.15375	0.18394
	upper	0.45130	0.53276	0.53464	0.62924	0.58155	0.58592
T_h	lower	0.03048	0.03294	0.04591	0.09643	0.11675	0.13111
	upper	0.53846	0.73977	1.06045	0.69664	0.81578	0.81005
Dataset excluding Prague							
V_x	lower	0.05258	0.04701	0.05666	0.15717	0.14365	0.16107
	upper	0.10266	0.07839	0.11877	0.37149	0.37885	0.38601
G_i	lower	0.02881	0.02937	0.03123	0.07838	0.07701	0.07706
	upper	0.05921	0.04621	0.06185	0.19463	0.20656	0.19977
T_h	lower	0.00126	0.00114	0.00162	0.01143	0.00995	0.01194
	upper	0.00436	0.00336	0.00548	0.05888	0.06009	0.06915

Tab. 4: The 95% confidence intervals for GDP per capita and entrepreneurial activity in Czech Regions
Source: Authors' table based on computation in R environment (R Development Core Team, 2010)

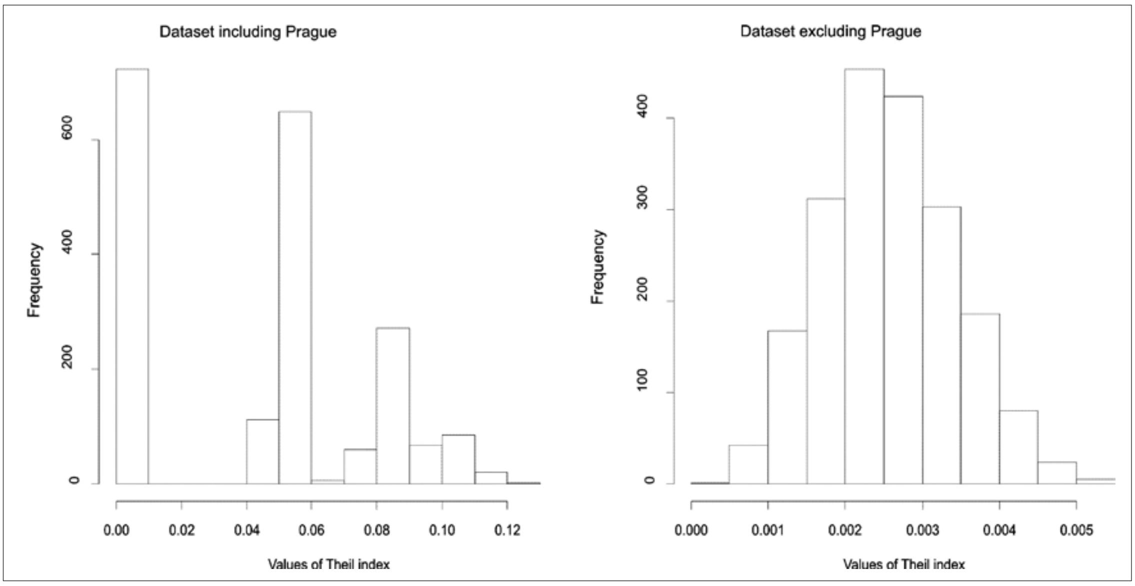

Fig. 4: Histograms of values of the Theil index values for GDP per capita in 2008
Source: Authors' chart based on computation in R environment (R Development Core Team, 2010)

considered as flat. These small deviations are likely to have been caused by the increase of economic performance in Prague compared to other regions (increase by 39 percent between 2004 and 2008). In 2008, Prague reached more than a double level of GDP per capita in comparison with all other Czech administrative regions.

Entrepreneurial activity

The indicator of entrepreneurial activity, measured as a number of corporate businesses per 1,000 inhabitants, demonstrated a relatively high increase within the monitored period, with higher intensity between 2004 and 2008. The highest increase of entrepreneurial activity was reported in the Karlovy Vary Region (83%), followed by Prague (63%). Conversely, the lowest increase of entrepreneurial activity was experienced in the Liberec Region, Hradec Králové Region, Pardubice Region and Zlín Region (about 30%).

In all monitored years, entrepreneurial activity reached the highest values in Prague followed by the South Moravian Region albeit with a third of the value in Prague. These metropolitan regions are traditionally most attractive in terms of businesses. The growth rate of entrepreneurial activity is higher in Prague compared to the values of the South Moravian Region, which is falling behind. The high values of entrepreneurial activity in Prague may be influenced by the fact that a considerable part of companies operating in different regions have their headquarters formally registered in Prague due to a lower probability of financial controls (the capacity of annual financial controls in Prague is limited).

Besides these regions, the Karlovy Vary Region reached one of the highest values of entrepreneurial activity in 2008 (the highest increase). This fact is quite surprising with regard to the lowest values of GDP per capita in this region. High values of entrepreneurial activity can be caused by developed tourism and follow-up services in the region. It can be influenced also by the relatively low population in the region. According to CSO (2010), the Karlovy Vary Region shows strong intraregional inequality in terms of entrepreneurial activity, e.g. the district of Mariánské Lázně has several-fold higher values than the Sokolov or Kralice districts. Conversely, the lowest values of entrepreneurial activity are found in the Vysočina Region and the Olomouc Region.

The impact of the development of entrepreneurial activity upon the level of regional disparities is depicted by the values of inequality measures (Tab. 3). It can be observed that these measures achieved relatively the highest level of interregional differences within the monitored indicators. Generally, the size of interregional differences of entrepreneurial activity is however statistically insignificant especially with regard to the low values of the Gini coefficient of concentration and the Theil index. At the same time, there are no important trends indicated in the development of these differences in 2000, 2004 and 2008 (Fig. 3). This statement is supported by very narrow and overlapping 95% confidence intervals within the dataset of the regions excluding Prague (Tab. 4).

The comparison of values of individual inequality measures computed in two different ways (including and excluding data for the capital Prague), as well as the comparison of their bootstrap histograms, shows the evident impact of extremely high entrepreneurial activity in Prague on the overall size of regional differentiation. Due to the growing entrepreneurial activity in Prague, the difference of this indicator between Prague and other administrative regions was broadening during the period 2004–2008. Histograms of bootstrap distribution (Fig. 5) clearly demonstrate the impact of Prague on the overall level of regional variation. Whereas the set of regions excluding Prague has the peak of distribution ranging from 0.2 to 0.25 in the coefficient of variations, the inclusion of Prague into the dataset caused a bimodal distribution with the most frequent values of sampling around 0.7 and 0.2. Similar distribution can be found in all inequality measures of this indicator for all monitored years.

5. Conclusion

The paper monitors the size and the development of interregional differences in selected socioeconomic indicators of the Czech Republic in 2000, 2004 and 2008. Due to the highly limited availability of data, NUTS 3 regions were chosen as territorial units for this analysis. The regional differences were computed from the dataset including the data of the capital Prague and the dataset excluding Prague, which allowed us to identify the expected discrepancy caused by the extreme values of selected indicators of Prague. Three different statistical measures of variability were used for the evaluation of interregional differences – the coefficient of variation, Gini coefficient of concentration, and Theil index. Finally, the authors used the bootstrap method for determining sample distribution and 95% confidence intervals for all inequality measures. Thus, it was possible to verify the statistical significance of the results.

The results show that the interregional differences in monitored indicators are very small, especially in the set of regions excluding Prague. In this case, the

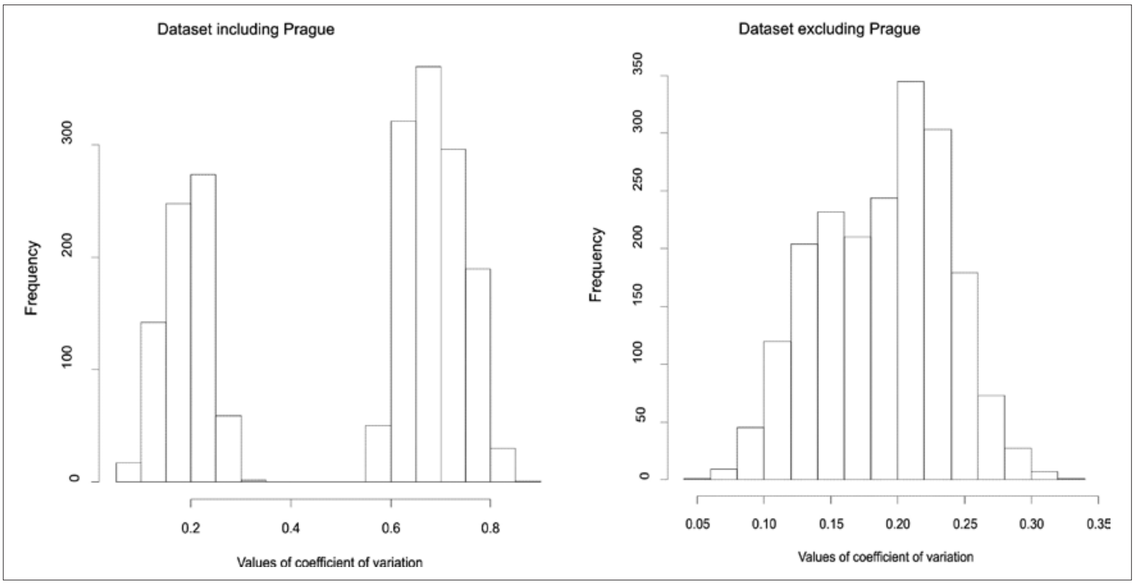

Fig. 5: Histograms of values of the coefficient of variation for entrepreneurial activity in 2000
Source: Authors' chart based on computation in R environment (R Development Core Team, 2010)

highest values of inequality measures were recognized in the indicator of registered unemployment rate computed by the coefficient of variation (0.37 in 2000) and the Gini coefficient of concentration (0.19 in 2000). The interregional differences based on the dataset including Prague achieved values several times higher; however, the values were still relatively low. In this case, the highest values of the coefficient of variation were recognized in the indicator of entrepreneurial activity (0.75 in 2008) and the Gini coefficient of concentration (0.27 in 2008). The values of the Theil index were lower than 0.1 for all indicators in all selected years (except for entrepreneurial activity based on the set of regions including Prague).

These results indicate that significant factor of differentiation at the level of NUTS 3 regions are the extreme values of the capital Prague in all monitored indicators as expected. This fact was confirmed by the histograms of bootstrap distribution of individual inequality measures.

Regarding all of these findings, it would be more effective to analyze regional disparities at the level of lower administrative districts, where deeper regional disparities can be expected. However, this is limited by the non-availability of data for lower administrative regions.

The comparison of inequality measures among the individual indicators uncovered some differences where the relatively highest values were found in registered unemployment rate and entrepreneurial activity. The other indicators (average monthly gross wage and GDP per capita) exhibited small interregional differences, which are however statistically insignificant. Moreover, it was found that the Theil index reports the lower level of inequality for all selected indicators in comparison with the other measures. At the same time, the coefficient of variation and the Gini coefficient of concentration recorded similar values for all the statistical indicators, as evidenced by their strong dependence measured by a correlation coefficient equal to 0.9.

The size of regional disparities in the monitored socioeconomic indicators did not change significantly in the studied years. In other words, there is no clear trend in the development of interregional differences. Therefore, the results did not confirm the expected impacts of the Czech Republic's accession in the EU in 2004 and the beginning of the economic crisis in 2008. At the same time, it is possible to affirm the findings of Blažek and Csank (2007) that there is no longer a general tendency to the deepening of regional disparities in the Czech Republic after 2000 and that these differences fluctuate only slightly.

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STABILITY AND ACTUALITY OF AVIATION NETWORKS IN BRATISLAVA AND PRAGUE

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Abstract

Air transportation is one of the most dynamic modes of transport and it has been considerably influenced in the Slovak and Czech Republics by the politico-economical developments occasioning major changes since 1989. The aim of this paper is to analyze the aviation networks of Bratislava and Prague and particularly the changes of air transport connections between these cities from before the EU enlargement in 2003 until the present. Stability and actuality of aviation networks in these two cities were assessed by using comparative analyses. The liberalization and deregulation of air traffic in Europe have had a great impact on the airline networks of both airports. However, the Prague aviation network has shown much greater stability than the Bratislavan entity between 2003 and 2009.

Shrnutí

Stabilita a aktuálnost letecké sítě Bratislavy a Prahy

Letecká doprava patří k nejdynamičtějším druhům dopravy. Ve Slovenské i České republice byla ovlivněná až do roku 1989 politicko-hospodářským vývojem v rámci socialistického bloku. Cílem příspěvku je zhodnocení letecké sítě Bratislavy a Prahy. Příspěvek je zaměřený na analýzu změn v letecké dopravě Bratislavy a Prahy před vstupem do EU až do současnosti. Byly použity komparativní metody zhodnocení stability a aktuálnosti letecké sítě těchto dvou měst. Liberalizace a deregulace letecké dopravy v Evropě měla největší dopad na leteckou síť obou analyzovaných letišť. Ve sledovaném období 2003–2009 vykazuje letecká síť Prahy (ve srovnání s Bratislavou) vyšší stupeň stability.

Keywords: *aviation network, stability, actuality, Bratislava, Prague*

1. Introduction

The recent evolution of aviation shows that the airline industry has become more global. The liberalization of air traffic in Europe has resulted in spatial changes emerging in the aviation network (Ivy, 1997; Derudder and Witlox, 2009; Burghouwt and Huys, 2003; Reynolds-Feighan, 1995; Thompson, 2002; Morrell, 1998; Graham, 1998). EU air transport liberalization began about a decade after the US's, and it took place over the period 1987–1997. The situation in Central/Eastern Europe has mainly changed since May 2004 when EU liberalization admitted 10 new members.

Since this latest extension of the European Union, a fairly rapid integration of Europe´s air transportation network has also occurred (Reynolds-Feighan, 2007). The recent EU enlargement has created greater demand for travel between Europe's eastern and western fringes and the major airlines have responded by expanding their networks (Dobruszkes, 2009). For all new member countries, the integration into the European international airline industry was a great opportunity to access the global flow of money, goods, people and information. In addition, economic growth and lower prices generated sufficient demand for new services from both primary and smaller airports. This paper particularly concentrates on the consequences of the EU enlargement in the aviation network of the two new member countries, Slovak and Czech Republics, which were formerly united as one country. Among all the new member states, the Czech–Slovak airline connection achieved the highest international patronage with 190 thousand passengers in 2004 (Eurostat: Statistics in focus 2004). Their membership in the European Union and in the Schengen Area currently provides a great opportunity for their further growth as an important gateway to Europe.

Without doubt, the split of the former Czechoslovakia has influenced the aviation of both countries. This influence was especially notable in the Slovak Republic since its government aviation policy departments and infrastructure had to be developed from scratch. These difficult changes to the air transport network occurred since the political and economic reorientation of the former Eastern block, and they were analyzed by R. Ivy (1995). However, the most important evolution and change as far as the passenger volume and number of destinations is concerned occurred since 2004 when the two countries became EU members.

The number of passengers carried at Prague-Ruzyne Airport rose by 29.9% in 2004. This showed an increase of 5.6% in the similar category European airports catering for 5–10 million passengers (Praha Ruzyne Airport Annual Report 2004). In 2004, the Prague Airport achieved the highest growth in operations since the founding of the company in 1991, thus recording it's best-ever result. The air traffic increase on the Prague Ruzyně Airport was not recognized as being important until 2003 and before the Czech Republic's accession to the European Union, evidence of such a dramatic increase was not noted (Air Navigation Services of the Czech Republic, 2004). Additionally, the Slovak Republic recorded the largest increase in the EU with 73% (Eurostat). This data therefore highlights the significance of the year 2004 for the aviation of both countries, with the Bratislava airport recording a sharp rise mainly between 2004 and 2006. During this period, the number of passengers there maintained a 60% average annual increase, while the Prague-Ruzyne airport recorded 16% annual growth. These increases on both airports were driven by the market liberalization and airline expansion and especially low-cost carriers (LCCs), tourism and country development.

Another atypical year for the aviation of both countries was 2009, when the global financial crisis came to a head. The unprecedented traffic decline experienced since September 2008 coupled with the financial nature of the crisis severely affected the position of most European airports including those of Prague-Ruzyne and Bratislava. Unlike previous crises, European airports have experienced a sharp and entrenched decrease in air traffic. Three years of growth were lost for European airports as passenger traffic over that period fell just below 2006 levels (ACI, 2009).

This paper focuses on

1. exploring the changes in the aviation network of Bratislava and Prague airports which have occurred since the enlargement of the EU in 2004,
2. supplementing the evidence of the aviation network evolution of both hubs after their entrance to EU, their networks during the period 2003–2009,
3. analyzing the spatial and temporal actuality and stability of air transport linkages in the Bratislava M. R. Štefanik Airport and the Prague/Ruzyne Airport during 2003–2009, (herein "actuality" refers to the period of time between the existence of the last flight in the aviation network and the present date), and
4. investigating how the spatial and temporal dimension of this airline network changed between 2003 and 2009. Here, spatial dimension denotes the geographical structure of the airline networks of these two selected airports.

2. Brief literature review

Air transportation is one of the most dynamic modes of transport and aviation represents the fastest way to ship passengers and most types of cargo over long distances.

Traditional analysis of airline networks measures the network structure by means of variables such as traffic distribution and flight frequency (Caves et al., 1984; Toh and Higgins, 1985; Reynolds-Feighan, 1994, 1998, 2001; Bowen, 2002). Several measures of network configuration and organisation were presented in the previous literature and many geographical network analyses use different measures to capture elements of the spatial configuration of individual airline networks. These include the Herfindahl index, the Gini Index and the Theil Antropy measure (Reynolds-Feighan, 1998, 2001, 2007; Lee, 2003; Burghouwt, Hakfoort and van Eck, 2003).

Geographically, there are a number of studies analyzing aviation at both airport and route levels (Ivy, 1995; O´Kelly, 1998; Burghouwt and Hakfoort, 2001; Burghouwt et al., 2003; Burghouwt and De Wit, 2005; Reynolds-Feighan and McLay, 2006 etc.). G. Burghouwt and J. Hakfoort (2001) examined the evolution of the European aviation network in the former EU 15 between 1990 and 1998, and changes in the European air transport network occurring since the political and economic reorientation of the former Eastern block were elucidated by R. Ivy (1995). This author focused on the airline network of eight major airports in Eastern Europe in 1989 and 1993. At the airport level, D. Seidenglanz (2007, 2008) analyzed central European cities according to their location and accessibility and G. Burghouwt and J. De Wit (2005) examined the temporal configuration of air transport in the period 1990–1999 of selected European airports. This research focused on the temporality of airline operations investigated arrival and departure times while A. Reynolds-Feighan (1995) concentrated on the future of regional airports in the European Union. Meanwhile, the spatial structure of the European aviation network, was researched by

G. Burghouwt and J. Hakfoort (2001), G. Burghouwt et al. (2003), A. Reynolds-Feighan and P. McLay (2006), R. Ivy (1995), B. Graham (1998), A. Reynolds-Feighan (1995, 2001, 2007, 2010) etc.

3. Methodology and data

The appropriate indicator of the spatial configuration analysis of the aviation network is the amount and localization of the destination hubs. Methods used in this paper replicate those in the study of D. Gurňák (2000, 2003) who focused on the stability and actuality of European boundaries. The complete description of these methods is contained in D. Gurňák's 2007 work. A quite involved methodology was applied to evaluate the aviation network of Bratislava and Prague airports, comprising an analysis by two main indices and also by an additional one. The first main index was the stability of air linkages where this stability is related to the airport's ability to maintain an unchanging destination course (Ch) as long as possible:

$$As_i = \sum Ch_{ij}(t) \quad (1)$$

where, As_i is the stability of air linkages from the origin i (i_1 = Bratislava and i_2 = Prague), Ch are aviation network changes between nodes i and j for $j \in J$, $J = \{j_1, j_2, j_3, \ldots, j_n\}$ during the time period (t) 2003–2009.

The longer unaltered period of flights to the destination nodes ensures better stabilization of the aviation network's flights. The stability of the aviation network can be hierarchically graduated in relationship to its level of flight stability. One of the best of several alternative ways of describing flights stability is the cartographic method, which utilizes line thickness in agreement with D. Gurňák (2003). Here, a thicker line denotes a more stabilized flight to the destination node, and vice versa.

The second main index is the actuality of air connections. This actuality refers to the period of time between the existence of a last flight in the aviation network and the present date:

$$Aa_i = L_{ij}(t_n) - L_{ij}(t_n - 1) \quad (2)$$

where Aa_i is actuality of air linkages from the origin i (i_1 = Bratislava and i_2 = Prague), L_{ij} are flights in the aviation network, which come from the origin i to the destination j for $j \in J$, $J = \{j_1, j_2, j_3, \ldots, j_n\}$during the time period ($t$) 2009–2003.

