Jaroslav Ramík

Jana Hančlová

MULTICRITERIA METHODS FOR EVALUATING COMPETITIVENESS OF REGIONS IN V4 COUNTRIES

Abstract

Regional competitiveness is the source of national competitiveness. This paper presents multi-criteria decision making methods for evaluation of the regional competitiveness and regional differences and disparities. Specific indicators reflect the economic productivity of the region in form of factors of production inside of the region. The technology for the evaluation of regional competitiveness is based on the application of two methods of multi-criteria decision making. The first one is the method of Ivanovic deviation, the second one is the well known DEA. The results of the applications of the methods are compared on the basis of the competitiveness of the NUTS2 regions (V4 – Visegrad Four countries) in the EU within the period of 7 years (2000-2006). In particular, the disparities between the Czech and Polish NUTS2 regions are discussed.

Keywords

Regional competitiveness, regional disparities, multi-criteria methods, Ivanovic deviation, DEA.

Introduction

This paper deals with multi-criteria decision making methods for evaluating the regional competitiveness and regional differences and disparities. Specific indicators reflect economic productivity of the region in form of factors of production and/or efficiency inside the region (effect of one-regional unit) and are revitalized by the capacity of actual employment in the region. In particular, we deal with the following indicators: Gross domestic product and Labour productivity per person employed, Gross fixed capital formation, Total intramural R&D expenditure, Income of households, Employment rates.

The technology of evaluation of regional competitiveness is based on the application of two methods of multi-criteria decision making. The first one is the method of Ivanovic deviation, the second one is the well known Data Envelopment Analysis – DEA. The results of both methods will be compared.

1. Method of Ivanovic deviation

There does not exist a "universal" methodology for assessing the degree of regional non-competitiveness. An "alternative way" for evaluating regional competitiveness is to define a group of specific economic indicators of efficiency [see: Melecký and Nevima 2010]. The basic idea is to assess the internal sources of regional competitiveness in detail [see: Krugman 1994]. The evaluation of the competitiveness through five specific indicators have been proposed and discussed in [Nevima and Ramik 2009].

The classical weighted average methods (WA) proved to be irrelevant to the problem of regional competitiveness as the usual assumption of independent criteria is not satisfied. That is why we were looking for other suitable methods. Here, we present an application of two methods of this kind: Ivanovic deviation and DEA.

To overcome the problem of dependent criteria, we propose the technique of evaluation of regional competitiveness called Ivanovic deviation (ID) [see: Nevima and Ramik 2009]. This method is a technique of multi-criteria decision--making and its purpose here is to assess the ranks of the regions, too. In comparison with the simple averaging [see e.g.: Ramík and Perzina 2008], it takes into account the importance and mutual dependence of the decision--making criteria, i.e. six specific indicators ranked by their relative importance, that is: Gross domestic product (GDP), Labour productivity per person employed (LP), Gross fixed capital formation (THFK_EUR), Total intramural R&D expenditure (GERD), Income of households (INDIC_NA) and Employment rates (Y15_MAX). This ranking is done by an expert evaluation; here, GDP is the most important indicator as it reflects the total economic efficiency of the region and it also includes the level of production. The second most important criterion is LP, the labour productivity per person employed. THFK_EUR is the gross fixed capital – an indicator of connections of expenditures for the creation of the fixed assets. These assets are also included in the regional production. GERD could be interpreted as the total R&D expenditures. INDIC_NA is the income of households and Y15_MAX is the criterion of employment rate. In this method, the weight of each criterion is based on its relative importance – the ranking takes into account the correlation coefficients with the previous (i.e. more important) criteria. Then the weighted distance of the current variant to the ideal (fictitious) one is calculated as follows [see: Nevima and Ramik 2009]:

$$I_j = \frac{\left|x_1^f - x_{1j}\right|}{s_1} + \sum_{i=2}^{n} \frac{\left|x_i^f - x_{ij}\right|}{s_i} \prod_{k=1}^{i-1} (1 - |r_{ki}|), \tag{1.1}$$

where:

x_i^f – value of *i*-th criterion of ideal (fictitious) variant (i.e. region),

x_{ij} – value of *i*-th criterion *j*-th variant,

r_{ki} – correlation coefficient *i*-th a *k*-th criterion (i.e. specific coefficient),

s_i – standard deviation *i*-th criterion calculates:

$$s_i = \sqrt{\frac{1}{m} \sum_{j=1}^{m} \left(x_i^j\right)^2 - \left(\bar{x}_i\right)^2}\ , \tag{1.2}$$

where *m* – total value of variants, *n* – total number of criteria.

