Usage of analytic hierarchy process for evaluating of regional competitiveness in case of the Czech Republic

Zuzana Kiszová[1], Jan Nevima[2]

Abstract. The contribution solves the problem of alternative access towards evaluating of competitiveness of regions of the Czech Republic. The basic aim of the contribution is due to the method of analytic hierarchy process to define the position of NUTS 2 regions in closed programming period of 2000 – 2006 years. The sense of applying the method will be setting the order of NUTS 2 regions reflecting their competitiveness reached for the year, based on selected criteria. We can obtain the idea of mutual competitive position of these regions by applying the method. The analytic hierarchy process (AHP) is a concrete method of multicriterial decision making method which uses the hierarchy of elements and a pair-wise comparison. The macro-regional indicators will be chosen based on expert estimation regarding to accessibility of relevant statistic data.
Based on the application of the method we can gain detailed view on regional competitiveness of regions by way of quantitative characteristics which can lead to more precise definition of reached competitiveness of NUTS 2 regional units in the EU.

Keywords: competitiveness, region, analytic hierarchy process, European Union

JEL Classification: C49, C61, O18, P48, R11, R58
AMS Classification: 90B50, 90C29, 62H99, 62P20, 91B50, 91B06

1 Introduction

Effectively analyzed competitiveness means to be based on a defined concept of competitiveness. For evaluation of regional competitiveness, we face the problem of the basic concept and definition of competitiveness due to absence of a consistent approach of its definition. Competitiveness has become quite a common term used in many professional and non-specialized publications. Evaluation of the competitiveness issue is not less complicated. In the absence of mainstream views on the assessment of competitiveness, there is sample room for the presentation of individual approaches to its evaluation. In our paper we will examine the possibility of evaluation the competitiveness of the regions of selected Czech regions at NUTS 2 level in terms of analytic hierarchy process. The level of NUTS 2 regions for evaluation of competitiveness seems to be legitimate especially because of the fact that European Commission accents the level of regional units from aims of economic and social cohesion view and realization of structural aid in the EU member states. When making concept of suitable evaluation tools of national and regional competitiveness it is necessary to suggest not only difficult but also simple methods which enable quick evaluation of competitiveness by accessible tools.

2 Concept of regional competitiveness

The concept of competitiveness has quickly spread into the regional level, but the notion of regional competitiveness is also contentious. In the global economy regions are increasingly becoming the drivers of the economy and generally one of the most striking features of regional economies is the presence of clusters [2], or geographic concentrations of linked industries [6]. The regional competitiveness is also affected by the regionalization of public policy because of the shifting of decision-making and coordination of activities at the regional level. To talk of regional competitiveness would seem to imply that regional economies are like firms [7], or nation-states, and are in competition with one another.

Decomposition of aggregate macroeconomic indicators is the most common used approach at the regional level, as well as comprehensive (mostly descriptive) analysis aimed at identifying the key factors of regional development, productivity [1], [13] and economic growth [11], [12].

Within governmental circles, interest has grown in the regional foundations of national competitiveness, and with developing new forms of regionally based policy interventions to help improve competitiveness of every

[1] Silesian University in Opava, School of Business Administration in Karviná, Department of Mathematical Methods in Economics, kiszova@opf.slu.cz
[2] Silesian University in Opava, School of Business Administration in Karviná, Department of Economics, nevima@opf.slu.cz

region and major city, and hence the national economy as a whole. Regions play an increasingly important role in the economic development of states.

2.1 Approaches to competitiveness evaluation

Creation of competitiveness evaluation system in terms of the EU is greatly complicated by heterogeneity of countries and regions and also by own approach to the original concept of competitiveness. Evaluation of competitiveness in terms of differences between countries and regions should be measured through complex of economic, social and environmental criteria that can identify imbalanced areas that cause main disparities. Comparing instruments for measuring and evaluation of competitiveness in terms of the EU is not a simply matter. Evaluation of regional competitiveness is determined by the chosen territorial region level, especially in terms of the European Union through the Nomenclature of Territorial Units Statistics (NUTS) – in our paper we apply NUTS 2 level.

Another approach is presented by EU structural indicators evaluation. These indicators are used for the assessment and the attainment of the objectives of the Lisbon Strategy. Specific approach is macro econometric modelling and creation of an econometric panel data model [3]. The approach based on application of specific economic coefficients of efficiency includes two methods of multi-criteria decision making. The first one is the classical *Analytic Hierarchy Process* (AHP) where relevance of criteria's significance is determined by the method of Ivanovic deviation. The second method - *FVK* is a multiplicative version of AHP [4]. Also *DEA* methodology was presented in case of Visegrad four regions. DEA evaluates the efficiency of regions with regard to their ability to transform inputs into outputs [8]. In other words - what results a region can achieve while spending a relatively small number of inputs (resources). This fact is vital for us to perceive the efficiency like a "mirror" of competitiveness [5]. This aspect is also crucial in this paper, where we present analytic hierarchy process to gain more detailed view on competitiveness of regions by way of quantitative characteristics.