The maximum value of the actuality measure is 0, which is related to the actual existing flight. Analogously the level of non-actuality index of flights can also be measured.

The actuality of the air linkages can be distinguished by the type and shade of its line. In this paper, various line shades were used. As D. Gurňák (2003, 2007) suggested, this can be evaluated in the percentage of the observed period. Both stability and actuality in this analysis were examined over a period of seven years (2003–2009).

One additional aspect in the aviation network analyses is quite important. Since the aviation network is characterized by distinctive dynamics (Goetz and Graham, 2004; Goodovitch, 1996; Seidenglanz and Červenková, 2009; Steiner et al., 2008), besides the main indexes of stability and actuality, the additional index of the existing connectivity of the nodes and its continuity was also analyzed. Continuous flights were flights, which carried on without suspension. In this case, the stability and respective actuality of the flights is not important. On the other hand, discontinuous flights in the aviation network were those, which had been suspended at least once – regardless of the time length. Since in some cases the flight actuality does not have a large value in terms of the comparison and ephemerality of some flights, the continual (resp. discontinual) index represents an appropriate tool for aviation network analysis. The spatial aspects of the aviation network can be interpreted by this methodology, while interrupted lines on the maps mark discontinuous flights.

These methods exactly describe the observed phenomenon since they focus on the development of flights (aviation network) during the entire observed period.

The data set used consists of OAG/ABC data for 2003–2009, which contains variables based on the published information on scheduled flights. These variables include departure and destination airports, flight frequency, aircraft type and seat capacity. This data is based on the annual representative month of October, except in 2004 where September data was utilized because of inaccessibility of October data[1]. Since passenger volumes fluctuate considerably during the year because of seasonal charter flights, data was analyzed for the chosen representative month which was less influenced by seasonal exceptions.

[1] However, this has no influence on the results since both months belong to the same flight schedule season.

The basic aviation statistical data for both airports was drawn from the Eurostat database and from the airports' official publications and annual reports.

4. Analysis

Due to the political situation during the Cold War period, most transport infrastructure, services and flows between the East and the West of Europe were limited. Air transportation in the Slovak and Czech Republics was also considerably influenced by this politico-economical development. The political upheaval at the end of the 1980's brought huge changes in the air infrastructure and a quite rapid integration of Europe´s air transportation network occurred (Ivy, 1995), with destinations gradually moving from east to west. The next turning point in the air industry in both countries occurred upon their entrance into the European Union in 2004 (Belianska, 2008). The growth in air transportation for all new Member States in Central and Eastern Europe was significantly higher than the average for EU 25. While Slovakia recorded the largest increase of 73% (Eurostat), air transport growth in the Czech Republic in 2004 was almost 30%. The Prague/Ruzyne airport with almost 10 million passengers remained the premier airport of the new member states, moving to the 27th place within the EU in terms of passengers carried. Therefore, this paper is focused on analyzing the changes in air transport linkages in the period from before the EU enlargement in 2003 until the present.

In 2003, it was possible to fly from Bratislava as the primary departure airport to only 11 destinations within seven states in Europe and two in Asia (Tab. 1), while the number of destinations from the Prague airport was incomparably higher. Before the EU accession, there were 74 possible destinations from the Prague airport with a majority of 81.1% of arrival airports in Europe, while eight destinations were in Asia, three in North America and three in Africa. Results show that the aviation market grew considerably in the period 2003–2009, mainly in Bratislava, since the number of destinations from Bratislava increased to 22 in 2009, representing a 100% growth. Meanwhile, the number of arrival destinations from the Prague airport increased to 100, which indicated a growth by 35%.

4.1 Bratislava Airport

With the constitution of the Slovak Republic in 1993, the government also created a state airline – Slovak Airlines – to provide for air transport links following the withdrawal of CSA. Initially, all the country's airports were owned and operated by the state. Then, the state owned airline known as Slovak Airlines was created in 1998 to address the lack of air service following the breakup of the former Czechoslovakia and the subsequent withdrawal of the majority of CSA services. The Slovak government announced its intention to privatize the Slovak Airlines in 2004 since the corporation had not grown significantly, accounting for only 3% of scheduled airline capacity from the Slovak Republic. The largest Slovak carrier in 2004 was SkyEurope, which accounted for 44% of the scheduled capacity. In January 2005, Austrian Airlines purchased a controlling 62% stake in the airline (Air Transport Infrastructure: The Slovak Republic). Austrian Airlines aimed to improve scheduled capacity to Brussels and Moscow, and to increase charter services to Egypt, Greece and Turkey. The airline also integrated services with its own schedules via code-sharing and joint operations since Austrian Airlines already operated from Bratislava to London, Brussels and Paris. Low-cost carriers account for the majority of capacity to and from the Slovak Republic, and in 2004,

Year/ Airport	Arrival destinations total*		Europe (%)		W. Europe (%)		E. Europe (%)		Africa (%)		Asia (%)		N. America (%)	
	BTS	PRG	BTS	PRG	BTS	PRG	BTS	PRG	BTS	PRG	BTS	PRG	BTS	PRG
2009	22	100	95.5	82.0	77.3	55.0	18.2	27.0	0	1.0	4.5	14.0	0	3.0
2008	23	101	87.0	87.1	73.9	60.4	13.0	26.7	0	1.0	17.4	7.9	0	4.0
2007	25	93	88.0	87.1	76.0	58.1	12.0	29.0	0	1.1	12.0	7.5	0	4.3
2006	26	94	88.5	87.2	65.4	58.5	23.1	28.7	0	2.1	11.5	7.4	0	3.2
2005	23	91	91.3	86.8	69.6	59.3	21.7	27.5	0	2.2	8.7	7.7	0	3.3
2004	22	92	90.9	79.3	54.5	55.4	36.4	23.9	0	3.3	9.1	14.1	0	3.3
2003	11	74	81.8	81.1	45.5	52.7	36.4	28.4	0	4.1	18.2	10.8	0	4.1

*Tab. 1: The share of arrival destinations from the Bratislava Airport and the Prague/Ruzyne Airport in 2003–2009. Source: OAG/ABC (2003–2009); * city with more airports was considered as one destination; however, there might be flight connections to different airports of the city*

they had a 58% share of the total capacity with Slovak based SkyEurope filling the majority of this amount. The SkyEurope was founded in February 2002, and with its significant foreign investment capital it was the dominant carrier in the Slovak Republic between 2004 and 2009. Although the network grew rapidly, frequencies were low on most routes and the carrier filed for bankruptcy on 31st August 2009, suspending all flights on 1st September 2009. Since there were then stranded passengers, other low-cost airlines, such as Ryanair and Wizz Air offered flights. The national carrier SkyEurope Airlines' share in the scheduled traffic on the Bratislava Airport in 2008 was 46% and it progressively gained the position of the most favourite airline from 2004. In 2008, the two low-cost SkyEurope and Ryanair companies together carried 1,566,940 passengers, which accounted for almost 90% of the entire scheduled traffic volume (Bratislava Airport Annual Report, 2008). Subsequently, the Irish airline Ryanair became the top passenger airline at the Bratislava Airport in 2009 with a proportion of almost 60% of the scheduled transport. The Slovak SkyEurope Airlines company was thus replaced at the top spot, being relegated to the second place with a 28% share of scheduled transported passengers. Seagle Air then completed the top three with its non-scheduled transport (Bratislava Airport Annual Report, 2009).

The year 2007 can be considered as a year of stabilization. At the same time, this was the year when the airport exceeded the threshold of two million handled passengers for the first time in the airport's history. The beginning of the year, however, was not very promising because following the announcement of a tender for Slovak Airlines in February 2007, the airport lost two regular lines with stable performance – Brussels and Moscow. Additionally, although Slovak Airlines was the most important air charter carrier at the Bratislava airport, it was replaced by the Air Slovakia airline. Despite the aforementioned negative factors, the new air connections of the two main low-cost carriers on the Bratislava Airport (SkyEurope Airlines and Ryanair) retained their effectiveness, especially during the second half of the year. After the "boom", which was recorded mainly from 2004 to 2006, when the number of passengers maintained a 60% average annual increase, the curve had stabilized. The increase of 4.5% in 2007 can be considered adequate when the size of the country and the airport capacity are taken into account (Bratislava Airport Annual report, 2007).

Due to the global financial crisis, 2009 was one of the most difficult years in the history of civil aviation in both Slovakia and the Czech Republic. This crisis caused a general decline in the passenger demand for air transport, with its first effects being felt as early as the last few months of 2008. The Bratislava Airport handled 1,710,018 passengers in 2009, recording a 23% fall in comparison with the previous year and by approximately 200,000 passengers less than in 2006. This decrease in passenger numbers was also undoubtedly influenced by the fact that many Slovak citizens terminated work activities abroad due to the effects of global economic crisis and returned home. Moreover, the closure of the two most important airlines, Sky Europe Airlines and Seagle Air, which had the Bratislava airport as their home base, only accentuated the sensitivity of the Slovak market to the economic crisis and reduced the demand for air transport. At the same time, this period also highlighted Bratislava's and Slovakia's limitations as attractive destinations for foreign visitors.

Besides the Bratislava Airport, the Slovak Republic's aviation network is represented by five additional international airports – Košice Interantional Airport, Airport Piešťany, Airport Žilina, Airport Sliač and Airport Poprad-Tatry. Dominance, however, remains with the Bratislava Airport, which has provided 80% of the entire air transportation volume in Slovakia since 2004 (Ministry of Transport, Post and Telecommunications SR: http://www.telecom.gov.sk/files/statistika_vud/vykony_letisk.htm).

The consideration of the total number of passengers shows that the aviation market recorded a great increase at the Bratislava Airport over the studied period. While the volume of passenger transport in 2003 was approximately 480 thousand, the number of passengers in 2008 increased to more than two million, and this represents a 360% growth. Finally, the evolution of Slovak air transport was highly dynamic over the past period, with the evolution of the Bratislava aviation network between 2003 and 2009 apparent in Fig. 1 (see cover p. 3).

Changes that occurred in the examined period are presented in Tab. 2, which clearly shows that the number of arrival destinations oscillated over time. As stated above, the number of destinations from Bratislava airport at the beginning of the examined period was 11 and this number doubled to 22 during this period. However, the growth was uneven, with the highest number of direct connections from Bratislava recorded in 2006 and since then they have been decreasing slightly. Bratislava recorded its most accessible number of countries in 2006, with the number of destination countries doubling that of 2003. However, the statistics have been slightly decreasing since 2006. Our data set allows examination of the number of airlines active on a given route. The consideration of carriers showed that their total number peaked in 2004 and 2006. Despite the collapse of the low-cost carrier Sky Europe, which formerly had a base in Bratislava, the number of carriers remained constant in 2009 compared with 2008. This shows the flexibility and dynamics of the aviation network. New routes from Slovakia, mostly operated by the low-cost carriers Danube Wings and Ryanair commenced during 2009. The average travel time was slightly longer due to the increased number of destinations and destination distance. This followed the substantial decrease in average travel time and average seat capacity between 2008 and 2009 as depicted in Tab. 2. This may have been due to the decreasing number of destinations from Bratislava during the global financial crisis, and because of the lost connections with far-distant destinations such as Amritsar, Kuwait, Larnaca and Istanbul which were formerly serviced by high capacity aircrafts. Although the average flight frequency for one hub has remained more or less stable during the 2003–2009 period, the average seat capacity has considerably increased with the growing demand for aviation services.

Besides this considerable growth in quantitative indicators, the analysis also shows important changes in the spatial configuration of arrival destinations. In particular, it is clear that the percentage of western destinations has increased considerably over eastern ones during the examined period. Table 3 shows the top 10 destinations in the terms of the number of passenger departures from Bratislava in 2008 compared to 2003, and it is evident therein that the spatial concentration of passenger demand has moved to important Western Europe centres.

Indicator/year	2003	2004	2005	2006	2007	2008	2009
Direct connections*	11	22	23	26	25	23	22
Arrival countries	9	16	17	19	17	14	11
Carriers	4	8	7	8	5	6	6
Average travel time (min)	131.1	123.2	128.9	145.5	146.4	160.9	126.4
Average seat capacity (per destination)	344.6	468.5	641.4	790.1	866.0	940.4	651.0
Average flight frequency (flights per week)	6.2	6.5	7.2	6.2	5.5	6.2	5.1

Tab. 2: Selected indicators of the Bratislava aviation network in 2003–2009
*Source: OAG/ABC (2003–2009); own calculations; *city with more airports was considered as one destination however there might be flight connections to different airports of the city*

Year 2003		Year 2008	
destination	**number of passengers**	**destination**	**number of passengers**
Prague	77,025	London	368,116
Košice	31,308	Košice	193,138
Moscow	22,958	Dublin	150,785
London	22,899	Milan-Bergamo	113,974
Paris-Orly	19,499	Paris-Orly	109,826
Zurich	17,356	Hurghada*	94,581
Bourgas	13,225	Prague	93,625
Milan-Bergamo	11,987	Frankfurt-Hahn	81,911
Tel Aviv	9,813	Manchester	81,064
Larnaca*	8,105	Birmingham	65,959
Total	**234,175**	**Total**	**1,352,979**

Tab. 3: Top 10 destinations from the Bratislava Airport in 2003 and 2008
*Source: Airport Bratislava (2009); *non-scheduled charter destination*

From the spatial aspect, Fig. 1 shows that the evolution of the Bratislava aviation network is quite heterogeneous. The stability of connections has varied considerably over time. During the examined period, 49 destinations departing from Bratislava airport could be accessed[2]. More than a third (34.7%), of these connections appeared unstable because they were accessible for only one year between 2003 and 2009. Destinations with 2–3 years accessibility were considered to have slightly stable connections, and therefore this category recorded only 28.6% of all connections during this period. However, the connections accessible for 4–5 years denoted relative stability, and these connections accounted for 20.4% of all destinations. The smallest category at 16.3% represents destinations accessible throughout 6–7 years of the examined period. These connections can be considered as stable. It can therefore be concluded that between 2003 and 2009, the Bratislava air network was quite changeable.

The index of actuality does not correlate with the stability of the connections. The analysis showed less stable connections from the beginning of the period (BER) and from the end of the examined period (BRE), too. Moreover, some stable connections (e. g. TLV) are losing their actuality. Meanwhile, it is necessary to bear in mind that the western linkage at the Bratislava airport is becoming more developed.

4.2 Prague/Ruzyne Airport

The Prague Airport is an operator of the most important international airport in the Czech Republic and the biggest airport of the new EU member states. It is one of major hubs for Central and Eastern Europe (Fig. 2, see cover p. 3). In 2008, the Prague Airport was voted the best Eastern European airport in the World Airport Awards poll. Because of its exceptional location in the centre of Europe, the Prague Airport is also becoming an increasingly important transit hub. Its long-term growth was fuelled by the Czech Republic's accession to the European Union in 2004 and its subsequent admission to the Schengen agreement. Since the end of March 2008, the handling of passengers and baggage destined for Schengen countries has been disencumbered from customs and passport control. The national airline of the Czech Republic, Czech Airlines (CSA), with more than 40% of the airport operations share, has been the largest carrier active at the airport, while the most dynamically growing sector has become that of the low-lost carriers. CSA reported that 2004 was a successful year recording its largest ever growth rate of 21% carrying a record number of 4.34 million passengers (Air Transport Infrastructure: The Czech Republic). Punctuality also improved significantly with the airline moving from 20th to 6th place overall amongst the European carriers. In 2004, CSA provided over 53% of all capacity to and from the Czech Republic, with the majority of the remainder provided by full service carriers at 23%. While Czech Airlines was the dominant carrier in Prague, Europe's low-cost carriers (LCC) were very well represented, with SmartWings being the locally-based one operating since May 2004. This airline belongs to Travel Service, a company currently majority-owned by the Icelandair Group. LCC's accounted for approximately 16% of all capacity to and from the country in 2004, with Easyjet providing the greatest capacity flying to the Czech Republic. This carrier operated flights to Prague mainly from London and other UK destinations. The LCC's share has been increasing rapidly since 2004 at the Prague airport and in 2008, it attained about 27% of the scheduled flights. Although low-cost airline flights were used mainly by passengers from the United Kingdom to the Czech Republic, the Prague airport also served as a destination for LCC's arriving from other European airports. SkyEurope initiated services from Prague only in 2006 but during the peak summer season of 2007 it operated 15 routes. Frequencies increased on key business routes such as Amsterdam, Milan and Paris, while there where new daily regional services to Bratislava, Kosice and Vienna (Anna, 2007).

Due to the attractions of the Czech Republic as a leisure and business destination, it is most likely that all LCC's will increase their future capacity (Air Transport Infrastructure: The Czech Republic).

In 2004, the Prague-Ruzyne airport was the most important hub not only in the Czech Republic, but according to its performance growth it was one of the leading airports in countries that became new EU member states on 1st May 2004. After the accession of the Czech Republic to the EU, the number of flights to European cities by classic airlines also increased. The commencement of regular flights to a number of new destinations and the considerable increase in flight frequency on existing regular routes was also an important factor influencing the growth in the number of movements at the Prague-Ruzyne airport. In 2004, Prague-Ruzyne also played the role of an important transit point for passengers whose target destination was not Prague and the Czech Republic. This mainly involved flights from Western Europe or North America to Eastern Europe or target destinations in the Near or Middle East areas and vice versa (ANS Annual report, 2004). Therefore, the Prague airport

[2] Comparison with the Vilnius airport, which is in a similar category, recorded a total of 36 accessible destinations.

holds a specific position compared with the Bratislava airport.

The airports of the Czech Republic can be divided into three main categories:

1. The Prague/Ruzyne airport is considered to be an airport of national importance,
2. The regional airports of Brno, Ostrava, Karlovy Vary and Pardubice are classified as international airports and
3. The remaining regional airports are considered less important (Ministry of Transport CZ – http://www.mdcr.cz/cs/Letecka_doprava/letiste/).

As is also the case in Slovakia, the Czech Republic has a small land area, and aviation there concentrates mainly on international transportation, especially that provided by the Prague airport. Consequently, during the entire examined period, the Prague Airport contributed by more than 90% to the Czech Republic's total air transportation. Although the Bratislava airport has undergone considerable development in recent years, the Prague Airport's has been more significant and dynamic. The total number of passengers handled by the Ruzyne airport from 2003 to 2008 increased by 70% to 12,630,557, and the number of arrival destinations of Prague Airport are shown in Tab. 4. Additionally, all Ruzyne's observed indicator values are more progressive than those of the Bratislava Airport.

Table 5 indicates that the top 10 destinations as to transported passengers have mostly remained stable over this period. It is noticeable that the aviation network of Prague Airport is mainly oriented towards the important hubs and metropolitan cities of Western Europe. In this comparison of the top 10 destinations,

Indicator/year	2003	2004	2005	2006	2007	2008	2009
Direct connections*	74	92	92	95	93	101	93
Arrival countries							
Carriers	32	36	32	38	36	37	39
Average travel time (min)	112.7	115.7	110.5	110.1	115.5	111.6	141.5
Average seat capacity (per destination)	615.9	718.3	745.0	797.1	886.0	788.4	879.1
Average flight frequency (flights per week)	5.8	6.3	6.7	7.2	7.9	6.9	7.1

Tab. 4: Selected indicators of the Prague aviation network in 2003–2009
*Source: OAG/ABC (2003–2009); own calculations; *city with more airports was considered as one destination however there might be flight connections to different airports of the city*

Year 2003		Year 2008	
destination	**number of passengers**	**destination**	**number of passengers**
London	801,295	Paris	542,380
Paris	403,999	Amsterdam	447,017
Frankfurt	379,483	Frankfurt	429,834
Amsterdam	326,330	London	426,387
Moscow	200,569	Moscow	394,258
Tel Aviv	184,546	Madrid	316,916
Zurich	171,722	Brussels	308,750
Copenhagen	161,289	Dublin	288,535
East Midlands	158,969	Rome	282,358
Brussels	150,018	Copenhagen	261,888
Total	**2,938,220**	**Total**	**3,698,323**

Tab. 5: Top 10 destinations from the Prague/Ruzyne Airport in 2003 and 2008
Source: Prague/Ruzyne Airport (2009)

Table 5 also shows no significant change in the spatial configuration of the aviation network since the Czech Republic accession to the EU. Only three destinations out of ten were changed. The number of passengers traveling into these destinations changed considerably and it became more balanced.