The approach based on the application of the Ivanovic deviation seems more relevant as compared to the results of the method of simple averaging. As we know the importance of the criteria and correlations (i.e. dependences) among the criteria, we are able to determine the "distance" to the ideal region in a more realistic way. Then the final rank of regions corresponds to the different economic importance of individual criteria (i.e. specific indicators of efficiency). Thanks to this fact we consider the final rank as another contribution of this alternative approach to the evaluation of regional competitiveness of the NUTS2 regions in the V4 countries, see Table 1 and Figures 3, 4 and 5.

2. DEA

Data Envelopment Analysis (DEA) is a relatively new data-oriented approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) converting multiple inputs into multiple outputs. Here, we applied DEA to all 35 central European NUTS2 regions in Visegrad Four countries (V4). Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries [see: Cooper et al. 2000]. These DEA applications have used DMUs of various forms to evaluate the performance of entities, such as hospitals, US Air Force wings, universities, cities, courts, business firms, and others, including the performance of countries, regions, etc.

As pointed out in [Cooper et al. 2000], DEA has also been used to supply new insights into activities (and entities) that have previously been evaluated by other methods. Since DEA in its present form was first introduced in 1978 [see: Charnes et al. 1978], researchers in a number of fields have quickly recognized that it is an excellent and easily used methodology for modeling operational processes for performance evaluations. In their original study [Charnes et al. 1978], DEA is described as a “mathematical programming model applied to observational data that provides a new way of obtaining empirical estimates of relations – such as the production functions and/or efficient production possibility surfaces – that are cornerstones of modern economics”.

In most management or social science applications the theoretically possible levels of efficiency are not known. Our model is based on the inputs and outputs, which must be chosen carefully with regard to their definition in economic theory. This fact is vital for us to perceive the efficiency as a “mirror” of competitiveness. Moreover, here we present only one version of the DEA model, that is, the most popular input oriented CCR model and also the output--oriented CCR model [see: Charnes et al. 1978]. For more detailed analysis of efficient regions (coefficient of efficiency is equal to one) we applied DEA super-efficiency models [see e.g.: Cooper et al. 2000].

Now we introduce criteria for selecting inputs and outputs used in the DEA model as applied to efficiency of NUTS2 regions in V4 (i.e. Czech Republic, Slovakia, Poland, Hungary). It is evident that the overall performance of the regional economy affects the number of people employed in various sectors, their skills and working age (15-55 years). Therefore, we selected the criterion of employment rate and that of the creation of the THFK_EUR (Gross Fixed Capital Formation). This criterion includes, in general, investment activity of domestic companies and fixed assets of foreign companies, which are the “engine” of the innovation competitiveness. The total intramural R&D expenditure (GERD) is considered for the future development of the region. The third input included is the net disposable income of households (INDIC_NA). In terms of competitiveness the disposable income plays an important role, especially because it directly reflects the purchasing power of the region [see: Nevima and Ramik 2010]. The last input indicator is the employment rate (Y15_MAX).

There are two outputs in our DEA model [see: Zhu 2002]. The outputs are measured by GDP in purchasing parity standards and labor productivity per person employed. The GDP is the most important macroeconomic aggregate, and if it is measured per region, we can take into account a limited number of inputs for its calculation. Similarly, the labor productivity (LP) may be taken into account, as it shows what amout of production was created by economically active people or employed persons.

In Figure 1 and 2 we compare the Czech and Polish region super-efficiency and in Table 2 it is evident that the best results are traditionally achieved by economically powerful "capital" regions being efficient during the whole period 2000-2006. It is clear that whereas in the Czech regions the regional disparities between the capital region and the other NUTS2 regions diminish within the given period, in Poland the disparities in economic efficiency between the capital region and the other NUTS2 regions increase within the given period. Hence, the tendency in Poland is opposite to that in the Czech Republic.

Conclusions

The paper aims at presenting multi-criteria approaches to evaluating competitiveness (efficiency) and disparities of the European regions (NUTS2). This evaluation was based on the applications of two models (Ivanovic deviation and DEA) calculating an "efficiency index" of each region. Since no universal methodological approach to regional competitiveness exists, this paper should be understood as a contribution to the discussion of quantitative measurement of competitiveness at the regional level.