2.2 Data base

Data base for evaluation of regional competitiveness in the NUTS 2 regions of the Czech Republic countries is made up of regional data, which were taken from the database of the *OECD iLibrary* – section Statistics - **OECD Regional statistics**. Under regional data have been used time series of 4 indicators (in our case indicators mean "criteria"), annual basis, including: Gross domestic product (GDP), Gross fixed capital formation (GFCF), Gross expenditure on research and development (GERD), Net disposable income of households (NDI). Comparability of data over time was ensured by using time series of the available indicators in purchasing power parity (PPS) per capita in euro currency. The data analysis cover reference period 2000 - 2006.

2.3 Description of entrance criteria for evaluation of competitiveness

GDP was chosen as it is one of the most important macroeconomic aggregate which is simultaneously suitable basic for competitiveness assessment of the country, but also for the regional level, where also NUTS 2 regions belong. It is obviously not always valid that with increasing level of GDP [11] (i.e. increasing efficiency of regions) also the rate of obtained competitiveness/competition advantage grows.

Gross fixed capital formation (GFCF) due to international accounting is a basic part of gross capital (capital investments), in which is also the change of inventories and net acquisition of valuables included. According to ESA 95 methodology GFCF consists of the net assets acquisition minus decrease of fixed assets at residential producers during the time period plus certain increasing towards the value of non-produced assets originated as a consequence of production activity of producers or institutional units. Net fixed capital formation is the difference between gross fixed capital formation and fixed capital consumption. It is estimated in purchase price including costs connected with installment and other costs on transfer of the ownership. Fixed assets are tangible or intangible/invisible assets produced as the output from production process and are used in production process repeatedly or continuously during the one-year period. However, GFCF sense is much broader. It is an index of innovating competitiveness which enables to increase production on modern technical base.

Gross domestic expenditures on research and development (GERD) are sources for further economic growth increasing as stimulation of basic and applied research creates big multiplication effects with long-term efficiency and presumptions for long-term economic growth in economics. R&D is defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including human knowledge, culture and society and the use of this stock of knowledge to devise new applications.

Net disposable income (NDI) is the result of current incomes and expenditures, primary and secondary disposal of incomes. It explicitly excludes capital transfers, real profits and loss from possession and consequences of the events as disasters. In contrast to gross disposable income, it does not cover fixed capital consumption.

Disposable income (gross or net) is the source of expenditures on final consumption cover and savings in the sectors: governmental institutions, households and non-profit institutions for households. In sectors of non-financial enterprises and financial institutions is disposable income equal to savings.

3 Analytic hierarchy process

We use multicriteria decision-making method called **analytic hierarchy process** (AHP) to evaluate competitiveness of Czech regions. This method allows including both quantitative and qualitative criteria and is used to determine priorities. Using hierarchies and pairwise comparisons are important attributes of AHP.

Hierarchies allow dividing the problem of evaluation into individual hierarchical levels. The evaluator gets an overview about the problem and its internal relations. Three-level hierarchy is classical example (Figure 1). The goal of the problem is situated on the top level, the level of criteria follows. Criteria represent properties of elements on the lowest level, i.e. of alternatives. The principle of hierarchy ensures that an element located at a higher level influence elements on lower level, but not vice versa.

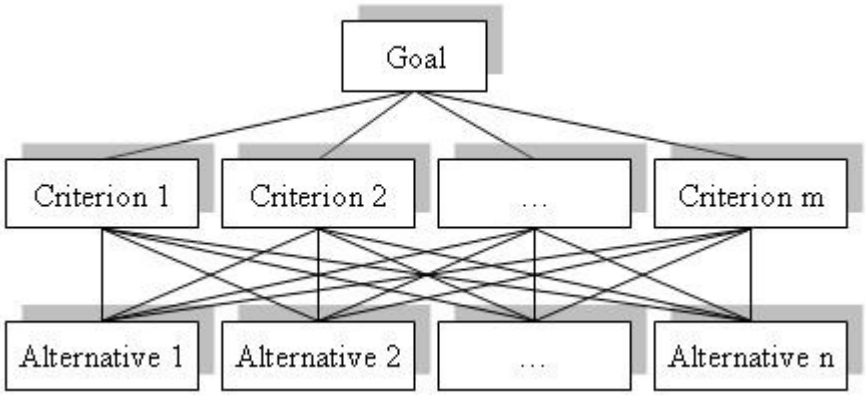

Figure 1 Three-level hierarchic structure

The essence of pairwise comparison is mutual measure of all pairs of considered elements within the same hierarchical level with respect to the level immediately above. We compare criteria among themselves or alternatives with respect to given qualitative criterion. For numerical expression of intensity of relations between compared elements Saaty created nine-point scale [10], see Table 1.