In contrast to Bratislava, the Prague aviation network showed much greater stability over the period 2003–2009 (Tab. 6), and Fig. 3 clearly denotes that stable connections are dominant. These represent slightly more than 50% of all destinations during the period. On the other hand, unstable connections create only about 15%, which is half the percentage attained by Bratislava. Lower values were also recorded for slightly stable (17.9%) and relatively stable connections (14.2%), with these percentages representing the smallest number of all connections. Thus, changes in the spatial configuration of the Prague air network between 2003 and 2009 appear small in comparison with the Bratislava aviation network. Nevertheless, it must be noted that the selected indicators of the Prague air transportation increased over this period. Prague proved to be a high

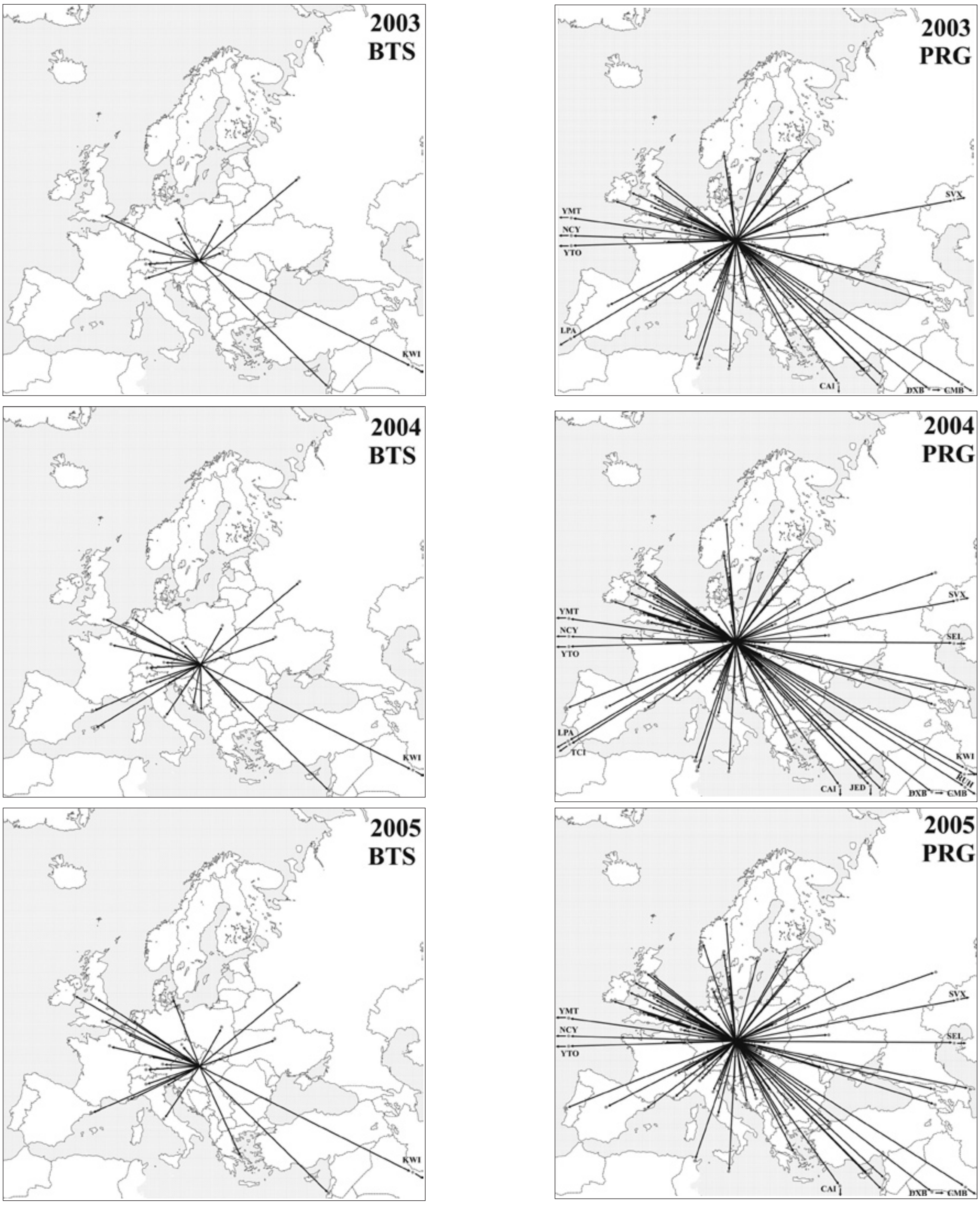

Fig. 3 – continue

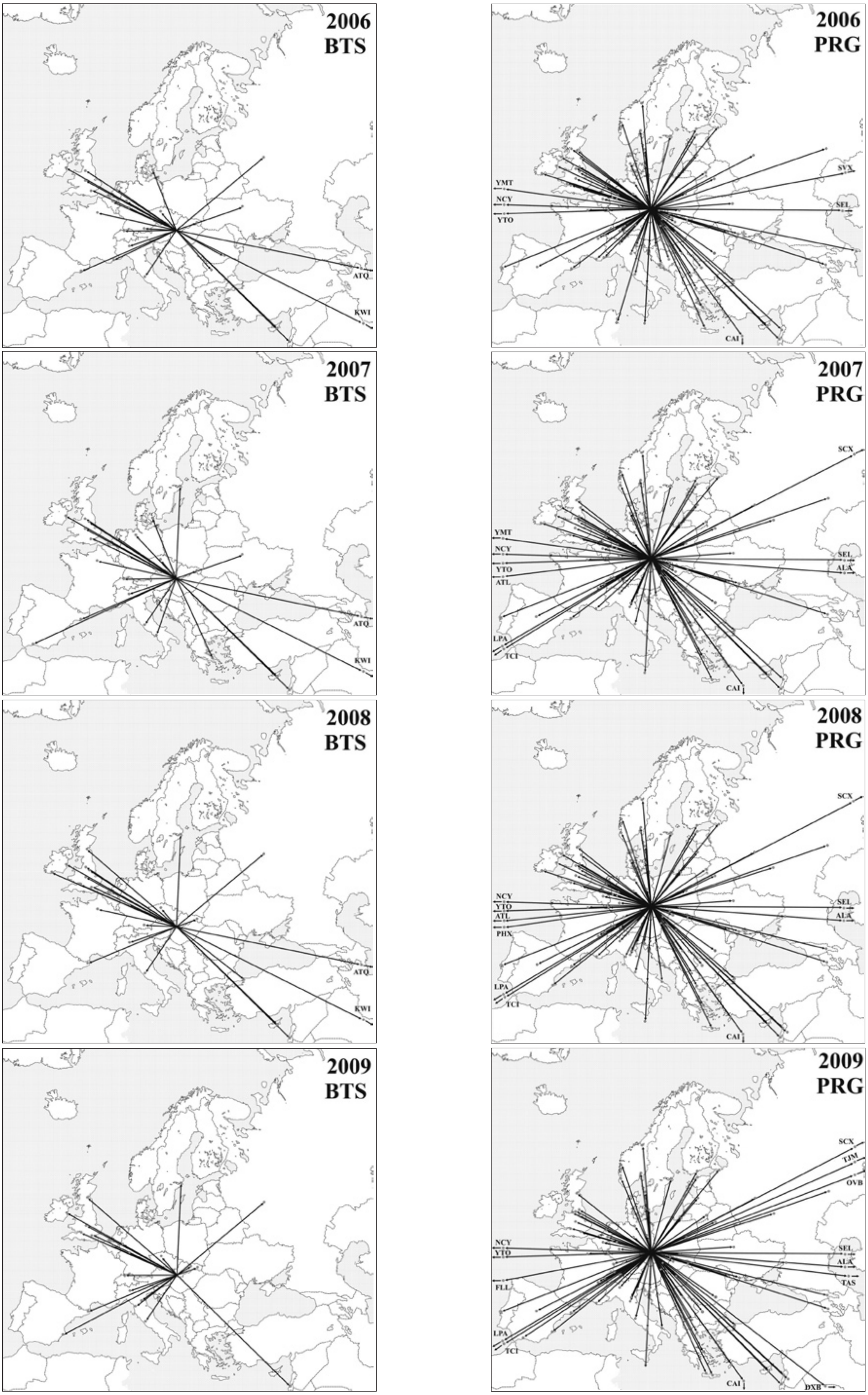

Fig. 3: Development of the Bratislava and Prague aviation networks between 2003 and 2009

Airport/stability	Unstable	Slightly stable	Relative stable	Stable
BTS	34.7%	28.6%	20.4%	16.3%
PRG	15.7%	17.9%	14.2%	52.2%

Tab. 6: Stability of the Bratislava and Prague/Ruzyne aviation networks
Source: OAG/ABC (2003–2009); own calculations

demand centre for air transportation within Europe, particularly within the EU. It proved to have stronger linkages with Western Europe than other new member states, particularly including Slovakia, even before EU enlargement. The Prague Airport is also prospering in comparison with Vienna as it transported 65.6% of the Vienna operation in 2004, which is a great achievement compared to 35.7% 10 years ago (Prague Ruzyne Airport Annual Report). Therefore, the Prague Airport is beginning to compete successfully with the Vienna airport and, importantly, it is gradually becoming a sound competitor able to be counted on in Central Europe. The Prague-Ruzyne Airport is the largest airport of those in all countries which joined the European Union in 2004, and it is currently recording exceptional escalation in operating performance. It handles the largest number of passengers compared to the Warsaw and Budapest rival airports in this region. According to the World Travel and Tourism Council, the Czech Republic is among the top ten fastest growing countries in tourist demand. Prague is one of the world's most popular tourist destinations, with the inbound number of foreign tourists increasing by a million between 2003 and 2004 (Czech tourism). Tourists are arriving mainly from Germany, which registered 23% in 2006 and from the UK, Italy and the USA (Czech Statistical Office).

5. Discussion and conclusion

The entrance of Slovak and Czech Republics to the EU has contributed to their growth in trade, increased mobility of capital and movement of labour, and this has resulted in emerging new travel destinations and the growth of demand in the aviation market. Factors determining the air transport market include trends in income, fares and costs, while institutional reforms such as liberalization, rising incomes and increased leisure time have contributed to the steady growth of demand occurring in the aviation market.

In summary, air transportation in the examined countries of Slovak and the Czech Republic is mainly concentrated in one primary hub, which is naturally the capital city.[3] Therein, Bratislava and Prague international airports account for more than 80% of the air passenger volume. This paper therefore presents an overview of changes in the spatial concentration of the airline networks of Bratislava and Prague/Ruzyne airports during the period 2003–2009.

Through the analysis of selected indicators, important temporal and spatial changes in the aviation networks of both hubs were identified. It was observed that both airports had recorded significant growth in aviation since their integration into the EU in 2004. However, this growth was not linear throughout the period. Moreover, the situation and position of the Prague/Ruzyne airport is entirely different compared to that of Bratislava. While the Prague/Ruzyne airport ranks among the top 30 airports of the EU, gaining the 27th place in 2008, Bratislava rated as the 103rd airport within the EU in terms of passengers carried. Furthermore, when the stability of the air networks during the examined period is considered, the Prague air network has proven to be much more stable compared to Bratislava's. One of the reasons for this is Prague's advantageous location and significant position even prior to EU accession. Although the Czech Republic joined the EU only in May 2004, thanks to more liberal air service agreements with other countries (especially the UK), traffic was already booming well before 2004 due to low-cost carriers. Low-cost services go started from London Stansted as early as September 1999.

It is also worth noting that although western linkages dominate both networks, more striking changes are noticeable in the Bratislava's aviation network than in the Prague's. A significant growth in western linkages, together with increased seat capacity, occurred in Bratislava during the period of analysis. Compared to the Bratislava aviation network, the significant intercontinental orientation of the Prague aviation network should be noted, especially regarding North American and Asian links. According to the airport, its principal interest is to develop long-haul routes with North America and Asia, more city-pair connections within the European region and to become the main Eastern European hub (Prague Airport).

[3] In air passenger transportation the term hub serves as transhipment point and allows for the replacement of direct connections between all nodes with fewer, indirect connections (Bryan and O´Kelly, 1999, p. 276.). In this paper in the case of Bratislava, the term hub is taken to mean a transportation node.

Concluding, the Prague/Ruzyne airport certainly dominates in terms of air traffic volume. Meanwhile, during the examined period of 2003–2009, there was very rapid and dynamic air traffic growth in Bratislava. Analysis also showed a considerable growth in quantitative indicators and significant changes in the spatial configuration of the Bratislava aviation network. Bratislava's rapid growth from a low-base is explained by the fact that after Czechoslovakia split into two separate states, the national flag carrier –CSA remained in Prague in the Czech Republic. The vacuum in Slovakia was filled by the emergence of SkyEurope, an LCC, which in effect became the new flag-carrier for the country. Following the void in the Slovak market left by SkyEurope in September 2009, other carriers tried to fill this market gap. During 2009, when SkyEurope was struggling and finally exited the market, new routes from Slovakia operated mainly by DanubeWings and Ryanair were initiated. With 60% of seat capacity on the Bratislava airport, Ryanair became the country's biggest airline, marketing Bratislava as a secondary airport to Vienna. Additionally, in its early days SkyEurope expected that many passengers would use Bratislava as a secondary airport to nearby Vienna where low-cost flights were virtually non-existent. However, the airline changed its philosophy, and in March 2007 it began to operate a growing base in Vienna with more routes and aircraft based there than in Bratislava.

The liberalization and deregulation of air traffic in Europe have had a great impact on the airline network of both airports. According to G. Burghouwt et al. (2003), one of the most profound effects of deregulation was the entrance of low-cost carriers into the European aviation market. These low-cost carriers experienced rapid growth, especially after 1999. In Europe, the development of low-cost carriers is a significant factor in the evolution of airline networks, competition, and demand trends. Moreover, the accession of 12 new member countries to the EU automatically extended the territories and the number of airlines resulting from this liberalization. In these countries, low wage costs, low incomes and the weakness of flag carriers are additional elements favouring the development of LCC´s. New East-West low-cost supply could also be quite attractive for migrants from Central Europe, who might substitute low-cost airlines for international coaches (Dobruszkes, 2006). Hence, low-cost airlines play a significant role in the aviation market of the new member states. Since the enlargement of the EU to East Central Europe, the low-cost air service has diversified in favour of new west-east air links (Dobruszkes, 2009). Low-cost airlines responded to the emerging need and demand resulting from the new geopolitical arrangements in Europe. The new west–east routes reflect new forms of mobility including post-migration flows from the east by those who have gone to work in Western Europe, new tourist practices and new types of business. (Dobruszkes, 2009). According to F. Dobruszkes (2009), the low-cost supply of west-east links grew from 2% in 2004 to 13% in 2008. This indicates that low-cost airlines play an important role in the air industry of the new member states. The European low-cost carriers offer point-to-point air services rather than indirect connecting one routed through carrier hub airports (Reynolds-Feighan, 2007). They offer low fare services between mainly under-utilized secondary airports close to key European metropolitan areas (Button, 2004).

On the other hand, it is important to note the factors, which have negatively influenced the air industry recently. These factors especially include the global financial crisis, the collapse of low-cost carriers and the threat of terrorism. Hence, an evident slowdown in the dynamic evolution of air transportation in recent periods can be observed. The effect of the economic crisis on the air transport industry became apparent mainly during the end of 2008. After an uninterrupted period of six years of sustained growth in EU aviation, the data exhibited a decline. European airports lost 100 million passengers in 2009 (ACI, 2009), and the overall passenger traffic at European airports for 2009 decreased by 5.9% compared with 2008 (Anna, 2009). For Bratislava, the monthly seasonality profile also shows that passenger numbers have fallen since October 2008, when the global economic downturn affected air travel. In 2009, the passenger numbers in Bratislava fell by 23% on the previous year. This declining trend from the last quarter of 2008 was also recorded at the Prague airport. However, the overall decrease of 7.8% was not as sharp as the Bratislava's. An example specific to the Slovak Republic as a consequence of the crisis was the return of huge numbers of workers from Great Britain and Northern Ireland. These workers represented an important segment of the stable customer base of Bratislava Airport. Proof also lies in the comparison of the volume of transport to and from destinations in Great Britain, where flights from Bratislava posted a slump of 20% (BTS Annual Report, 2009). In addition, the crisis reflected in the decreased interest in flight holiday packages during the summer season.

The summary of world financial crisis impacts is as follows:

1. bankruptcy of very important stable airlines operating from the Bratislava airport,
2. sharp decrease of passengers working abroad,
3. decreasing public demand for air transport, and
4. changes in holiday destination preferences negatively influenced passenger air traffic

in 2009 much more at the Bratislava airport than at the Prague-Ruzyne airport.

This concurs with the ACI 2009 report that major hubs tended to be comparatively less affected than other airports, mainly due to the strength of their local market and better performance from their connecting traffic. On the other hand, the large/medium regional airports tended to be more affected, while small regional airports only randomly performed better due to growth opportunities offered by low-cost airlines.

In the long-term analysis, however, the dynamic growth of both airports is quite noticeable, especially for the Bratislava Airport, which reported record values within the EU throughout the entire examined period.

In conclusion, for the completion of the development of business and tourism within Europe, it is necessary to build transportation linkages that break the former East-West barrier. Air transport can certainly help these countries achieve a high level of access to global markets and foreign investment, and it might be also an important source of economic stimuli for local economic development. K. Button (2004) states that the availability of air transport can also act to enhance economic growth as well as being a follower of it.

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CENTRAL EUROPEAN ONE-DAY PRECIPITATION RECORDS

Jan MUNZAR, Stanislav ONDRÁČEK, Ingeborg AUER

Abstract

One-day precipitation amounts over 300 mm are exceptional in the climate of Central Europe. They were recorded only three times within the time span of more than a hundred years: 29th July 1897 in Bohemia at the station Nová Louka/Neuwiese (345.1 mm), 5th July 1947 in Austria at the station Semmering (323.2 mm) and 12th August 2002 in Germany at the station Zinnwald-Georgenfeld (312.0 mm). The hitherto unbroken record daily precipitation amount thus remains the oldest one.

Shrnutí

Středoevropské jednodenní srážkové rekordy

Jednodenní srážkové úhrny, které přesahují 300 mm jsou v klimatu střední Evropy naprosto výjimečné. Za posledních více jak sto let byly v tomto regionu zaznamenány pouze třikrát: poprvé 29. července 1897 v Čechách na stanici Nová Louka / Neuwiese (345,1 mm), dále 5. července 1947 v Rakousku na stanici Semmering (323,2 mm) a 12. srpna 2002 v Německu na stanici Zinnwald-Georgenfeld (312,0 mm). Dodnes nepřekonaným středoevropským rekordem je tedy ten nejstarší z nich, který byl naměřen před více než 110 lety v severních Čechách.

Keywords: *daily precipitation amounts, Central Europe*

1. Introduction

Identifying extraordinary precipitation amounts is rather important due to a number of ecological, economical and societal impacts. Large and intense floods are one of them, and any additional knowledge of causes and processes of such events contribute to a better disaster management in order to reduce and prevent flood consequences and damages. The increased incidence of extraordinary hydro-meteorological extremes in the last twenty years has led to numerous discussions about their reasons: are these phenomena symptoms of natural climate changes and variability or results of human impacts on the climate? (See e.g. Brázdil, 2002; Kundzewicz et al., 2005; and others.)

Our impetus for writing this paper arose from two pieces of information excerpted from meteorological publications about the causes of disastrous floods in Central Europe in the summer of 2002. Very interesting was the information on a record precipitation of 352.7 mm measured on 12th August 2002 within 24 hours at the German meteorological station Zinnwald-Georgenfeld in the Krušné hory Mts. / Ore Mts. (Erzgebirge in German), south of Dresden (Rudolf and Rapp, 2003). In addition to this, Marsh and Bradford (2003) informed that a new all-Germany one-day precipitation record of 312 mm was recorded at the same station during the extremely wet period, which culminated on 12th August 2002, and that the same one-day precipitation amount was recorded at the station Cínovec in the Czech Republic.

Why the two pieces of information fascinated us? Because in the first case, the message indicates that the more than 110 years old Central European record of 345.1 mm measured at the station Nová Louka / Neuwiese in the Jizerské hory Mts. / Isergebirge in northern Bohemia from 29th July 1897 was exceeded[1]. And in the second case it seems only hardly believable that accurately the same amount of daily precipitation 312.0 mm occurred simultaneously both at the German and Czech side of the ridge of the Krušné hory Mts. (even if the localities were near each other).

[1] As „Central Europe" we understand in this paper the region of countries: Austria, Czechia, Germany, Poland and Slovakia.

2. The precipitation record of 345.1 mm from 29th July 1897

Although one-day precipitation amounts of 300 mm and higher are exceptional in the Central European climate, two stations recorded such in 1897. Apart from the already mentioned 345.1 mm measured in Nová Louka/Neuwiese, the nearby station Jizerka / Wilhelmshöhe in the Jizerské hory Mts. / Isergebirge recorded a one-day precipitation amount of 300.0 mm on 29th July 1897, too. Precipitation amounts over 200 mm were recorded on that day also by many other stations occurring both on the Czech and German side of the Jizerské hory Mts. / Isergebirge and Krkonoše Mts. / Giant Mts. (Riesengebirge in German). The extreme amounts of precipitation in this region on that particular day for three stations in Bohemia and three stations in Silesia and the isohyetal map of one-day precipitation amounts in Bohemia for 29th July 1897 were presented in the paper by Munzar, Ondráček, Elleder, Sawicki (2008). In respect to dating, the incidence of extreme precipitation amounts measured by stations on the Silesian side of the Krkonoše Mts., historical German meteorological data and papers, e.g. Hellmann (1897) and Krause (1957) speak of 30th July. This is because the daily precipitation amount in Prussia was related to the day on which the measurement was taken at 07.00 o'clock, in contrast to the observing rules of the Austrian meteorological service.