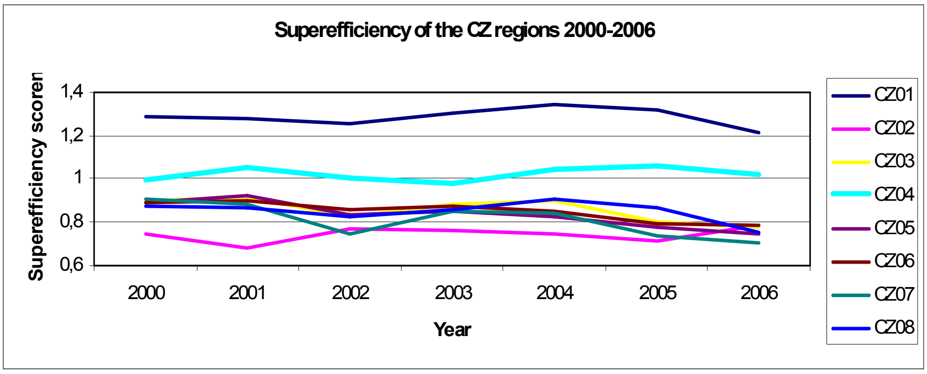

Figure 1. Superefficiency of the Czech NUTS2 regions

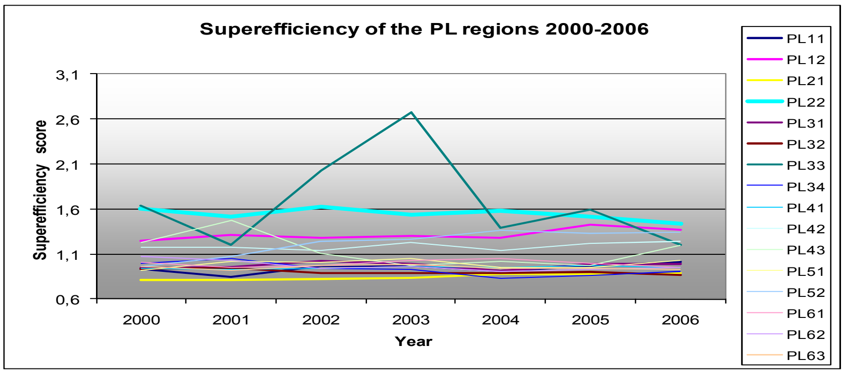

Figure 2. Superefficiency of the Polish NUTS2 regions

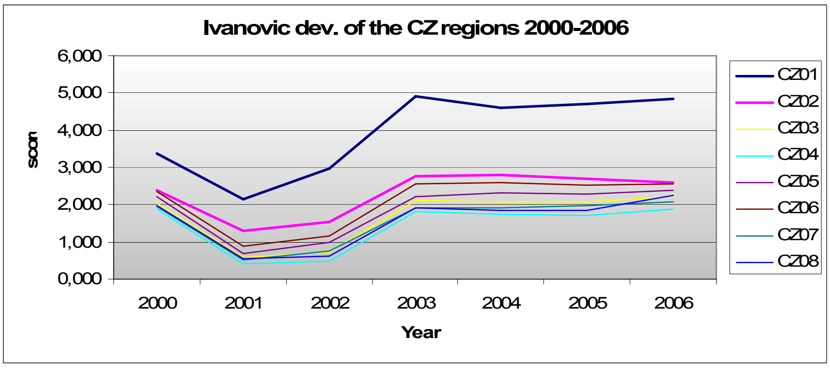

Figure 3. Ivanovic deviation of the Czech NUTS2 regions

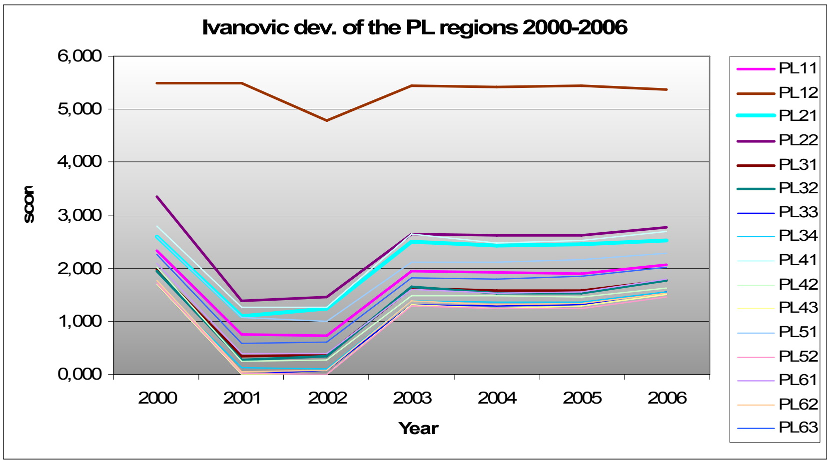

Figure 4. Ivanovic deviation of the Polish NUTS2 regions

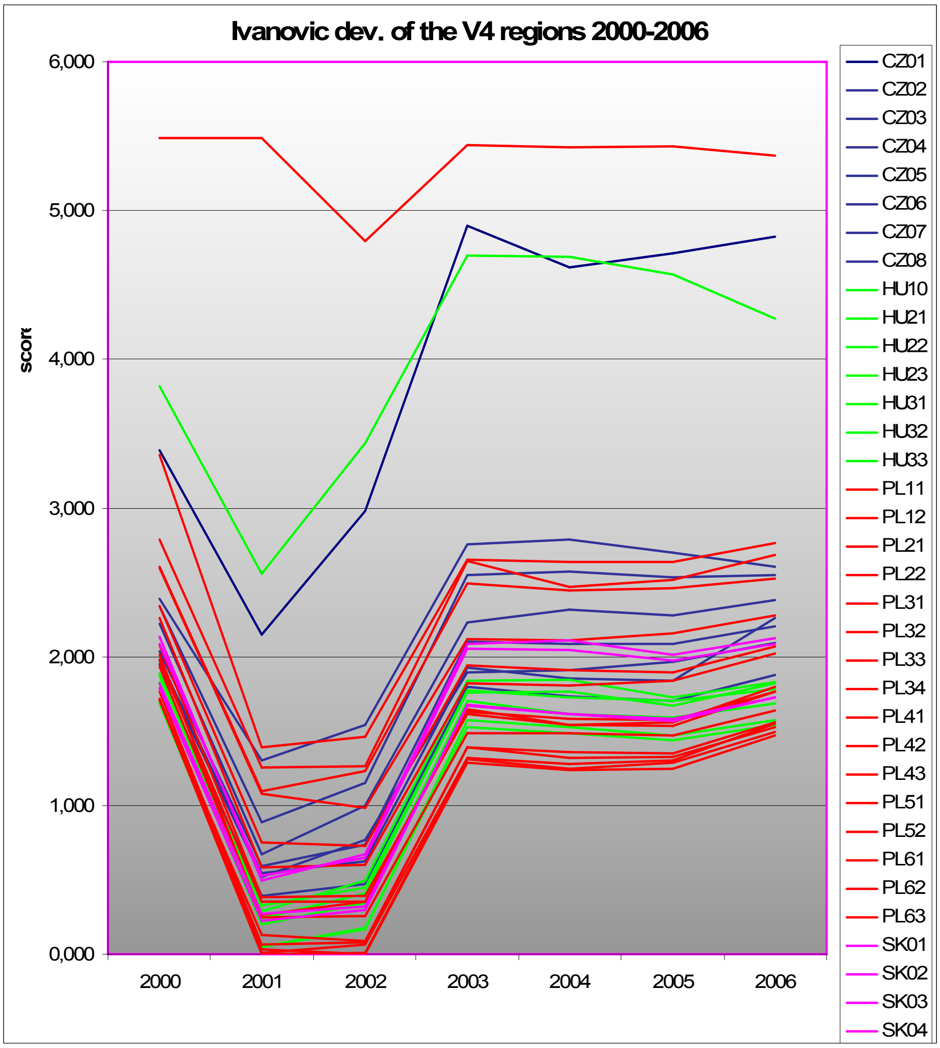

Figure 5. Ivanovic deviation of the V4 regions

Table 1

Application of Ivanovic deviation in NUTS 2 regions

Code	Region	2000	2001	2002	2003	2004	2005	2006
CZ01	Praha	3,388	2,150	2,981	4,898	4,617	4,714	4,829
CZ02	Strední Cechy	2,392	1,302	1,543	2,753	2,786	2,702	2,604
CZ03	Jihozápad	2,035	0,595	0,732	2,100	2,088	2,085	2,204
CZ04	Severozápad	1,883	0,393	0,469	1,801	1,735	1,706	1,877
CZ05	Severovýchod	2,220	0,675	1,001	2,226	2,321	2,276	2,380