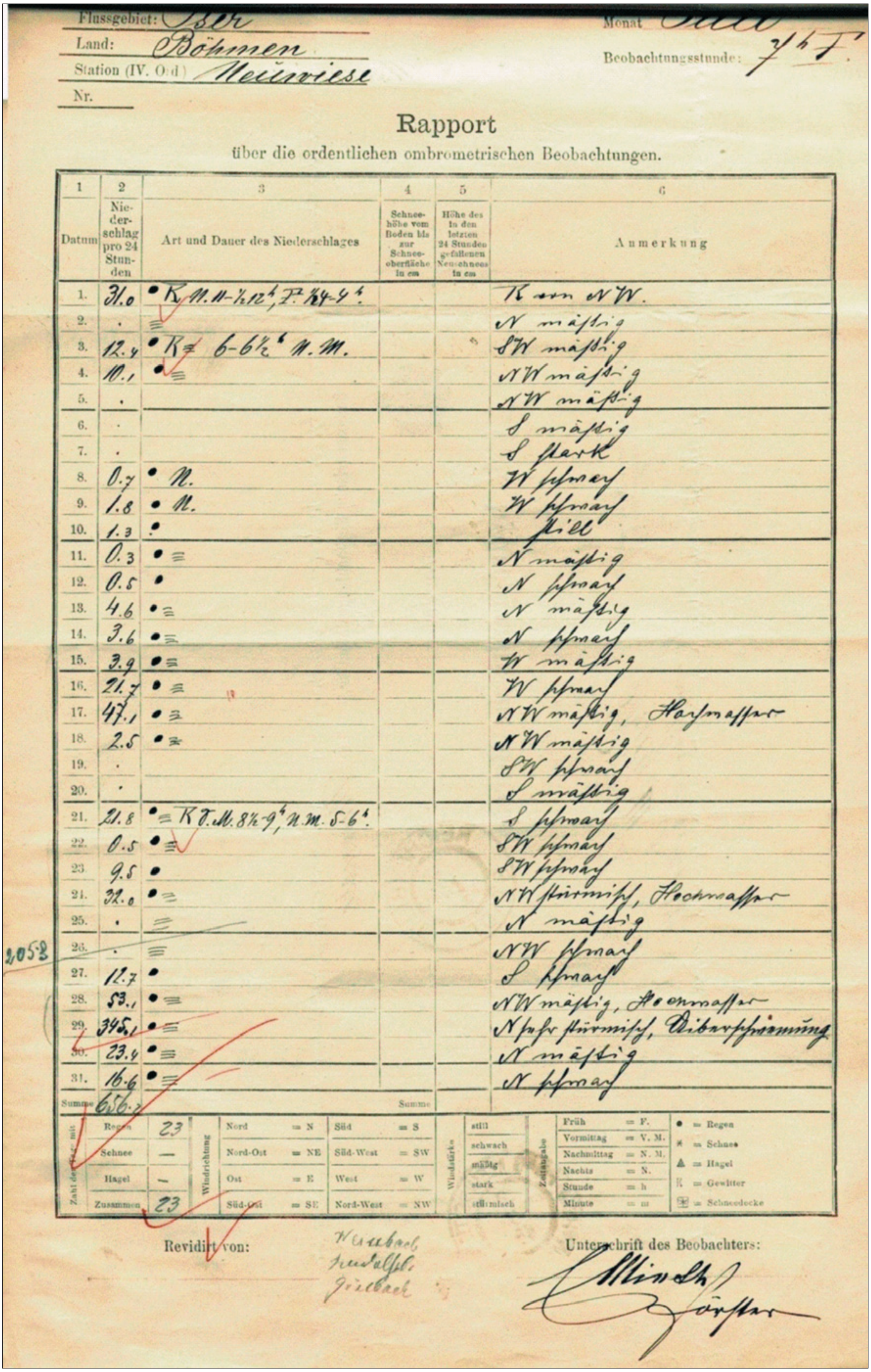
Let us return to the history of the Nová Louka station (50°49'N, 15°09'E, 780 m a.s.l.) and to the historical documentation of the record precipitation amount. The very first measurements were taken by a forest warden near the local forester's house and the hunting lodge on a forest clearing as early as in 1878. However, the observations were disrupted at the end of the 1880s. The station was restored on 1st January 1891 and its observer became forester Franz Bartel who was replaced by Franz Mieth two years later. Just F. Mieth measured the legendary 345.1 mm on 29th July 1897. This value is mentioned both in the original monthly precipitation report for July 1897 (Fig. 1), and later in the Austrian meteorological yearbook for 1897 (Jahrbücher... 1899).

The record was evidently checked by several comptrollers from the K. K. Central-Anstalt für Meteorologie und Erdmagnetismus in Vienna. There were other meteorological elements measured at the Nová Louka station at that time (according to the yearbook) too, such as atmospheric pressure, air temperature, wind direction and force. After 1900, the successor of Franz Mieth was observer Karl Neuwinger (Krause, 1954). In spite of the fact that the forester's house was destroyed by fire in 1926, the observations at that locality continued until the beginning of 1943 when the meteorological station was moved some 1.5 km to the west, onto the dam of water reservoir Bedřichov on the Černá Nisa River. Only the hunting lodge has remained in the locality of Nová Louka until these days, which serves as a mountain cottage and is a sought destination of hikers (Fig. 2 – see cover p. 4).

The first two publications mentioning the extreme precipitation event are articles by G. Hellmann and W. Trabert, which appeared in the very same year 1897 in the 14th volume of journal Meteorologische Zeitschrift (i.e. 32nd volume of the Zeitschrift der Oesterreichischen Gesellschaft für Meteorologie)[2]. Hellmann´s article about the cloudburst from 29/30th July 1897 in the Krkonoše Mts. (Hellmann, 1897) appeared already in August. Afterwards in October, Trabert (1897) informed about abundant rains lasting several days, affecting a relatively big part of Central Europe. It is logical that such extreme precipitation amounts raised extreme floods and caused much damage in the territory of nearly two thirds of Bohemia, part of Moravia and Silesia, Lower and Upper Austria and extensive parts of Germany. For example, Hellmann and von Elsner (1911) described the flood on the Oder River at the end of July and beginning of August 1897 together with its causes.

The extreme precipitation was caused by an atmospheric low moving along the Vb trajectory according to the classification of W. J. van Bebber. An extensive low-pressure area with three nuclei (1005 hPa) developed above Central Europe on 28th July 1897: above the northern part of Adriatic Sea, Hungary and southern Poland. On the following day, the three nuclei merged into one centre (1006 hPa) north of the Vysoké Tatry Mts./High Tatras Mts. At the same time, the pressure gradient above the territory of Bohemia grew with the north-western to northern flow (atmospheric pressure above the western part of Bohemia was 1020 hPa and above the Jizerské hory Mts. only 1010 hPa!!). The reason was an unusual retrograde displacement of the low-pressure centre to the west and southwest above eastern Moravia (Štekl et al., 2001) – see Fig. 3.

[2] At that time, this journal was published jointly by the Austrian meteorological society and the German meteorological society with editors Dr. J. Hann (Vienna) and Dr. G. Hellmann (Berlin).


Flussgebiet: Iser
Land: Böhmen
Station (IV. Ord.) Neuwiese
Nr.
Monat: Juli
Beobachtungsstunde: 7h F.

Rapport

über die ordentlichen ombrometrischen Beobachtungen.

1 Datum	2 Niederschlag pro 24 Stunden	3 Art und Dauer des Niederschlages	4 Schneehöhe vom Boden bis zur Schneeoberfläche in cm	5 Höhe des in den letzten 24 Stunden gefallenen Neuschnees in cm	6 Anmerkung
1.	31.0	• K N.M. 11-½12, F. ½4-4			K von NW.
2.	·	≡			N mäßig
3.	12.4	• K≡ 6-6½ N.M.			SW mäßig
4.	10.1	•≡			NW mäßig
5.	·				NW mäßig
6.	·				S mäßig
7.	·				S stark
8.	0.7	• N.			W schwach
9.	1.8	• N.			W schwach
10.	1.3	•			still
11.	0.3	•≡			N mäßig
12.	0.5	•			N schwach
13.	4.6	•≡			N mäßig
14.	3.6	•≡			N schwach
15.	3.9	•≡			W mäßig
16.	21.7	•≡			W schwach
17.	47.1	•≡			NW mäßig, Hochwasser
18.	2.5	•≡			NW mäßig
19.	·				SW schwach
20.	·				S mäßig
21.	21.8	•≡ K V.M. 8½-9, N.M. 5-6			S schwach
22.	0.5	•≡			SW schwach
23.	9.5	•			SW schwach
24.	32.0	•≡			NW stürmisch, Hochwasser
25.	·	≡			N mäßig
26.	·	≡			NW schwach
27.	12.7	•			S schwach
28.	53.1	•≡			NW mäßig, Hochwasser
29.	345.1	•≡			N sehr stürmisch, Überschwemmung
30.	23.4	•≡			N mäßig
31.	16.6	•≡			N schwach
Summe	656.2			Summe	

Zahl der Tage mit		Windrichtung				Windstärke	Zeitangabe		
Regen	23	Nord = N	Süd = S			still	Früh = F.		• = Regen
Schnee	—	Nord-Ost = NE	Süd-West = SW			schwach	Vormittag = V. M.		* = Schnee
Hagel	—	Ost = E	West = W			mäßig	Nachmittag = N. M.		▲ = Hagel
Zusammen	23	Süd-Ost = SE	Nord-West = NW			stark	Nachts = N.		K = Gewitter
						stürmisch	Stunde = h		⊞ = Schneedecke
							Minute = m		

Revidirt von: Weissbach, Friedland, Griesbach

Unterschrift des Beobachters: [illegible] Förster

Fig. 1: The original monthly report of rain-gauging observations at the Nová Louka / Neuwiese station for July 1897 with the record daily precipitation amount of 345.1 mm from 29th July 1897 (Rapport...1897)

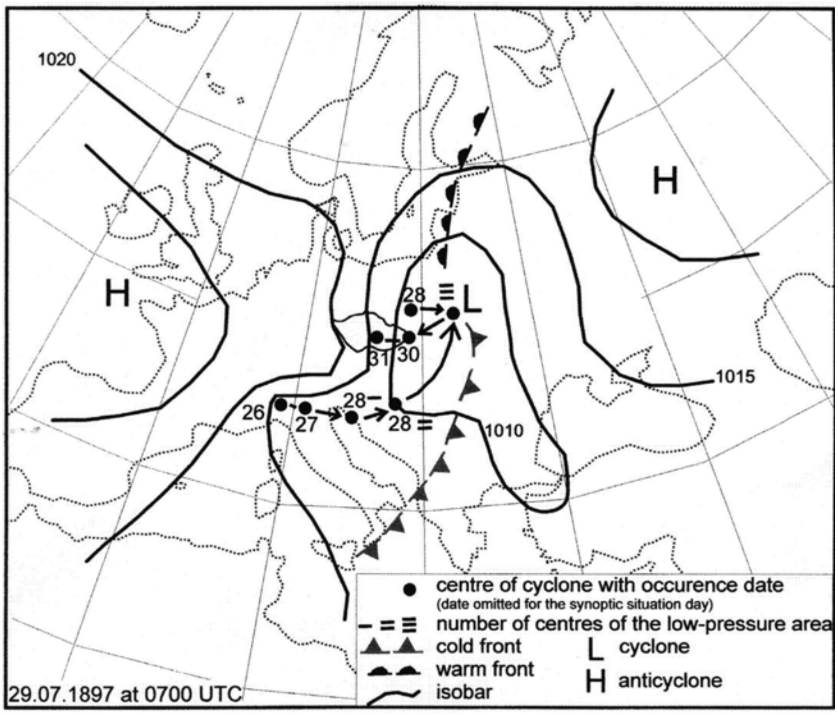


Fig. 3: The synoptic situation on 29th July 1897 at 07.00 UTC and cyclone trajectories (according to Kakos in Štekl et al., 2001)

3. The precipitation record of 312.0 mm from 12th August 2002

As already mentioned, two different record precipitation amounts were reported for that day at the Zinnwald-Georgenfeld station (50°44'N, 13°45'E, 877 m a.s.l.): 352.7 mm and 312.0 mm. The first value would have meant exceeding of the old central European extreme by 7.6 mm. However, the precipitation amount for 24 hours was determined non-traditionally on the basis of a pluviogram recorded from 05.00 o'clock of Central European Summer Time (CEST = GMT + 2 hours) on 12th August 2002 to 05.00 o'clock of the following day. Therefore, the time of measurement was shifted by three hours compared with the usual determination of daily precipitation amounts, i.e. from 08.00 o'clock (CEST) on 12th August to 08.00 o'clock on 13th August.

In respect to this classical concept of one-day precipitation amount, "only" 312.0 mm fell at the concerned station; yet, this amount meant a new all-Germany record. The hitherto record rainfall amount of 260 mm was until that time measured at the Zeithein station (District Riesa, Saxony) on 6th July 1906 and at the Stein station (District Rosenheim, Bavaria) on 7th July 1954. This shows that the new record surmounted the original by 52 mm.

It is worth adding that according to Malitz (2002), the one-day precipitation amount of 200 mm was exceeded at further six German stations on 12th August 2002; of those, the highest values were recorded at the Klingenberg (280.6 mm) and Lauenstein (267.3 mm) stations. Apart from these, a value of approximately 300 mm was reported from the Oberbärenburg recreation centre, situated about 8 km to the northwest of Zinnwald at an altitude of 750 m a.s.l. (Goldberg, 2002).

In this context, we have an interesting comparison of precipitation amounts in Bohemia from 12th and 13th August 2002. The amount of 200 mm was exceeded at ten Czech meteorological stations, seven of which were situated in the Jizerské hory Mts. / Isergebirge and three in the Krušné hory Mts. / Erzgebirge. The highest rainfall amount of 278.0 mm on the 13th August was recorded by rain gauge in the experimental catchment of the Czech Hydrometeorological Institute in the Jizerské hory Mts. / Isergebirge at the Knajpa station (967 m a.s.l., circa 12 km to the east of the Nová Louka station where the above-mentioned historical record was measured in 1897).

The highest amount of rain (226.8 mm) falling on the Czech side of the Krušné hory Mts. / Erzgebirge on 12th August 2002 was recorded at the Český Jiřetín – Fláje station (790 m a.s.l.). The information that the one-day precipitation amount of 312.0 mm measured at the German station Zinnwald-Georgenfeld was recorded at the same time at the Czech station Cínovec (Zinnwald in German) is assumed erroneous (Marsh and Bradford, 2003) because this station was closed in 1993 (Munzar and Ondráček, 2003).

The distance between two mentioned meteorological stations on the Czech-German border being only 0.5 km, it is very likely that the precipitation amount of about 300 mm could have occurred in the territory of the Czech municipality Cínovec as well. The error arose because Květoň et al. (2002) included in their list of precipitation data for August 2002 the already non-existing Cínovec station (District Teplice), allocating to it the value of precipitation extreme measured at the nearby German station.

The primary cause of the extreme atmospheric precipitation amounts in Central Europe in the first half of August 2002 and subsequent disastrous floods was an atmospheric low moving along the "classical" Vb trajectory. Thus, the synoptic situation was analogous to the one occurring towards the end of July 1897. Besides, the record precipitation was caused by the interference of several others factors namely by the atmospheric low moving slowly due to stationary high-pressure areas over East and West Europe, the extremely warm and moist air from the Mediterranean area coming into a cyclonic circulation and precipitation being orographically intensified on windward sides of mountains. The synoptic causes, atmospheric precipitation amounts and resulting floods were described in detail and evaluated in a number of papers (e.g. Goldberg, 2002; Malitz, 2002; Rudolf and Rapp, 2003; Ulbrich et al., 2003a, 2003b; Marsh and Bradford, 2003).

4. The precipitation record of 323.2 mm from 5th June 1947

As far as we know, the only other verified record one-day precipitation amount exceeding 300 mm is the Austrian record of 323.2 mm, which was measured on 5th June 1947 at the Semmering station (1 012 m a.s.l., 47°38'N, 15°50'E). It was recorded during a cloudburst that affected a relatively small territory, located primarily on the windward side of a mountain ridge in the area of Semmering and its surroundings. This is documented i.a. by a map of isohyets according to Hader (1951), which we present in Fig. 4. An extraordinary amount of 133.5 mm was also recorded at the Eichberg station (750 m a.s.l.), located about 7 km northeast of Semmering (at other stations in the area, one-day precipitation amounts did not exceed 75 mm).

The cloudburst and the flooding of local watercourses caused by it, in addition to a strong hailstorm caused appreciable damage, as Hader (1949) described on the basis of an exceptional report about this event, written by an observer at the Semmering meteorological station. The hailstones were as large as heart cherries, their average weight was 4.3 g and they fell in a relatively narrow band. At Semmering itself, the hailstones were still lying on the ground the next day even though the morning temperature was 9.5 °C! It is understandable that this hailstorm destroyed field crops in the affected area.

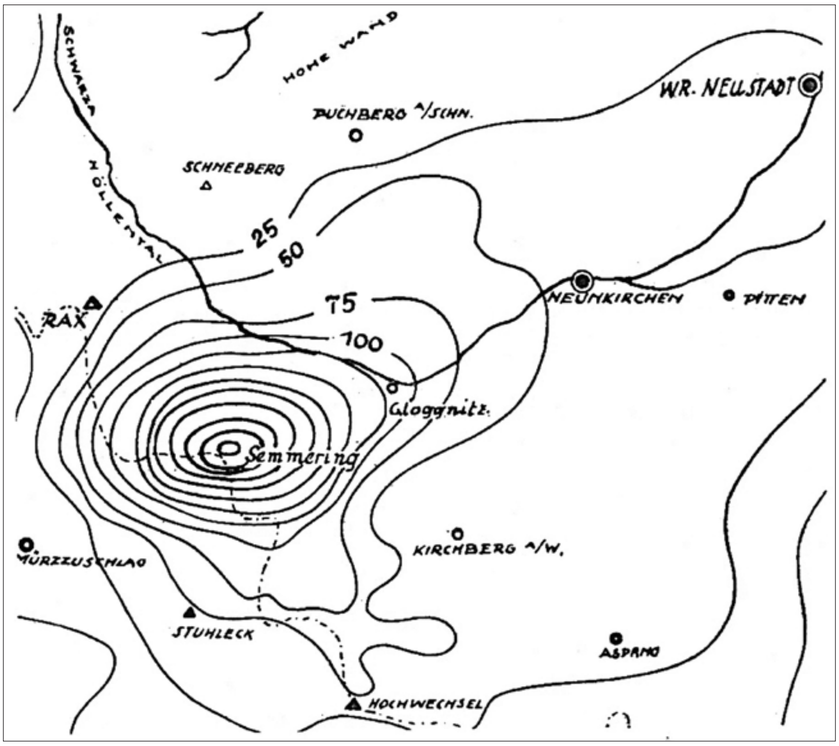


Fig. 4: The map of 1-day precipitation isohyets in the area of Semmering (Austria) on 5th June 1947 in mm from Hader (1951)

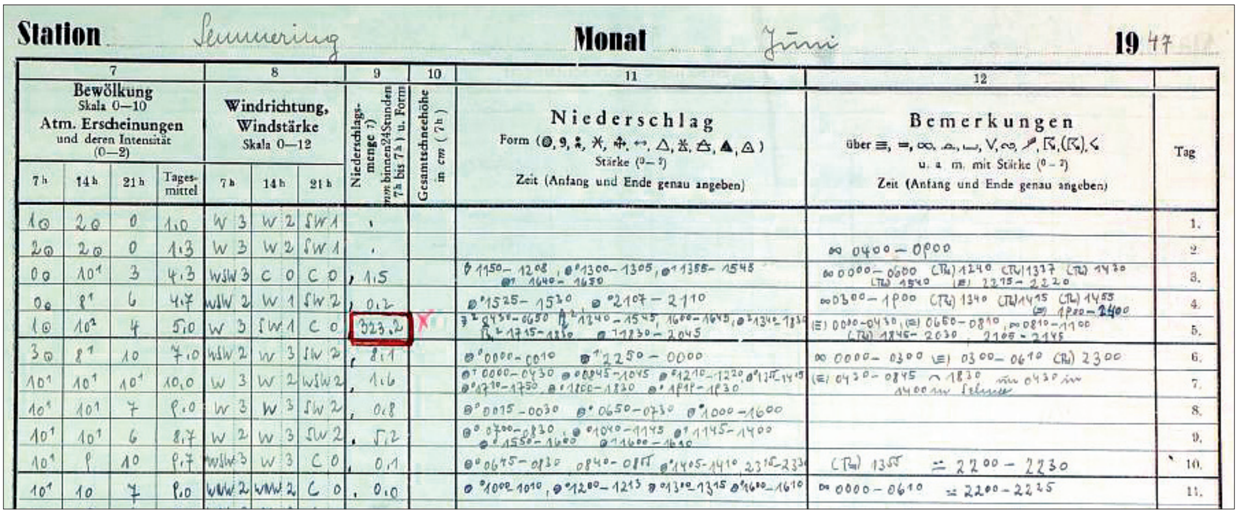
It is likely that no one has studied the weather situation and meteorological causes of the Austrian record in more detail. They were different from the described cases from 1897 and 2002. To reconstruct the causes of this historical case we had at our disposal only a surface synoptic map, listed in the archive at http://www.wetterzentrale.de, and a catalogue of general weather situations (Grosswetterlagen) by Hess and Brezowsky (Gerstengarbe et al., 1999). This classifies the synoptic situation of all days in the period from 4–10th June 1947 as WZ (Westlage, zyklonal = West cyclonic situation above Central Europe). On 5th June, in a westerly flow, a cold front advanced across Austria and neighbouring countries in a shallow low pressure trough, which is attested i. a. by the course of air pressure and temperature recorded in the observation report of the Semmering station. There were thunderstorms at places in the rear of this front. The one that struck Semmering and its close surroundings in that afternoon was absolutely extraordinary. According to meteorological observation reports, it lasted almost five hours with two short breaks. It was accompanied by a cloudburst and a hailstorm. After the thunderstorm was over, it was still raining but at lower intensity for other two hours – Fig. 5a, 5b (Meteorologische Beobachtungen... 1947). Thus, the record precipitation amount fell over a total time of seven, not five hours as Lauscher (1971) wrote. Orographic influences undoubtedly contributed to the precipitation amount.

Lauscher (1971) mentions also two legendary Austrian one-day precipitation amounts from Styria, exceeding an unbelievable amount of 600 mm. The first of them is allegedly a precipitation amount of 600–670 mm measured in Stiftingtal near Graz on 16th July 1913 and the second one is a rainfall amount of 650 mm that is said to have been recorded in Schaueregg on 10th August 1916. Unfortunately, none of these two cases could be properly verified and corroborated in nearly a hundred of years. As to the first case that was dealt with by Forchheimer (1913), it appears that the mentioned recorded amount had been de facto not directly measured but rather estimated by the author and his students from the field observations. After the cloudburst on that day, they inspected various vessels, containers, reservoirs etc. and measured the amount of intercepted water, combining their own measurements with interviewing local farmers etc. The actual precipitation amount measured at stations in the concerned region was however approximately only one tenth of the values published by P. Forchheimer according to preserved reports.

As far as the second case is concerned, it turned out that it is dated both as 10th August 1916 and as 10th August 1915. Which of the two dates is correct could not be verified. The value of the traditionally quoted extreme precipitation amount could not be documented from data collections preserved in the archives of Zentralanstalt für Meteorologie und Geodynamik in Vienna not even for one of these two dates and the two cases cannot be considered therefore as plausible records.

5. Conclusion

Concluding we can state that according to our findings, there were only three cases of one-day precipitation amounts higher than 300 mm occurring in Central Europe within a time span of more than a hundred years – in 1897, 1947 and 2002.



Station Semmering Monat Juni 1947

7 Bewölkung Skala 0–10 Atm. Erscheinungen und deren Intensität (0–2) 7h	14h	21h	Tagesmittel	8 Windrichtung, Windstärke Skala 0–12 7h	14h	21h	9 Niederschlagsmenge mm binnen 24 Stunden 7h bis 7h u. Form	10 Gesamtschneehöhe in cm (7h)	11 Niederschlag Form (Stärke 0–2) Zeit (Anfang und Ende genau angeben)	12 Bemerkungen u. a. m. mit Stärke (0–2) Zeit (Anfang und Ende genau angeben)	Tag
1⊙	2⊙	0	1.0	W 3	W 2	SW 1	·				1.
2⊙	2⊙	0	1.3	W 3	W 2	SW 1	·			0400 – 0800	2.
0⊙	10¹	3	4.3	WSW 3	C 0	C 0	1.5	1150–1208, 1300–1305, 1355–1545, 1640–1650	0000–0600 (T) 1240 (T) 1337 (T) 1430 (T) 1540 2215–2220	3.
0⊙	8¹	6	4.7	WSW 2	W 1	SW 2	0.2	1525–1530, 2107–2110	0300–1800 (T) 1340 (T) 1415 (T) 1455 1800–2400	4.
1⊙	10²	4	5.0	W 3	SW 1	C 0	323.2	0450–0650, 1240–1545, 1600–1645, 1340–1830, 1715–1830, 1830–2045	0000–0430, 0650–0810, 0810–1100 (T) 1845–2030, 2105–2145	5.
3⊙	8¹	10	7.0	WSW 2	W 3	SW 2	8.1	0000–0010, 2250–0000	0000–0300, 0300–0610 (T) 2300	6.
10¹	10¹	10¹	10.0	W 3	W 2	WSW 2	1.6	0000–0430, 0845–1045, 1210–1220, 1315–1415, 1710–1750, 1800–1830, 1818–1830	0430–0845, 1830	7.
10¹	10¹	7	9.0	W 3	W 3	SW 2	0.8	0015–0030, 0650–0730, 1000–1600		8.
10¹	10¹	6	8.7	W 2	W 3	SW 2	5.2	0700–0830, 1040–1145, 1145–1400, 1550–1600, 1600–1610		9.
10¹	9	10	9.7	WSW 3	W 3	C 0	0.1	0645–0830, 0840–0855, 1405–1410, 2315–2330	(T) 1355, 2200 – 2230	10.
10¹	10	7	9.0	WNW 2	WNW 2	C 0	0.0	1000–1010, 1200–1213, 1310–1315, 1600–1610	0000 – 0610, 2200 – 2225	11.

Fig. 5a: The observation report of the Semmering meteorological station with the Austrian record daily precipitation amount of 323.2 mm from 5th June 1947 (Meteorologische Beobachtungen...1947). Fig. 5b with detail – see cover p. 4

A hitherto record daily precipitation amount remains to be the oldest one, i.e. 345.1 mm measured at the Nová Louka / Neuwiese station in northern Bohemia on 29th July 1897. Exceptionally abundant atmospheric precipitation in the days from 26th till 31st July 1897 affected a relatively big part of Central Europe and caused extreme floods in vast territories of Czechia, Austria and Germany.

The second highest documented one-day precipitation amount is the Austrian record of 323.2 mm measured at the Semmering station on 5th June 1947. The record amount was caused by a cloudburst related to a thunderstorm in the rear of a cold front; strong orographic intensification of precipitation also played a significant role. The torrential rain affected a relatively small area located mostly on the windward side of the mountain ridge. (Two legendary Austrian one-day precipitation amounts higher than 600 mm in the years 1913 and 1916 were not verified and corroborated and cannot be considered as plausible records.)

The third highest one-day precipitation amount is the German record of 312.0 mm measured at the Zinnwald-Georgenfeld station on 12th August 2002. A several days lasting atmospheric precipitation period culminated on that day. Heavy rains caused disastrous floods in the Danube River basin and above all in the Elbe River basin. (At the Zinnwald-Georgenfeld station, a 24-hour precipitation amount of 352.7 mm was determined on the same day, but from 05:00 CEST of this day to the same time of the following day from pluviogram.) The information that the one-day precipitation amount of 312.0 mm was simultaneously measured at the nearby Czech station Cínovec is erroneous, because the station was closed in 1993.

As far as we know, the absolute one-day precipitation records on the territory of Poland and Slovakia did not exceed 300 mm. These extreme precipitation records from all five mentioned Central European countries are presented in Tab. 1. In order to have a full picture, it is necessary to add the geographical positions of the Polish and Slovak stations: Hala Gasienicowa 49°15'N, 20°00'E and Salka 47°53'N, 18°45'E.

For the sake of completeness, we mention multi-day record precipitation amounts only from the territory of the Czech Republic, too. In July 1897, two-, three- and five-day precipitation amounts of 398 mm, 422 mm and 451 mm were recorded at the Nová Louka station. While the two-day amount was not surpassed until now, this does not apply to amounts of three and more days. These were surmounted in the Czech Republic at several gauging stations but only after a hundred of years – in July 1997. At that time, total 3-day and 5-day rainfall amounts gauged by the station at the Šance water reservoir (49°31'N, 18°25'E, 445 m a.s.l.) in the Beskydy Mts. amounted to incredible 537 mm and 617 mm, resp. and resulted in the biggest and most extensive flood in the 20th century, which occurred in the eastern part of the Czech Republic, mainly in the upper watershed of the Odra / Oder River and in the Morava / March River catchments (Kakos, 1997). For comparison: in August 2002, a three-day precipitation amount of "only" 406 mm was measured at the Zinnwald-Georgenfeld station (see chapter 3). Thus, the record three-day precipitation amount for Germany has remained until today the amount of 458 mm recorded at the Stein station in July 1954.

Today, changes in the frequencies and intensities of precipitation dominate in the public debate concerning the climate change, although the relationship between single events and the general increase of temperature is hardly to prove. Nevertheless, it is necessary to pay constant attention to findings about the occurrence of extreme precipitation, as its impacts are very significant for disaster management and flood prevention.

Acknowledgements

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Amount [mm]	Date	Station	Altitude [m a.s.l.]	Country
345	29.7.1897	Nová Louka	780	CZ
323	5.6.1947	Semmering	1012	A
312	12.8.2002	Zinnwald-Georgenfeld	877	D
300	30.6.1973	Hala Gasienicowa	1520	PL
232	12.7.1957	Salka	111	SK

Tab. 1: One-day precipitation records in Central Europe

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GEOSPATIAL ANALYSIS OF THE SPATIAL CONFLICTS OF FLOOD HAZARD IN URBAN PLANNING

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Abstract

The possibilities of using GIS in the planning process are discussed in this paper. A new approach to the identification of environmental conflicts is introduced, in the domain of legal demands for the creation of regional planning records and documentation. Conflicts caused by hydrological events have been chosen as a model situation from a wide range of such spatial conflicts.

Shrnutí

Analýzy prostorových konfliktů v územním plánování s ohledem na nebezpečí povodní

Příspěvek se primárně zabývá možnostmi GIS v procesu územního plánování. Přibližuje nový přístup k identifikaci environmentálních konfliktů v území pro zákonem danou potřebu tvorby územně plánovacích podkladů a územně plánovací dokumentace. Z rozsáhlé škály konfliktů, jež je třeba v území řešit, uvádí jako modelovou situaci konflikty způsobené hydrologickými jevy.

Keywords: *spatial conflicts, floods, hydrologic modelling, urban planning, GIS*

1. Spatial planning and GIS

In the last few years, we could see a significant increase in the importance of spatial planning as a part of the social process and development of affected regions in developed countries. It is suitable to use GIS for high-quality spatial planning on the level of municipalities and regions.

Unfortunately, spatial planning sometimes strives for the best distribution of human activities at the expense of environmental conditions. However, the environmental conditions should play an essential role in the spatial planning. In practice, it often happens that new buildings are built at places unsuitable for human activities (floodplains, landslide areas), thus leading to a conflict between physico-geographic conditions and human activities both existing and proposed.

Geographic information system (GIS) is one of available tools designed for the global assessment of landscapes and for the simulation of the effects of calculated measures. GIS is also a powerful tool for the appraisal of existing conditions and for designing alternative scenarios. Together with the knowledge base, GIS can help in the decision making regarding what type of measure should be used and where the measure will make a difference.

Implementation of GIS into the local government dwells on joint management, combined information, integrated and seamless services, web accessibility, efficiency savings and other factors. Rapid advances of GIS technology in recent years have greatly expanded the utility of GIS and the scope of the application of these spatial data management tools (Laurini, 2001; LeGates, 2005). The elegance of modern GIS tools is their ability to instantly relate varied information types and sources to concrete, real-world circumstances in combination with powerful tools for analyzing and visualizing the feasibility of what can be imagined. However, many current GIS applications do not exploit the full capacity of GIS techniques to facilitate the information needs of top-level management (LeGates and Stout, 2000). Future GIS is likely to develop additional capabilities in this direction, which would build on the large volume of operational spatial data found in many large organizations and governments.

In many foreign countries (USA, Germany, Canada), where the GIS implementation has an older history, the implementation of GIS tools in urban planning is more extensive. Urban planners use the GIS software more commonly and so their results are based on expert analysis. An example is ArcGIS – the Model Builder tool for regional planning around Munich, described by

Schaller (2007). Maantay and Ziegler (2007) introduced several examples of the application of GIS analytical tools for the urban environment. Case studies focused on for example crime pattern analysis, community-based planning, urban environmental planning or urban services and urban populations.

Zwick and Carr (2007) introduced LUCIS (Land-use Conflict Identification Strategy) as a strategy to explore optimal suitability to three broad land-use categories (agriculture, conservation and urban) and compared them to identify where conflicts among them exist. LUCIS is also introduced as a tool with the potential for many other applications, including the strategic conservation planning, real estate investments, infrastructure planning or general market analysis. The LUCIS model is a good example of the combination of GIS analytical tools into extension available for urban planners. Kumar et al. (2006) showed a possibility of using free GIS analytical tools. Geographic Resource Analysis Support System (GRASS) was used in their research as a tool for urban planning.

Using the ESRI software, our team applied mapping capabilities, which are fully integrated into computer applications for any business sector that deals with spatial data, including applications accessible via Internet. Moreover, through creative layering and geo-referencing of all forms of digital data (including text, graphics, spreadsheets, architectural and engineering plans/drawings, aerial photographs, video, environmental data, and map features) we applied the powerful analytical, management, and communication tools of GIS. GIS was applied to manage and analyze spatial data related to the micro-region of Hranice (Hranicko), as well as to develop and deploy desktop map applications for the local government sector.

Geographical information systems are subjects with very powerful analytical capabilities. By integrating these tools and incorporating the mapping functions into spatial planning and decision-making processes, the project enhanced the understanding of what is really happening in the Hranice micro-region and further enhanced the municipalities' visions of what can be achieved.

Ideal GIS compatibility for powerful and sufficient project implementation means the same configuration of all GIS components (hardware, software, data, and system structure) which are not strictly required. However, the interoperability of all processes, analyses, modelling and simulation in GIS is necessary. Configuration of our GIS approach consisted of a university hardware platform (servers and workstations, peripheral devices – digitizer, scanner, and plotters) and licensed software products (ESRI ArcGIS 9.x, Autodesk Map 3D 2005, Bentley MicroStation V8). Spatial planning uses GIS capabilities for evaluating business plans and activities in regions. These evaluate questions referring to business plans and human activities:

1. what to introduce or establish,
2. what to support,
3. what to sustain,
4. what to reduce,
5. what to terminate,
6. what to eliminate and not allow to create.

All the above-mentioned topics include three basic aspects: spatial (where to locate them), temporal (when to carry them out) and procedural (how to implement them). Within the spatial framework of the GIS implementation, the area under investigation was analyzed.

The application framework of the GIS approach involved setting up a number of spatial applications (participatory processes – given questions), some of which are common for all partners and some of which were peculiar to individuals. To solve problems in the region, all members of the research team defined indicators of crucial conditions and activities, collected geodata and entered them into GIS, formulated questions (topics) to be answered, processed analysis and modelling procedures, and finally produced many maps and an atlas of development. There is a close relationship between GIS and decision support systems because geographic data are relevant to many types of problems where spatial decisions are used. Many applications in decision support systems use a geographical context for the development of visual interactive techniques (Burian, 2008).

2. Spatial conflict analysis

To make a geographic assessment of development activities in the region we selected an approach, which was easy to implement into GIS that maintains the necessary quality and accuracy of spatial information. The methodologies used for landscape and spatial planning are most suitable for this goal as they work with relevant geographical topics and search for localities where conflicts exist between development activities (social and economic) and environmental conditions (Burian et al., 2007a).

The observed conflicts were selected based on the extent of the compiled geo-database. It is appropriate to use digital data from planning materials for building this database because it is possible to get all the key inputs from them. The analysis of data availability and their processing into the form useable for GIS is beyond the scope of this article, see more in Marchetta (2007).

The following were labelled as development activities: areas newly designed in the municipality plan for human activity, e.g. areas intended for utility services, parking spaces, industrial areas, manufacturing areas, arable land, and agricultural production premises. The analytical processing separately included similar existing activities, too. Data layers of functional areas, built-up areas, areas possible to build on, and transportation areas were used for these purposes.

Particular spatial conflicts were analysed with the use of the “select by attributes” and “select by location” GIS operations, which were used to locate the overlay of the given physico-geographic phenomenon with the existing and proposed development activities. Such spatial analyses to discover the overlay of data layers will be referred to as spatial conflict analyses. Spatial conflict refers to a conflict between the environmental conditions and human activity (existing and proposed) in the area. Statistical GIS tools were used to calculate the share of all the affected areas for each conflict.

Spatial conflicts can be divided into three categories according to the degree of seriousness. No publication is known to the authors that would make use of such an analysis of spatial conflicts (Burian et al., 2007b). The most serious conflicts are placed in Category 1, the least serious ones are in Category 3. Because the opinions of experts concerning this issue often differ, in some cases the categorization may be debatable. The same can be said about the conflict weight with the 1st and 2nd level buffer zones of water resources. Conflict with an active landslide has a higher weight than conflict with a potential landslide. Analogically, such an example may be found in every category. Therefore, the categorization has to be considered as targeted for the given method.

Category 1 includes conflicts that may have a disastrous impact on the proposed activities but where construction in these natural localities will not have a significant influence on environmental conditions. Category 2 includes conflicts that would mean deterioration of the quality of the environment in the case of human activity. Category 3 includes other conflicts that are rather related to inappropriateness of human activities in the given areas and whose weight is not as high as in the two preceding categories.

3. LOREP

There are many commercial software products for hydrologic modelling and each of them has pros and cons. If used in land use planning, a necessary feature of the model is to provide results in finer than subbasin scale. The formulated LOREP model represents an application of the solution using a methodological approach for the identification and localisation of areas with low flood storage capability. This makes it possible to compare the projected scenarios. The structured catalogue of non-technical solutions for the landscape is a part of the model.

The fact that linear features (such as lines of trees) can be a part of land use analysis is the key element of the model. This is possible because the raster data of high resolution (pixel size 5 m) are used and because the modelling is focused on the hydrology of small basins (Kulhavý and Kovář, 2000). The development of the model was launched in 2000 under the grant project GA ČR 103/99/1470 "Extreme hydrological events in the basin" and outcomes were compared with the outcomes of model WBCM–4 (Raukner, 2006).

The procedure for the computation of territorial specific surface runoff is based on a combination of specific functions in GIS, hydrological equations of the runoff curve number method, spatially distributed unit hydrographs and tools for the support of the decision making called EMDS (Ecosystem Management Decision Support).

LOREP is written in Python and is designed for ArcGIS. The input data is expressed as a thematic raster (grid of pixels) in agreement with the rules of raster representation in ArcGIS. Spatial resolution of the pixels is chosen so that it is high enough to identify the influence of linear features in the landscape on the extent of surface runoff (Pechanec, Cudlín, 2005).

3.1 Computation of specific surface runoff in the territory

Computation of territorial specific surface runoff is a determinant step for the localisation of areas with a low flood storage capability. These raster data of high resolution are input layers for the analysis of surface runoff in the model:

1. Hydrologically correct Digital Elevation Model (Hutchinson, 1988),
2. Raster of curve number method (CN-values),
3. Raster of land use – it leads to the raster of Manning’s roughness coefficient values.

It is possible to use any method of producing DEM (Digital Elevation Model) but it is necessary to adhere to the rules of the creation of correct DEM (e. g. uniform format and resolution). Raster of CN-values is created according to the methodology recommended for the Czech Republic (Janeček, 1992, 2007). If the area does not contain forests, the CN-value is determined by combining data and land use categories plotted in the soil type map and in the complex survey of soils. If the area contains forests, hydrologic groups of soils are derived from the forest typology unit (Pechanec et al., 2009). The process assumes a zero previous rainfall.

The layer of land use is created / updated with the help of data sets ZABAGED (Fundamental Base of Geographic Data) and orthophotomaps of the concerned basin. The field survey has to be realized in poorly identifiable areas. The values of Manning's roughness coefficient are determined by land use categories according to conversion tables (Chow et al., 1988; Janeček et al., 1992).