CZ06	Jihovýchod	2,343	0,884	1,154	2,547	2,575	2,529	2,550
CZ07	Strední Morava	1,953	0,522	0,766	1,896	1,907	1,964	2,089
CZ08	Moravskoslezsko	1,984	0,540	0,625	1,925	1,855	1,838	2,261
HU10	Közép-Magyarország	3,816	2,555	3,437	4,699	4,691	4,567	4,275
HU21	Közép-Dunántúl	1,866	0,284	0,493	1,841	1,846	1,724	1,830
HU22	Nyugat-Dunántúl	1,888	0,325	0,443	1,761	1,765	1,673	1,824
HU23	Dél-Dunántúl	1,694	0,045	0,175	1,526	1,484	1,441	1,543
HU31	Észak-Magyarország	1,688	0,046	0,170	1,570	1,524	1,469	1,576
HU32	Észak-Alföld	1,812	0,236	0,408	1,777	1,722	1,701	1,779
HU33	Dél-Alföld	1,830	0,197	0,342	1,699	1,616	1,588	1,685
PL11	Lódzkie	2,341	0,752	0,731	1,939	1,912	1,897	2,070
PL12	Mazowieckie	5,486	5,489	4,796	5,442	5,427	5,435	5,370
PL21	Malopolskie	2,601	1,092	1,233	2,490	2,441	2,459	2,527
PL22	Slaskie	3,353	1,388	1,464	2,649	2,633	2,634	2,761
PL31	Lubelskie	1,971	0,352	0,353	1,628	1,580	1,577	1,767