The procedure core point is an algorithm of the direct runoff capacity $Q(t)$ with spatially distributed terrain parameters (parameters were published by Olivera, Maidment, 1998). This algorithm (see equation No. 1) makes it possible to trace the direction of surface runoff in the landscape and to specify the influence of terrain on the runoff. It is necessary to divide the basin into uniform non-overlapping subareas (subbasins in grid structure) i for the application of this algorithm and to calculate $Ii(t)$ and $Ui(t)$ for each subbasin (see equations No. 2 and 3).

$$Q(t) = \sum_{i=1}^{Nw} \int_0^{\infty} A_i I_i(\tau) U_i(t-\tau) d\tau \qquad (1)$$

where $Q(t)$ – direct runoff from the concerned basin, t – time, N_{1-w} – number of subbasins, A_i – area of subbasin i, $I_i(\tau)$ – excess precipitation in subbasin i (direct runoff from basin i, see equation No. 2) and $Ui(t-\tau)$ – flow-path response function (response at the basin outlet yield by a unit instantaneous input in subbasin i, see equation No. 3)

$$I_i(t) = \alpha_i P_e(t) \qquad (2)$$

where $I_i(t)$ – excess precipitation in subbasin i (based on the appraisal of balance in the "soil – water" system), t – time, α_i – compensative index and $P_e(t)$ – precipitation excess

$$U_i(t) = \frac{1}{2t\sqrt{\pi(t/T_i)\Delta_i}} \exp\left\{-\frac{[1-(t/T_i)]^2}{4(t/T_i)\Delta_i}\right\} Ki \qquad (3)$$

where $U_i(t)$ – flow-path response function, t – time, T_i – mean distribution value, Δ_i – scatter around average of the distribution and K_i – flow-path loss factor (determines the loss of water along the flow-path.)

The curve number method (CN) is used for the calculation of excess precipitation in subbasin i. This method takes into account the fact that flood storage capability depends on hydrologic attributes of the soil, on the initial condition of water saturation in the soil and on land use activities in the landscape. A detailed description of the algorithm and its derivation is in the paper of the authors Olivera and Maidment (1998).

3.2 Area specification of hydrologic zones in the basin

The basin is divided into hydrologic zones. It is necessary to know in which zones the areas with high $Q(t)$ are located for the selection and application of suitable flood control measures. Topography determines ecological conditions such as slope orientation, gradient of the slope and energy supply. This means that trophic and water relations of the zone and the amount of transported solids from the zone are changing dynamically. Terrain can be differentiated into zones with different attributes as follows:

- Denudation zone – The supply of solids is minimal and the loss of solids is considerable. The zone's resistance to extrinsic load is very low (example of zone: plateau),
- Transfer-denudation zone – The amount of supplied solids is less than the amount of lost solids. The resistance of the zone to extrinsic load is low (example of zone: convex slope),
- Transfer zone – The amount of supplied solids and the amount of lost solids are equable here. The resistance of the zone to extrinsic load is moderate (example of zone: plain),
- Accumulative-transfer zone – The amount of supplied solids is greater than the amount of lost solids. The resistance of the zone to extrinsic load is high (example of zone: concavity slope),
- Accumulative zone – The loss of solids is minimal and the supply of solids is considerable. The resistance of the zone to extrinsic load is very high (example of zone: alluvial plain).

The algorithm of the hydrologic zone grid in the basin is a part of LOREP and it is consistent with the work of Pennock et al. (1997). Pennock and his colleagues classified 11 basic landforms and then defined hydrologic zones from these landforms.

3.3 Localisation of areas with high surface runoff and detection of reasons for a low flood control capability

The next step is to create two raster grids. One grid is connected with the database of information for each pixel in the basin about its geographic conditions. The conditions are soil conditions, vegetation conditions in forests, gradients of the terrain, land use, land cover and hydrologic zones. The conditions in the database are deduced from GIS layers containing this information.

The second grid is connected with the database of information for each pixel in the basin about its direct runoff $Q(t)$. There are five categories for $Q(t)$: very high, high, middle, low and very low. It is possible, by using the tools of map query in GIS, to find the pixels with a very high or high direct runoff and by using the tools of database query in GIS for these pixels, to find their geographic conditions.

We can determine the areas with very high or high direct runoff thanks to the second grid and the information in its database. We can also detect the reasons for the low flood control capability of these areas thanks to the grid with the information about the basin conditions.

3.4 Design, comparison and recommendation of suitable measures

The list of measures is used to suggest the most appropriate solutions in LOREP. The complete name of this list is "Katalog opatření pro zvýšení retenční a akumulační schopnosti povodí" (The Catalogue of Measures for Enhancement of Flood Control Capability in the Basin) by dr. Kvítek (Cudlín et al., 2002). The catalogue of measures was created as a base of knowledge in NetWeaver for EMDS. NetWeaver is a freeware compatible with the ESRI's produced GIS. The Ministry of Environment of the Czech Republic and most departments of environment at regional and municipal levels in the Czech Republic use the ESRI software. The base of knowledge is produced using the tools of fuzzy sets and network architecture. It enables the evaluation, which is affected by missing data and allows a compilation of results with assessing the level of their uncertainty. It is also possible to supplement the base of knowledge in NetWeaver continuously. Those are the reasons why we have decided to use NetWeaver.

Information about the conditions in the basins and direct runoff in the basins is gathered from the third step of the procedure. The most important indicator is the amount of pixels in the categories "high" and "very high" whose direct runoff in various scenarios must be compared.

When we combine the conditions and suggest the measures for each combination in LOREP, we design the scenario for this concrete situation. We simulate diverse scenarios for each area of low flood control capability found in the third step of the procedure and we model new layers in GIS with modified land use in the basin. We modelled each scenario with one layer, which always participated in the previous steps. The map of potential surface runoff, the table with the amount of pixels can be prepared for each scenario. The results are compared and a recommendation is made for the most suitable measure for each area of low flood control capability (e.g. land use change from field to pasture).

4. Results

The Hranice region belongs in two major river basins (see Fig. 1), i.e. the Bečva River basin (80% of the territory) and the Odra River basin (20% of the territory).

The most important river in the area is the Bečva R. with its tributaries Velička R., Ludina R. and Juhyně R. The Bečva R. forms a confluence of the Vsetínská Bečva R. and Rožnovská Bečva R. at an altitude of 288 m a.s.l. The area of the Bečva basin is 1,625.7 km^2 and the river length is 119.6 km. The average discharge is 17.5 $m^3.s^{-1}$. The final part of the Bečva R. is situated in the valley of the Hornomoravský úval Graben. The basin of the Juhyně R. was chosen for the application of LOREP. The area of the river basin is 21.51 km^2 and the results from LOREP are in Tab. 1.

In the survey of spatial conflicts in the Hranice region, the established flood areas were compared with actual and proposed activities in the urban plans. The aim was to determine the extent of the flood areas where some human activities were in progress or planned and that could be characterized as a conflict (Burian et al., 2007b).

Based on calculations over the data model, it was possible to delimit 2,845 ha of land defined as a currently built-up area and 265 ha of land on which it is possible to build. As an example of the results of the spatial conflict analysis, we can state the delimitation

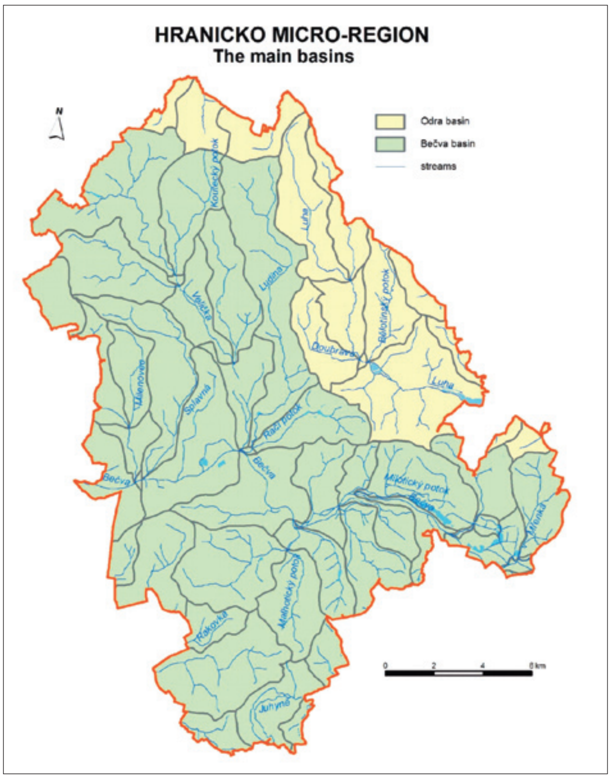

Fig. 1: The main basins in the Hranice region

of conflicting areas with the floodplain Q_{100}. A total of 180.1 hectares (6.3% of the Hranice region) of the built-up area and 8.23 hectares (3.1%) of the proposed built-up area can be characterized as conflict areas between human activities and the estimated Q_{100} flood level in the Hranice region.

If we make the same calculation using the spatial analysis of the floodplain area (taking the floods in 1997 as reference), the share of currently affected built-up areas would increase to 7.1% (202.5 ha) and the area possible to build on would increase to 4.9% (13 ha). A detailed analysis of each category is shown in Tab. 2.

No.	Category of direct runoff	Interval (mm)	Current land-use		Land-use projected in scenario	
			amount of pixels	area (ha)	amount of pixels	area (ha)
1	very low	0–20	378,723	946.81	390,672	976.68
2	low	20–40	248,047	620.12	304,785	761.96
3	middle	40–60	119,447	298.62	149,490	373.73
4	high	60–80	82,954	207.39	8,094	20.24
5	very high	80–100	26,424	66.06	2,566	6.42

Tab. 1: The amount of pixels with different surface runoff in the Juhyně River basin (homogenous precipitation 100 mm in the whole area of the basin)

Category of land-use in urban plans	Affected area (Q100)	Affected area (floods in 1997)
Housing	38.0 ha (4%)	37.0 ha (4%)
Proposed housing	6.6 ha (2%)	1.6 ha (0.5%)
Public facilities	6.8 ha (6.8%)	6.8 ha (6.8%)
Proposed public facilities	3.9 ha (11%)	2.7 ha (7.5%)
Recreation and sport	23.5 ha (25%)	26.7 ha (28.5%)
Proposed recreation and sport	2.0 ha (31.5%)	24.0 ha (34.2%)
Economical activities	10.1 ha (3%)	9.9 ha (2.5%)
Proposed economical activities	0.7 ha (0.5%)	5.9 ha (4.3%)
Roads	58.0 ha (7.5%)	52.1 ha (6.5%)
Proposed roads	1.1 ha (1%)	1.2 ha (1%)

Tab. 2: Detailed conflict analysis for main categories of land use in urban plans
Percentages show the proportion of the total area in each category in the Hranice region.

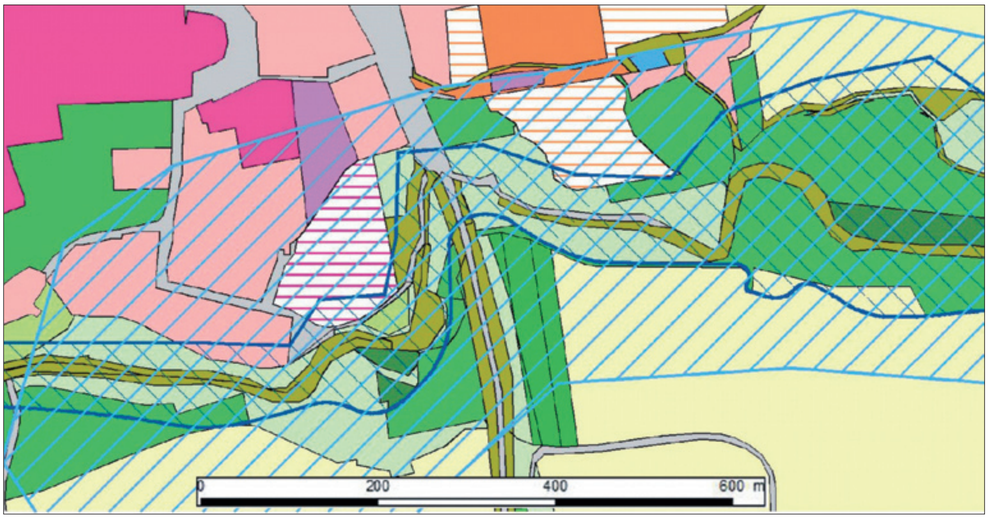

Fig. 2: Q_{100} flood level and the line of floods in 1997 in the Hranice region

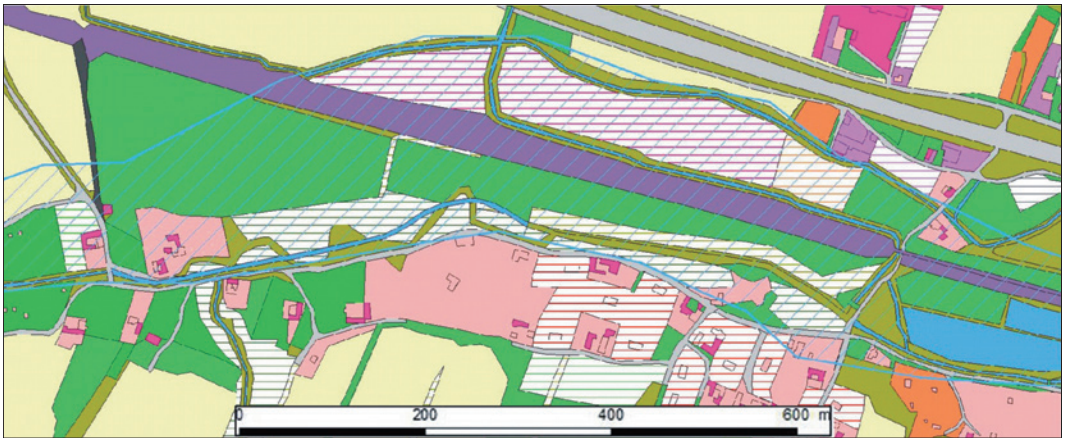

Fig. 3: Q_{100} flood level and the line of floods in 1997 in Všechovice (spatial conflict of human activities and flood areas)

The different lines of the estimated Q_{100} flood inundation and the lines of the floods in 1997 are compared in Fig. 2. Fig. 3 shows that in some cases, the Q_{100} flood level was not established and the floods in 1997 affected a relatively large number of areas for housing, sport and recreation. Legend to the maps is included in Fig. 4.

The outcome of the spatial analysis of existing and proposed activities (captured in urban plans of the municipalities in the Hranice region) is as follows:

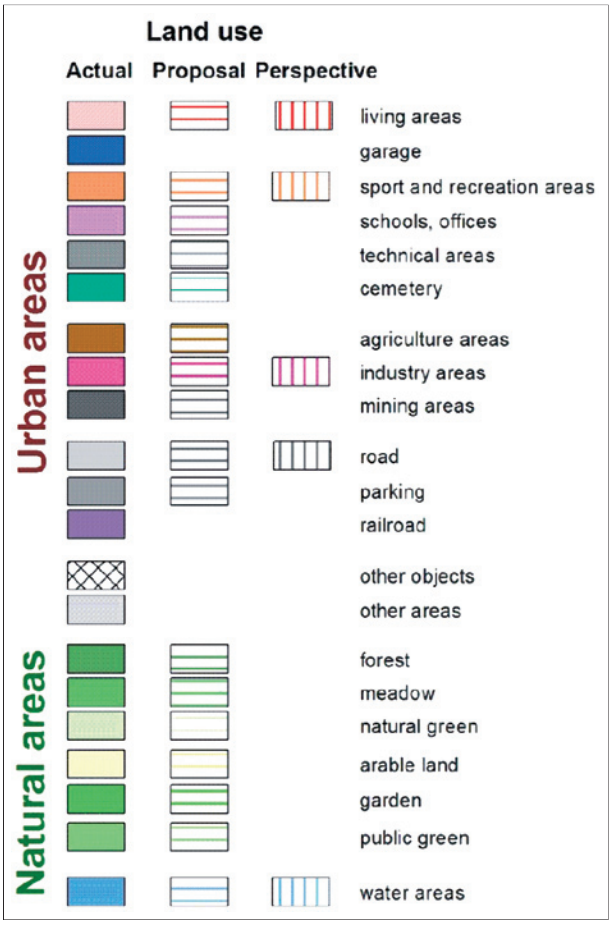

Fig. 4: Legend to maps in Figs. 2 and 3

- 6.3% of the built-up area is located in the flood areas,
- 3.1% of the proposed built-up area is located in flood areas,
- nearly 52 km of roads are located in flood areas,
- almost 800 hectares of agricultural areas are located in flood areas.

5. Discussion and conclusion

Flood areas are used intensively for a number of social and economic activities in these days and this is why floods can easily damage property and public health within these areas. One possible solution is to restrict human activities in the floodplains, the second one is a prediction based on the hydrologic modelling of floods and spatial conflicts in GIS. Planning materials and the planning documentation are the only respected documents for urban planning in the Czech Republic but the modern tools for spatial modelling are just very narrowly used during the creation of these documents.

The presented approach (model) is an example of GIS implementation in the process of the creation of these documents. The model was tested in practice and it helped to find the spatial conflicts. The outputs of GIS analyses of the model were raster data sets, hydrographs and tables. The model is able to take into account the current state and applied measures to reduce flood risk in a very detailed scale.

Despite a number of technical problems concerning the compatibility of data sources (borders of individual phenomena differed by up to 100 m), the imperfection of spatial planning (as to the quality of the digital processing of municipal plans and as to new activities proposed in unsuitable localities) was remedied thanks to the use of the GIS environment and other geo-information technologies (remote sensing, GPS navigation and positioning system, CAD, and others).

The submitted approach is based on a set of simple GIS methods. The main reason for this simplicity was the effort to make the conflict analysis accessible for any GIS product used in the urban planning practice. However, it is necessary to realize that high-quality digital data are crucial for the implementation of these analyses in GIS. When inaccurate or incorrect data are used, the presented advantage of the model (a detailed analysis of the landscape and modelling of small landscape features) can lead to incorrect results and misleading interpretations. The precision of input data is very important in areas where the land use layer and the layers of environmental conditions overlap (spatial conflict). The authors are aware of this fact and that is why they strongly urge the observance of elementary GIS rules and the creation of data with correct geometry, correct topology and correct attributes.

A wide implementation of GIS in the planning practice is possible only if the legislation will call for such an approach. Therefore, the demonstration of GIS advantages in land use planning is of great importance.

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AGRICULTURE OF THE CZECH REPUBLIC AFTER ACCESSION TO THE EU: REGIONAL DIFFERENTIATION

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Abstract

Czech agriculture entered a dynamic transformation period after 1990. Due to accession of the Czech Republic to the European Union and implementation of the Common Agricultural Policy, stabilization of the agricultural sector and its further development was expected. During this period, the output of the agricultural sector decreased, the number of bred farm animals was significantly reduced and the area of arable land was diminished. This paper focuses on the development of Czech agriculture in the period 2001–2008, paying attention to regional differentiation in the development of cattle, dairy cows and pig farming as significant agricultural characteristics in the Czech districts. Some specific problems of the Czech agricultural sector and its overall decline, despite Czech membership in the EU, are also highlighted.

Shrnutí

Zemědělství České republiky po vstupu do EU: regionální diferenciace

Se vstupem ČR do EU a ukotvením Společné zemědělské politiky se předpokládala stabilizace agrárního sektoru a jeho další rozvoj, neboť české zemědělství prošlo po roce 1990 dynamickým transformačním obdobím. Během tohoto období se snížil výkon zemědělského sektoru, významně se snížily počty chovaných zemědělských zvířat a výměra orné půdy. Předkládaný příspěvek se zaměřuje na vývoj českého zemědělství v období let 2001–2008, zejména je věnována pozornost regionální diferenciaci vývoje stavu skotu, dojnic a prasat, coby důležitých charakteristik celkového zemědělského významu v jednotlivých českých okresech. Příspěvek dále poukazuje na specifické problémy zemědělského sektoru a jeho klesající rozměr i v období po vstupu ČR do Evropské unie.

Keywords: *agriculture, regional differentiation, Common Agriculture Policy, Czech Republic, European Union, districts of the Czech Republic*

1. Introduction

Over the past twenty years, Czech agriculture faced continual decline. In terms of constant prices, current agricultural production is two-thirds compared to 1990 and the number of employees has dropped even more to a mere quarter of the 1990 level. This is mainly caused by the falling sales of agricultural commodities brought forth by falling prices.

The unfavourable price trend has resulted in the continual reduction of employees in agriculture and in the decline of kept animals. This can be regarded as some form of extensification of the Czech agriculture, particularly of its animal production, similarly to how R. Kulikowski (2005) describes this process with respect to the situation in Poland.