PL32	Podkarpackie	1,934	0,265	0,352	1,646	1,541	1,535	1,767
PL33	Swietokrzyskie	1,712	0,007	0,066	1,322	1,280	1,301	1,548
PL34	Podlaskie	1,706	0,127	0,086	1,389	1,362	1,353	1,562
PL41	Wielkopolskie	2,788	1,254	1,266	2,643	2,471	2,521	2,685
PL42	Zachodniopomorskie	2,015	0,248	0,256	1,485	1,485	1,467	1,637
PL43	Lubuskie	1,707	0,000	0,010	1,314	1,250	1,289	1,498
PL51	Dolnoslaskie	2,599	1,080	0,985	2,113	2,111	2,154	2,279
PL52	Opolskie	1,714	0,034	0,000	1,288	1,235	1,248	1,467
PL61	Kujawsko-Pomorskie	2,079	0,381	0,388	1,613	1,540	1,561	1,796
PL62	Warminsko-Mazurskie	1,766	0,060	0,082	1,393	1,320	1,326	1,529
PL63	Pomorskie	2,260	0,587	0,602	1,824	1,806	1,838	2,019
SK01	Bratislavský kraj	2,131	0,492	0,668	2,086	2,106	2,010	2,125
SK02	Západné Slovensko	2,082	0,529	0,645	2,054	2,042	1,974	2,086
SK03	Stredné Slovensko	1,819	0,268	0,321	1,672	1,614	1,578	1,726
SK04	Východné Slovensko	1,792	0,227	0,298	1,674	1,617	1,566	1,724