Since the Czech accession to the European Union (EU), Czech agriculture has profited from EU subsidies while in the previous years it was largely unprofitable. While it may seem that Czech agriculture has prospered regarding the volume of subsidies following our entry into the EU, the actual numbers show quite the opposite – continuously and significantly decreasing size and importance of the Czech agricultural sector. It becomes evident that without subsidies, Czech agriculture as such would be involved in a loss; therefore, the dependence of agricultural enterprises on subsidies further deepens (Kabrda, Jančák, 2007).

The nature of agricultural production is conditioned by physical-geographical and socio-economic characteristics, which are far from being homogenous in the Czech Republic. Significant differences in the development of agriculture in Czech districts should therefore be observed with taking into account the local conditions of production, especially those of physical-geographical nature.

The present article aims to describe the general context and trends in the Czech agricultural sector in the period of integration of the Czech Republic into the EU, with an emphasis placed on the analysis of relations within the sector itself as well as on its relations to political and economic environment. Attention will be paid namely to the identification of regional differences of the relevant process of development (per district units) where three key indicators of farm animal production will be observed: the number of cattle, dairy cattle and pigs. The differential regional development of the monitored characteristics will be presented on selected cases with respect to local physical geographic and socio-economic conditions for agriculture and specific characteristics of the districts.

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2. Theory, methodology and literature

The analysis of regional differentiation in the period of social transformation represents a basic framework for studying the trends of agro-rural structures in the geographical literature. The main subject of such works is divergence in the development of socio-economic differences among districts – e.g. in the studies of V. Jančák and A. Götz (1997), and A. Věžník and L. Bartošová (2004) relating to the Czech Republic, P. Spišiak and G. Lelkes (2003) in the Slovak area of Lower Nitra, the Polish authors W. Hasinski (1999) and R. Kulikowski (2005) and the publication of D. Turnock (1997) and A. H. Sarris et al. (1999) describing situation in Central and Eastern Europe.

Changes in European agriculture over the past thirty years are examined and explained by a number of Anglo-Saxon authors (Ilbery, Bowler, 1998) who interpret these shifts as a transition from agricultural productivism to the post-productivism era. G. A. Wilson (2001) describes several characteristics of this process of transition; however, he rather talks of transition to a so-called multifunctional agriculture regime. Multifunctional (farm-level) transition is conceptualised by G. A. Wilson (2007) as a certain position of a farm in the broad "multifunctionality spectrum" which is defined by the scope of productivist and non-productivist actions and the considerations of farms as the actors of agricultural activity. The difficulty of theoretical formulation of these transition processes as well as the on-going interest of scientists in this subject are proven by the multitude of critical texts (Evans et al., 2002; Potter, Tizley, 2005; Ward et al., 2008). For instance, C. Potter and M. Tizley (2005) argue that agriculture has merely become more polarized (given the prevailing neoliberal practices) between production areas with favourable conditions for agriculture and areas where agriculture is more extensified and which might be viewed as an alternative consumption area of population (of food-non-production nature).

Transformations in agriculture are also motivated by the current shape of the Common Agricultural Policy (CAP), which has increasingly phased out support provided for the production and has become less product-oriented, while greater emphasis is placed on environmental protection, development and maintenance of landscape, food security and welfare of farm animals (Ward et al., 2008). A. Vaishar and J. Zapletalová (2009) bring attention to the increasing role of agriculture as a "maintainer" of landscape in most border (micro) regions, since these areas are characterized by generally less favourable conditions for agriculture. Thus, expert literature concentrates rather on the research of individual preconditions of agriculture revitalization and strengthening of its non-production functions, together with the assessment of opportunities for rural development, as in P. Spišiak (2005), M. Shucksmith et al. (2007), I. Ramiceanu and R. Ackrill (2007) or P. Spišiak and J. Nemethová (2008). Evaluation of changes in agriculture, especially after the Czech accession to the EU, is a common theme for many agricultural economists, such as V. Bečvářová (2008) or M. Štolbová and M. Hlavsa (2008).

The time framework of the presented contribution is set by the aims of this study and by data availability. While the general trends in Czech agriculture on the state level are analyzed in the period 2001–2008 (or 2009), actual data of districts are related only to 2007. Due to the nature and availability of the data, the year of 2001 was earmarked as initial year (commencement of preparations of the Czech Republic for accession to the EU). The following years were already significantly influenced by the proceeding integration of the country into the European Union, adoption of the initial legislative and policy changes, application of some programs of subsidies, etc.

In each chapter, general development of Czech agriculture, possible causal links and specific problems of livestock production are discussed first. Following this introducing information, the chapters contain description and evaluation of regional differences (at district and regional level) in the development of the rates of bred animals surveyed and stock densities, and the context of different development in some districts and regions is discussed. A brief text on different land use in districts (2007) precedes, since the physical-geographical conditions for agriculture are reflected in the different land use (arable land – permanent grassland) and in the different share of agricultural land in total areas of district. Therefore, these conditions are largely involved in shaping the character of agriculture in the districts (e.g. different types of agricultural production).

The specific character of some districts (of "urban nature") where agriculture plays a minor role is limiting and distorting the overall analysis of trends. Therefore, these districts were identified on the grounds of selected indicators and were subsequently not included in the analysis for their low agricultural significancy. The maps enclosed to this analysis however capture the development and conditions of these districts too, in order to maintain the complex image of these maps; these districts are however labeled so that they can be distinguished. Districts that were excluded from the analysis are characterized by low employment in agriculture (share of workers in agriculture < 1% of total labour force in the district), by agricultural land of less than 200 hectares per 1,000 inhabitants, by at least 4/5 of population living in cities and by high population density which is more than 150 inhabitants/km^2 (Tab. 1). Despite the fact that these indicators seem quite uniform, the character of agriculture in these districts varies considerably, since they cover both districts with the high (city of Brno (BM), Most (MO), Karvina (KI), Ostrava (OV) and Prague city (PHA) – over 60%) and low share of arable land (Jablonec nad Nisou (JN) and Usti nad Labem (UL) – below 30%).

The definition of agriculturally specific districts on the ground of the above- mentioned criteria enables to make an exact list of districts not included in the analysis. On the other hand, in the regions of Karlovy Vary and Ústí nad Labem, the importance of agriculture is relatively low in other districts too, which however exceed some of the set criteria limits. For example, in the districts of Děčín (DC) and Sokolov (SO), agricultural land (per thousand inhabitants) represents more than 200 ha, and population density in these districts is lower than 150 inhabitants per km^2. The districts of Chomutov (CV) and Karlovy Vary (KV) exceed these criteria as well, and the share of employees in agriculture is higher than 1%. These facts have to be taken into account during the interpretation of results.

The term "region" is used to refer only to the territorial units defined in the Nomenclature of Territorial Units for Statistics as NUTS 3, while the term "regional differentiation" is especially related to spatial differences at a district level (LAU 1 under the Local Administrative Units).

3. Land use in the districts of the Czech Republic

Different utilization of land resources in the districts significantly reflects the physical-geographical conditions for agriculture and serves as an indicator of the relative importance and scope of agriculture in

District	Agricultural land (ha)	Agricultural land (ha) per 1000 inhabitants	Share of agri. workers in labour force*	Share of city population**	Population density***
Brno-City	7,935	21.7	0.4	100.0	1,613
Jablonec nad Nisou	12,939	146.1	0.7	81.1	225
Karviná	18,142	65.7	0.2	88.0	767
Most	13,546	116	0.3	90.4	251
Ostrava-City	15,791	46.8	0.3	96.4	1,012
Plzeň-City	12,749	71.5	0.4	93.8	711
Praha	20,692	17.5	0.1	100.0	2,518
Teplice	15,889	124.4	0.4	83.9	277
Ústí nad Labem	18,288	153.5	0.3	83.7	300

Tab. 1: Districts in the Czech Republic specific in terms of agriculture (2007)
*Source: COSMC, 2007; CSO, 2008b; MoLSA CR, 2011; *Share of agricultural workers in total labour force (%), **Proportion of population living in municipalities with city status, ***Inhabitants per 1 km^2*

the district. Districts with the highest proportion of agricultural land exceeding 2/3 of district total area are situated in fertile regions of the Elbe (the highest proportion – Kolín (KO) – 75%) and Ohře Rivers, Dyjskosvratecký úval (Graben) and Haná, while in most border districts, the share of agricultural land is less than a half of the district area (the lowest proportion – Jesenik (JE) – 33%); these areas are typically covered with extensive forests (Fig. 1). Especially in the border districts (Bruntál (BR), Český Krumlov (CK), Prachatice (PT), Vsetin (VS), etc.), permanent grassland prevails and the percentage of arable land is relatively low there in the national context (71%) because the highland, foothill and mountain nature of these districts is limiting for crop production. Inclusion of most cadastres of these districts into one of the designed less favoured areas (LFA) for agriculture corresponds to the natural handicaps of these areas, especially the mountain ones (see also Střeleček, Lososová, Kvapilík, 2004).

On the contrary, fertile districts with a high proportion of agricultural land are distinguished as areas with the highest degree of arable land (Kolín, Nymburk (NB), Praha, Mělník (ME), etc.) exceeding 80% and their favourable conditions for agriculture are documented by almost zero representation of certain LFA types in the municipalities of these districts.

4. The development of Czech agriculture (cattle, dairy cows and pigs) and its regional differentiation: empirical findings and discussion of results

Despite the fact that the profits of the agricultural sector have increased sharply since the accession to the EU, this overall growth of profits is caused mainly by increasing subsidies; indeed, it is but for those subsidies that the profits of the agricultural sector remain in positive numbers (see Tab. 2. – Total agricultural support). In 2008, the profit of the agricultural sector

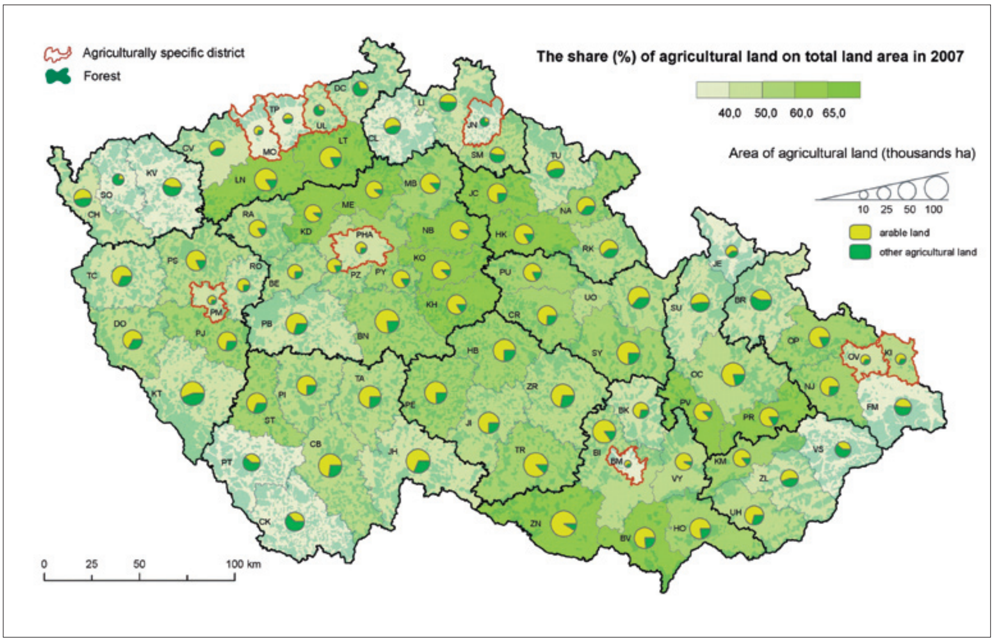

Fig. 1 Land use in the districts of the Czech Republic in 2007
Source: COSMC, 2007; CSO, 2008b; authors

amounted to 9.8 billion CZK, however in the previous year it reached the record level of 13.7 billion CZK. Nevertheless, the publication Agriculture 2009 (MoA CR, 2010) reveals that this year witnessed a significant drop in agricultural profits to mere 3.2 billion CZK (comparable to level in 2001).

The declining importance of agriculture may be further demonstrated by the continual release of employees in this sector on the grounds of redundancy. While more than a half million persons worked in agriculture 20 years ago, only 160 thousand persons worked in this sector in 2001. The loss of jobs in agriculture was not halted even in the period of integration into the EU. In 2008 alone, 4 thousand workers left the agricultural sector and the number of employees in the sector dropped below 130 thousand.

The decline of the Czech agriculture production is set off by the increasing import of agricultural commodities, foods and products. For the entire period 2001–2007, the import always prevailed over the export – agricultural trade balance deflected by more than 60% to the disadvantage of farmers.

Indicator	2001	2003	2006	2008	CHI (%)*
Agricultural output:	129.9	102.7	106.4	121.2	93.4
crops	*59.5*	*44.5*	*50.6*	*63.6*	*106.9*
animals	*70.4*	*58.2*	*55.8*	*57.6*	*81.8*
Profit	3.3	−2.5	7.0	9.7	293.9
Total agricultural support	7.5	16.0	35.8	36.7	489.3
Agricultural trade balance**	−19.8	−25.5	−32.9	–	163.6
Number of employees (in thousands)	159.8	148.0	134.0	126.4	79.1

Tab. 2: Development of gross agricultural output in the Czech Republic in the period 2001–2008 (in CZK bn., current prices)
*Source: MoA CR, 2003a, 2004a, 2007, 2009a, 2010; CSO, 2002, 2005, 2008a, 2009; *Change Index for 2008/2001, **Change Index of agricultural trade balance is compiled for 2007 (data for 2008 are not available)*

4.1 Cattle and beef

Cattle and milk production plays an indispensable role in Czech agriculture, being significant not only for the farm economy as such, but also for its social (employment) and environmental aspects (landscape). Cattle and milk production is furthermore closely linked to crop production (nutrient cycling, exploitation of crop production, especially of the grassland). Therefore, it represents one of the main pillars of Czech agriculture. Economic results achieved in cattle farming are often decisive for economic results of individual farms. In the past years, the sales of milk reached on average approx. Twenty billion CZK per year and five billion CZK were average sales of beef (43% of livestock sales). Thus, the sales of milk and beef provided for 20–25% of the total income of farms (MoA CR, 2009d).

In the period of 2001–2008, the numbers of cattle decreased by about 180 thousand animals (11%), the situation is however relatively stable since our accession to the EU, mainly due to the increasing number of reared suckler cows. The current CAP, supporting the use of cattle belonging to a meat breed for the purposes of landscape maintenance (especially in less favoured areas) and for the production of high quality beef, the current CAP has positively affected the increase in number of suckler cows.

Despite this trend, the development of cattle and beef production is rather negative. Cattle fattening remains a long-term loss, and this has a significant impact on the overall performance of the industry as well as on cattle farming. In the first place, the negative development is mainly invoked by the situation on the beef market, which directly contributes to the relatively high export of adult bovine animals and calves for slaughter in recent years in order to be processed in abroad for relatively reasonable prices. This subsequently mirrors in the reduction of the Czech processing industry (and consequently in the decrease of jobs), but it also undermines the demand for the production of feed concentrates and bulk feed. Accordingly, imports of beef have increased together with overall increase in the volume of imported and exported beef, while in 2001 these imports approached a zero level.

Nevertheless, the dynamic of cattle production in individual districts of the Czech Republic significantly differentiated in the reference period 2001–2007. The

Category	2001	2003	2006	2008	CHI (%)*
Cattle	1,582	1,474	1,374	1,402	88.6
Cows:	611	590	564	569	93.1
dairy cattle	529	466	424	406	76.7
suckler cows	82	124	140	163	198.8
Production	209	198	171	183	87.8
Import	0.4	6.9	31.6	29.9	7 475.0
Export	35.8	17.5	42.4	61.1	170.7

Tab. 3: Number of cattle and cows (in thousands of bovine animals), balance of beef production, imports and exports (in thousands of live weight tons) in the Czech Republic in the period 2001–2008
*Source: MoA CR, 2003a, 2009b; *Change Index for 2008/2001(%)*

fastest rate of the decrease of bred bovine animals was recorded in those areas, which, already in 2001, faced considerable reduction initiated in 1990, and where this downward trend enhanced even further in the following period. These were particularly the districts of Rakovník (RA), Mělník, Beroun (BE) and Kolín in Central Bohemia and the districts of Břeclav (BV), Hodonín (HO), Vyškov (VY) and Znojmo (ZN) in the South Moravia Region – both areas with a relatively high degree of arable land, but low stock density (number of cattle per 100 ha of agricultural land), which decreased even further due to declining numbers of cattle (Fig. 2 – see cover p. 2). In the fertile area of Central Bohemia, cattle farming have been reduced since the beginning of transformation even though a huge consumer market of Prague is localized there whose need of meat and dairy products supplies should form a sufficient consumer background for this area of Central Bohemia (Jančák, Götz, 1997).

The comparatively large decline in the number of cattle in the districts of the South Moravia Region induced the highest percentage reduction of cattle and stock density among all regions of the Czech Republic. Stock density of cattle in this region (17.4) is only half a level of the whole country (33.4) and second lowest among all regions of the CR, while the lowest density is reported in the agriculturally insignificant the Ústí Region. In the South Moravia Region, the significant decline of cattle reflects the preference of poultry farming and efforts to preserve high levels of pig farming, as the agricultural sector of district provides for a sufficient feed base for fattening these animal species (growing of maize and other fodder crops). This region abounds in fertile soils; therefore the nowadays enhanced promotion of crop production (and not just for fattening purposes) in this region is understandable.

Contrary to the South Moravia Region, the cattle numbers of the Karlovy Vary Region increased by one fifth; the districts of Sokolov and Cheb (CH) mainly contributed to this positive development (each recording an increase of more than a half the original levels) and slight accrual was witnessed in the Liberec Region. Despite this, the intensity of cattle farming still lacks behind the national level in the districts of the Karlovy Vary and Liberec Regions (except the district of Semily (SM)) and according to the number of reared cattle, these regions remain non-relevant. The increasing numbers of cattle or perhaps the stabilization of stock density were registered namely in the border districts with less favoured conditions for agriculture (Bruntál, Český Krumlov, Jesenik, Klatovy (KT), Prachatice and Tachov (TC)) and in the "traditional more intensive cattle farming belt" stretching from Eastern Bohemia, across the Českomoravská vrchovina the Bohemian-Moravian Highlands) and South Bohemia to the south of the Plzen Region.

4.2 Dairy cows and milk production

Although milk production reached approximately the same level each year during the last decade, the rates of dairy cows fell by more than 23% from 2001 to 2008 which also significantly added to the general decline of cattle farming. This relatively linear downward trend did not reverse in the period of Czech integration to the EU. Quotations for the sale of milk and large demand of subsidies for suckler cows farming are primarily responsible for a major reduction in the number of dairy cows (especially since 2003). The decline of dairy cows rates in recent years has been set off by the growth of average milk yield, while per capita milk consumption increased in the same period (MoA CR, 2009d).

The "Agriculture" reports (MoA CR) also reveal that imports of dairy products have distinctively increased after joining of the Czech Republic to the EU – by 250% from 2003 to 2008. The external trade balance of dairy products was CZK 2.5 billion in 2003, while it dropped to only 100 million CZK in 2008. The largest increase in imports was recorded for cheese, curd and butter. Thus, in 2008, imports of dairy products represented up to 27% of the domestic consumption. In this situation, Czech farmers were forced to respond to these increasing imports by considerably larger exports of raw milk to foreign countries in order to keep its price. Measures taken under a so-called "health check" of the Common Agricultural Policy (in force since 2009), negatively contribute to the problems of cattle and milk production in the Czech Republic.

Reduction of the number of dairy cattle and its limited farming occurred in all districts of the Czech Republic (except the Kladno district (KD)). The fastest rate of this decline at all was recorded in North-Western Bohemia – the rates of dairy cows in the districts of the Ústí region – Chomutov and Děčín dropped to less than 20% of the number in 2001 and overall, the number of dairy cows in the Ústí region was reduced by almost 70%. These drops, however, should be viewed with taking into account that the numbers of dairy cows were kept very low in many of these agriculturally non important districts already in 2001 and, therefore, in some cases they represented only very small decreases in absolute terms. Dairy cows rates in the Karlovy Vary Region fell even faster (23%); there was a significant decline in the district of Karlovy Vary (77%) and Sokolov, where the dairy cows farming was abandoned completely.

Fig. 3: Extensive cattle farming is developing in less favoured areas (photo from the Blansko district (BK)) where blocks of arable land prone to erosion were replaced by pastures (Photo: O. Konečný)

The districts of the Karlovy Vary Region as well as the districts of the Ústí Region have a very low stock density of dairy cattle – less than half the density of the Czech Republic (10 dairy cows per 100 ha of agricultural land).