Table 2

Superefficiency of NUTS2 regions in V4 countries

Code	Region	2000	2001	2002	2003	2004	2005	2006
CZ01	Praha	1,285	1,275	1,256	1,304	1,341	1,319	1,217
CZ02	Strední Cechy	0,749	0,681	0,768	0,761	0,747	0,716	0,784
CZ03	Jihozápad	0,901	0,918	0,824	0,883	0,903	0,803	0,776
CZ04	Severozápad	0,999	1,051	1,005	0,979	1,047	1,059	1,022
CZ05	Severovýchod	0,893	0,927	0,835	0,847	0,828	0,778	0,744
CZ06	Jihovýchod	0,892	0,902	0,855	0,875	0,851	0,796	0,790
CZ07	Strední Morava	0,910	0,884	0,743	0,848	0,842	0,734	0,705
CZ08	Moravskoslezsko	0,874	0,865	0,824	0,861	0,906	0,866	0,750
HU10	Közép-Magyarország	1,232	1,292	1,234	1,166	1,132	1,128	1,184
HU21	Közép-Dunántúl	0,954	0,955	0,813	0,850	0,898	0,898	0,863
HU22	Nyugat-Dunántúl	1,283	1,012	1,039	1,102	0,997	0,989	0,992
HU23	Dél-Dunántúl	1,090	1,038	0,948	0,936	0,970	0,909	0,886
HU31	Észak-Magyarország	0,926	1,065	0,946	0,926	1,016	0,996	0,904
HU32	Észak-Alföld	0,939	0,929	0,848	0,819	0,813	0,736	0,716
HU33	Dél-Alföld	1,102	1,009	0,890	0,831	0,835	0,769	0,756
PL11	Lódzkie	0,931	0,842	0,974	0,968	0,908	0,969	1,016
PL12	Mazowieckie	1,243	1,315	1,280	1,306	1,281	1,426	1,367
PL21	Malopolskie	0,809	0,816	0,825	0,837	0,878	0,879	0,887
PL22	Slaskie	1,610	1,516	1,622	1,541	1,579	1,514	1,441
PL31	Lubelskie	0,941	0,956	1,029	0,995	0,917	0,989	0,992
PL32	Podkarpackie	0,939	0,945	0,887	0,892	0,887	0,902	0,867
PL33	Swietokrzyskie	1,634	1,200	2,026	2,679	1,395	1,589	1,200
PL34	Podlaskie	0,993	1,049	0,939	0,924	0,830	0,859	0,902
PL41	Wielkopolskie	0,936	0,927	0,935	0,966	0,950	0,969	0,956
PL42	Zachodniopomorskie	1,169	1,180	1,138	1,231	1,140	1,223	1,246
PL43	Lubuskie	1,235	1,477	1,103	0,975	1,022	0,978	1,202
PL51	Dolnoslaskie	0,917	1,015	1,003	1,049	0,954	0,957	1,028
PL52	Opolskie	0,961	1,079	1,242	1,266	1,362	1,334	1,341
PL61	Kujawsko-Pomorskie	1,009	0,954	0,969	1,031	1,050	1,001	0,952
PL62	Warminsko-Mazurskie	1,078	1,030	0,943	0,962	0,906	0,926	0,948
PL63	Pomorskie	0,958	0,919	0,974	0,986	0,944	0,944	0,933
SK01	Bratislavský kraj	1,681	1,742	1,831	1,800	1,758	1,839	1,876
SK02	Západné Slovensko	1,030	1,085	1,036	1,006	0,958	1,024	1,076
SK03	Stredné Slovensko	0,884	0,941	0,979	0,965	0,910	0,920	0,965
SK04	Východné Slovensko	0,939	1,033	1,080	0,981	0,901	0,959	0,910

Acknowledgements

The research work was supported by the Czech Science Foundation, grant number 402/08/1015 – Macroeconomic Models of the Czech Economy and Economies of the other EU Countries.

References

Charnes A., Cooper W., Rhodes E. (1978), *Measuring the Efficiency of Decision Making Units*, "European Journal of Operational Research", No. 2.

Cooper W., Seiford L., Tone K. (2000), *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, Kluwer Academic Publishers, Boston.

Krugman P. (1994), *Competitiveness: A Dangerous Obsession*, "Foreign Affairs", March/April.

Melecký L., Nevima J. (2010), *Regionální konkurenceschopnost a možnosti jejího hodnocení v zemích V4 prostřednictvím aplikace specifických ekonomických koeficientů*, "Acta Academica Karviniensia", No. 1.

Nevima J., Ramik J. (2009), *Application of Multicriteria Decision Making for Evaluation of Regional Competitiveness*, in: *Mathematical Methods in Economics 2009*, Kostelec nad Černými lesy 9.-11.9.2009, Czech University of Life Sciences Prague: Faculty of Economics and Management.

Nevima J., Ramik J. (2010), *Application of DEA for Evaluation of Regional Efficiency of EU Regions*, in: *Mathematical Methods in Economics 2010*, České Budějovice 8.-10.9.2010, University of South Bohemia.

Total Economy Database – OECD. Regional statistics. 2010, http://stats.oecd.org /Index.aspx.

Ramík J., Perzina R. (2008), *Moderní metody hodnocení a rozhodování*. Studia Oeconomica, Slezská univerzita v Opavě, OPF v Karviné.

Zhu J. (2002), *Quantitative Models for Performance Evaluation and Benchmarking: Data Envelopment Analysis with Spreadsheets and DEA Excel Solver*, Kluwer Academic Publishers, Boston.