These areas with less favourable conditions for agriculture embarked on the extensive way of farming and dairy cows farming has been replaced by breeding suckler cows (Střeleček, Lososová, Kvapilík, 2004). Thus, the growing acreage of permanent grassland is utilized for the purposes of suckler cows farming, which is more effective than intensive dairy cows farming in the current setting of the CAP subsidy system. Districts such as Bruntál, Český Krumlov, Jeseník, Klatovy and Tachov represent areas with less favourable conditions for agriculture, high degree of forest cover and therefore relatively low share of total agricultural land area of the district, where numbers of dairy cows decreased by more than 40%.

Dairy cows farming (or their lower relative decline) was sustained in districts adjacent to regional centres with a high consumption of milk products (in the already mentioned district of Kladno (KD) and Prague-East (PV) (Prague), Příbram (PB) and Rokycany (RO) (Plzen), Blansko and Brno-Province (BI) (Brno), Prostějov (PV) and Olomouc (OC) (Olomouc), while the differences in the stock density of dairy cows in the districts were substantial (Fig. 4). Districts with the high (above-average) intensity of dairy cows farming were closing down slower and some of them situated in the Vysočina Region and in the eastern part of the Pardubice Region succeeded in maintaining the high intensity of farming dairy cows within the Czech Republic.

The relatively low decline in most of these districts is partly influenced mainly by the sustenance of local dairy processing industry, which provides sales and purchases of milk produced by local farms.

4.3 Pigs and pork

The rates of bred pigs have been falling, even though pork represents the most consumed meat in the Czech Republic and its consumption has for long stayed at a standard level of about 42 kg per person per year. In 2008, the rates of pigs dropped from 3.3 million in 2001 to 2.4 million and even the entry of the Czech Republic in the EU did not install the expected stabilization of its numbers (decrease of 22% in 2004–2008).

The most important factor of reduced Czech pig production is a long-term maintenance of prices that fail even to cover the costs of pork production. However, as the pork consumption in the Czech Republic does not fall, the decline of pigs and production of pork must be compensated for by steadily increasing imports. Since 2001, import of pork meat has increased almost ten-times and self-sufficiency of the country has gradually decreased. The significant reduction in the number of sows threatens farms engaged in pigs

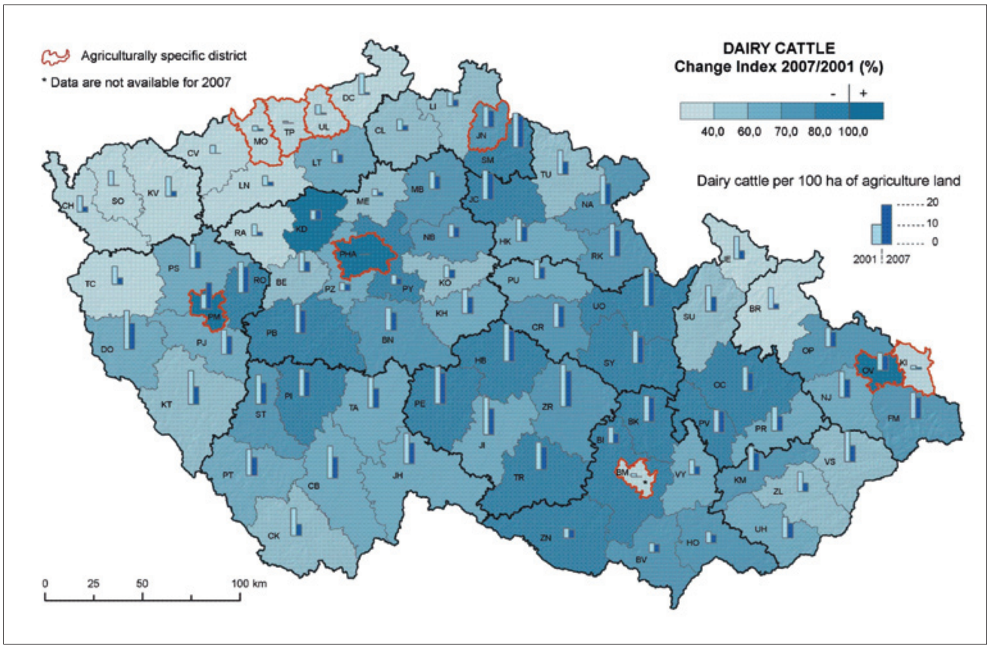

Fig. 4: Change of dairy cows rates and their stock density in the districts of the Czech Republic in the period 2001–2007
Source: CSO, 2001, 2008c; authors

fattening. Therefore, dependence on the imports of piglets from abroad has grown (especially from the neighbouring Poland) so that the fattening of pigs could be realized at all in the Czech Republic.

From the spatial point of view, neither the development of the number of pigs can be mentioned as an example of a homogeneous trend. Pig farming has almost extinguished in the district of Karlovy Vary (decline from 20,000 to 0.7 thousand pigs) and a significant decline has been recorded in other districts in north-western and northern Bohemia, which are generally districts with the low stock density of pigs (stock density used to be close to 100 pigs per 100 ha of arable land). Transition to more extensive forms of agriculture has manifested in the Karlovy Vary district through the fading feeding base (due to a continuous reduction of arable land, which decreased by 4.4 thousands ha in 2001–2007) for pigs and the necessity to import feed from distant districts (Fig. 6 – see cover p. 2).

The rates of pigs dropped to half the level of 2001 also in the north Moravian districts of Nový Jičín (NJ) and Opava (OP), in the north Bohemian district of

Fig. 5: Favourable area for agriculture (photo from Třebíč district (TR)) is still important for production purposes, for example as a feed base for livestock (Photo: O. Konečný)

Category	2001	2003	2006	2008	CHI*
Pigs	3,315	3,363	2,840	2,433	73.4
Sows	278	297	221	149	53.6
Production	584	576	449	432	74.0
Import	22	40	155	211	959.1

Tab. 4: Number of pigs (in thousands of animals), production and import of pork (thousand live weight tons) in the Czech Republic in the period 2001–2008
*Source: MoA CR, 2004a, 2009c; *Change Index for 2008/2001(%)*

Semily and Česká Lípa (CL), in the south Bohemian Prachatice district and in the central Bohemian district of Rakovník. It is evident that significant reductions of pigs affected agriculturally very different districts (notable differences in arable land, stock density, proportion of agricultural workers in labour force and proximity to markets). Thus, for instance, Nový Jičín farms supply meat packing plants in Ostrava, local farms have therefore convenient location in terms of consumption market (Jančák, Götz, 1997), but the number of pigs and namely the stock density still decreased remarkably and reach approximately two thirds of the average stock density at present.

In several districts, for example in Znojmo (with good feeding base), the numbers of bred pigs were higher than in some regions (Moravian-Silesian Region, Karlovy Vary Region and Liberec Region). Thus the highest decrease in numbers was recorded in the South Moravia Region (ca. 140,000 pigs) and in the Central Bohemia Region (decline by 100,000). Nevertheless, the regions are still the most important Czech pig farming regions. Unlike the Central Bohemia Region, where the stock density is lower than the national average (only in the district Beroun, Kolín and Nymburk it is higher), the density of pig farming in the South Moravia Region is kept still high. Lower than the national average it is only in the districts of Brno-Province and Břeclav.

Stabilization of pig farming and its low enhancement is noticeable in the "agricultural" Vysočina Region (Bohemian-Moravian Highlands) where the stock density of all districts is already now higher than the national average (in 2001 it was lower in the districts of Jihlava (JI) and Pelhřimov (PE)). Stock density and numbers of pigs rose also in the south Bohemian districts of Strakonice (ST) and Písek (PI), in the nearby district of Rokycany (RO) and in the fertile districts of central Bohemia (Kolín and Nymburk) and in the Moravian district of Kroměříž (KM). In summary, these are districts with a relatively high degree of arable land (except for Strakonice) exceeding the average value of the Czech Republic, showing an above-average stock density, a higher proportion of agricultural workers in total labour force and a below-average share of urban population.

5. Conclusion

Prerequisite for strengthening the competitiveness of Czech agriculture is a maximum utilization of the financial sources from the EU funds and Czech resources to modernize the agricultural sector and to comply with the demanding European standards of quality and food safety as well as with environmental requirements related to agricultural management stipulated in CAP.

The current setting of subsidies and compensation payments of the CAP in the context of necessity to respect ecological aspects and environmental protection causes that livestock (cattle) numbers become more extensive in some districts. The area of arable land continually decreases while at the same time the size of permanent grassland expands (Kabrda, Jančák, 2007); permanent grassland is grazed by an increasing number of suckler cows. This extensive way of farming "replaces" the intensive farming of dairy cows, whose range in the Czech districts decreased significantly (except for the Kladno district). This trend is promoted especially in less favourable agricultural districts (mountains, foothills and highland districts) with an already high degree of grassing which do not have potential for crop production and the municipalities of the districts often belong to one of the LFA (Střeleček, Lososová, Kvapilík, 2004).

Cattle farming has fallen namely in fertile areas characterized by a high share of arable land as well as by the already small number of cattle and rather low stock density. The situation resulted largely from the fact that while the decreasing numbers of dairy cows in areas less favoured for agriculture were relatively substituted with suckler cows, this downward trend in dairy cows farming (though generally lower) was not set off by the increase of suckler cows in fertile areas, mainly due to the fact that the area of permanent grassland is small (low degree of grassing) in these fertile districts. Although it is difficult to generalize the observed trends (there are usually some districts with similar physical-geographical conditions for agriculture, but still they face contradictory development), the number of dairy cows decreased insignificantly especially in districts localized close to major regional cities (Brno, Olomouc, Plzeň and Prague) and in the "traditional areas of high stock density with respect to cattle and dairy cows" – that is in a belt stretching from the eastern part of the Pardubice Region to the Vysočina Region.

Stabilization or sustenance of dairy cattle in some production areas is partly influenced by the maintenance of local dairy processing industry, which provides for sales and purchases of milk produced by local farms, and by proximity to large consumer markets. Conversely, districts with a high share of forest cover and hence a low share of total farmland represent areas where the numbers of dairy cows dropped most dramatically. Dualistic delimitation of agricultural areas according to C. Potter and M. Tizley (2005), dividing them between productive (intensive) and extensive areas, is also evident in the Czech Republic in terms of development of cattle and dairy cows in the Czech districts.

It can be noted that the continuing increase of exports of milk or even liquidation of dairy cows farming in some districts will bring the closure of local processing enterprises in the future. There is a risk that if this situation is not urgently solved, further dairy farms will be liquidated. The process of closing down dairy cattle farms is practically irreversible, since herd reproduction takes several years, and even then, considerable investment costs would in such case be inevitable. Closing down other current farms would encompass a loss of several thousand jobs in the primary sector and at least a similar number of jobs in related sectors (suppliers, processing industry, sellers), which can further decrease jobs in the Czech rural areas.

The dynamics of pig farming in terms of regional differentiation is similarly not easy to generalize because during the period of the Czech integration into the EU pig numbers changed (increase/decrease) in much different ways without a distinguishable link to physical-geographical conditions for agriculture of districts. Thus, the observed regional development (according to pig farming dynamics) can be related to G. A. Wilson's (2007) conceptualization of the multifunctional regime of agriculture, which puts emphasis on individual decisions of farms made within a certain decision-making space of production/ non-production nature. Unlike the trend in dairy cows farming, the number of pigs raised in some districts in spite of the fact that a decline by a fifth was reported in the entire Czech Republic. These districts can be characterized by a relatively high share of arable land exceeding the average of the Czech Republic, above average stock density, higher share of agricultural workers in total labour force and below-average share of urban population. On the other hand, while the numbers of pigs decreased significantly in the districts of Central Bohemia and South Moravia Regions - both being the major pig farming regions, the districts of the Vysočina Region (with comparable numbers of pigs) exhibited a further increase. This is why the Vysočina Region represented in 2007 a region with the highest stock density of not only cattle and dairy cows, but also pigs in the whole country and confirmed its agricultural "exceptionality" in the Czech Republic.

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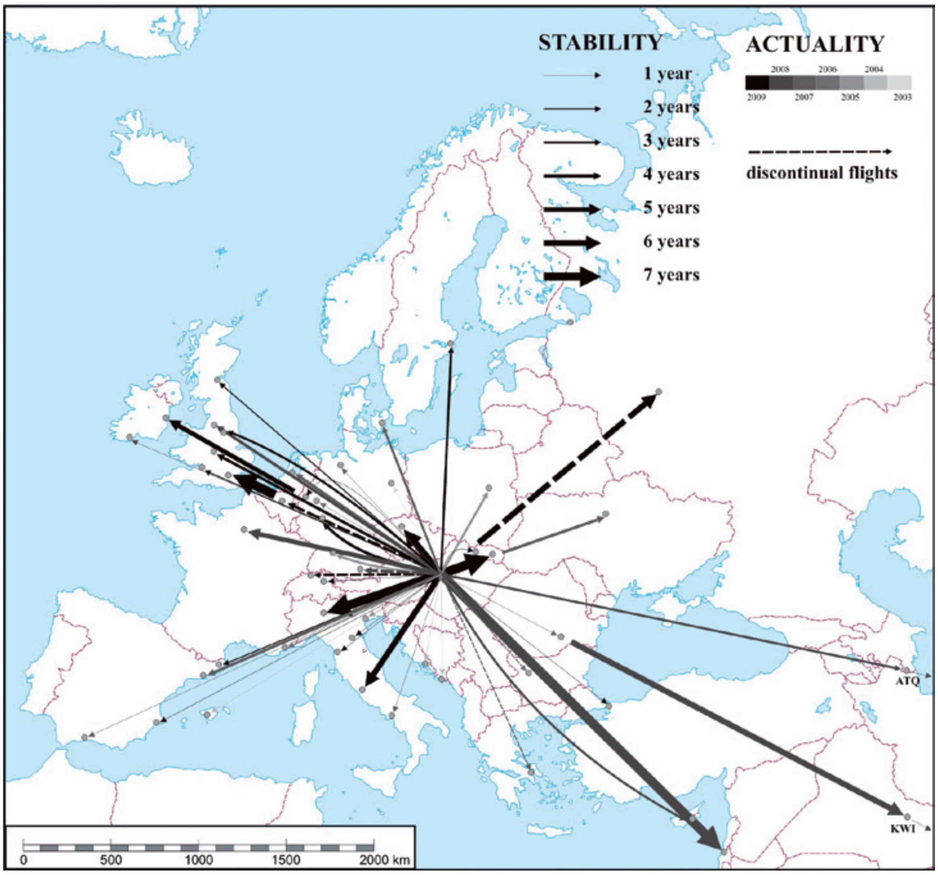

Fig. 1: Stability and actuality of the Bratislava aviation network

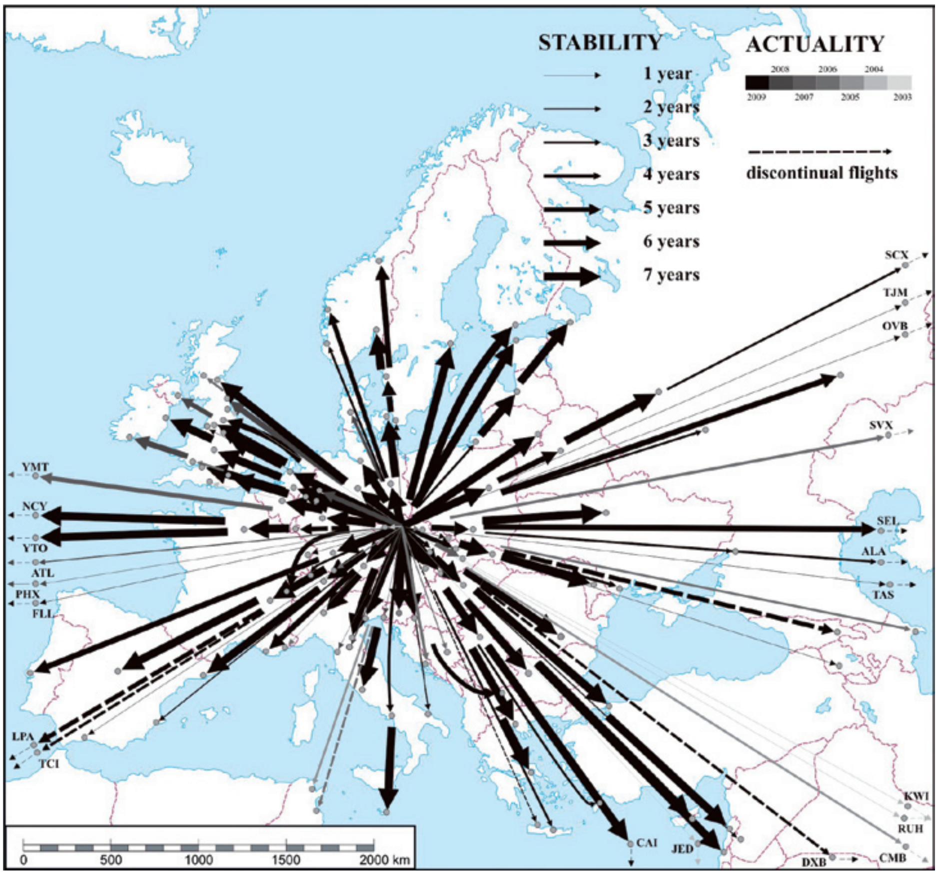

Fig. 2: Stability and actuality of the Prague/Ruzyne aviation network

Illustrations related to the paper by J. Grenčíková, F. Križan and L. Tolmáči

Fig. 2: The contemporary image of the Nová Louka/Neuwiese locality, where the historical extreme precipitation record was measured.

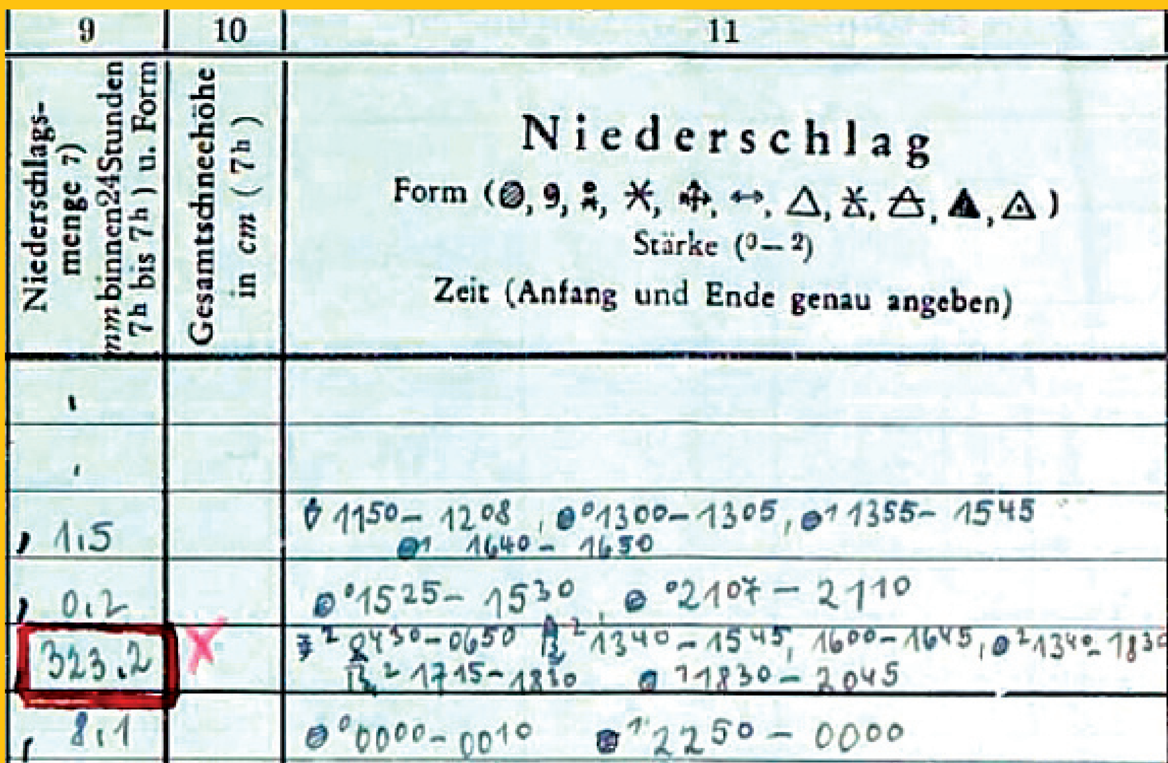

Fig. 5b: A detail from the observation report of the Semmering meteorological station with the Austrian record daily precipitation amount of 323.2 mm from 5th June 1947 with the duration of rain and thunderstorms (Meteorologische Beobachtungen ... 1947)

Illustrations related to the paper by J. Munzar, S. Ondráček and I. Auer