Intensity of importance	Definition
1	Equal importance
2	Weak
3	Moderate Importance
4	Moderate plus
5	Strong Importance
6	Strong plus
7	Very strong Importance
8	Very, very strong
9	Extreme importance

Table 1 Saaty's fundamental scale

Data obtained through pairwise comparisons are inserted into the pairwise comparison matrix A, its entries are signed generally a_{ij}. An n-by-n (square) matrix is created, see Figure 2.

$$\begin{array}{c} \\ \text{element } x_1 \\ \text{element } x_2 \\ \vdots \\ \text{element } x_k \end{array} \begin{array}{c} \begin{array}{cccc} \text{element } x_1 & \text{element } x_2 & \dots & \text{element } x_k \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1k} \\ a_{21} & a_{22} & \cdots & a_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ a_{k1} & a_{k2} & \cdots & a_{kk} \end{bmatrix} \end{array}$$

Figure 2 General pairwise comparison matrix

Such a matrix is created whenever there is no absolute evaluation of the element with respect to an element from a higher level, i.e. when it is not possible to compare the elements in the given hierarchical level based on their values with respect to an element of the level immediately above. Entries of the pairwise comparison matrix represent estimation of weight ratio of two compared elements of the same hierarchic level (we have to determine these weights through numerical operations). If a_{ij} is an element of pairwise comparison matrix, $a_{ij} \in \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$, w_i is wanted weight of the element x_i, w_j is wanted weight of the element x_j for all i and j, we can write:

$$a_{ij} = \frac{w_i}{w_j} \tag{1}$$

$$a_{ji} = \frac{1}{a_{ij}} \tag{2}$$

Formula (2) corresponds to one of the pairwise comparison matrix characteristic – the reciprocity.

We have to compute the eigenvector w corresponding to the maximal eigenvalue λ_{max} of the pairwise comparison matrix A to determine result element priorities of the given matrix. Normalized eigenvector w contents information about result priorities. If I is unit matrix, then:

$$Aw = \lambda_{\max} I \tag{3}$$

Pairwise comparison matrix is square, nonnegative and irreducible. These characteristics ensure existence of maximal eigenvalue λ_{max} and corresponding positive eigenvector [9].

The Wielandt theorem is used to compute the eigenvector, where e is unit vector and c is constant.

$$\lim_{k\to\infty} \frac{A^k e}{\left\|A^k\right\|} = cw, \left\|A^k\right\| \equiv e^T A^k e \tag{4}$$

Through normalization of eigenvectors of individual pairwise comparison matrices we gain weights of criteria with respect to the goal and weights of alternatives with respect to given criterion. The required result, i.e. weights of alternatives with respect to the goal, we obtain through synthesis of these information. If weight of i-th criterion with respect to the goal is w_i and weight of j-th alternative with respect to criterion f_i is $v_j(f_j)$, the overall weight of j-th alternative with respect to the goal is:

$$\sum_{i=1}^{m} w_i v_j(f_i) \tag{5}$$

where $j = 1, 2,\ldots,n$. On the basis of overall weights it is possible to rank evaluated alternatives from the best to the worst. Of course the best alternative gains the highest weight and vice versa.

4 Application

In our case the goal is to assess competitiveness of Czech regions. Alternatives are NUTS 2 Czech regions, i.e. Praha (CZ 01), Stredni Cechy (CZ 02), Jihozapad (CZ 03), Severozapad (CZ 04), Severovychod (CZ 05), Jihovychod (CZ 06), Stredni Morava (CZ 07) and Moravskoslezsko (CZ 08). These alternatives are evaluated by following criteria: gross domestic product (GDP), net disposable income of households (NDI), gross fixed capital formation (GFCF) and gross expenditure on research and development (GERD). All criteria are maximizing.

The pairwise comparison method is applied to determine weights of criteria with respect to the goal. The pairwise comparison matrix of criteria and data base for years 2000 – 2006 are shown in Table 2.

	GDP	*NDI*	*GFCF*	*GERD*
GDP	1	3	5	7
NDI	1/3	1	2	5
GFCF	1/5	1/2	1	2
GERD	1/7	1/5	1/2	1

Year 2000	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	26 000	3481.8	8827.3	490.2
CZ 02	12 300	1674.7	6937.6	369.6
CZ 03	12 100	1868.9	6539.4	69.9
CZ 04	10 700	1160.5	6172.6	30.4
CZ 05	11 700	1414.7	6380.2	91.2
CZ 06	11 700	1499.7	6290.2	125.4
CZ 07	10 700	1261.9	6157.4	65.5
CZ 08	10 200	1198.7	6001.7	83.7

Year 2001	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	28 700	3883.2	9532.6	499.8
CZ 02	12 900	1959.6	7275.4	377.5
CZ 03	12 800	1837.9	6961.5	72.3
CZ 04	11 000	1648.3	6440.6	29.3
CZ 05	12 300	1354.3	6749.7	94.3
CZ 06	12 700	1491.3	6701.0	119.0
CZ 07	11 200	1712.5	6532.2	67.2
CZ 08	10 800	1521.6	6373.5	80.4

Year 2002	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	30 200	5099.0	9707.7	498.5
CZ 02	13 700	1844.1	7591.8	384.5
CZ 03	13 100	1828.4	6968.2	81.1
CZ 04	11 500	1710.3	6401.6	27.0
CZ 05	12 600	1861.9	6833.1	93.6
CZ 06	13 000	1709.0	6778.9	123.3
CZ 07	11 500	1805.0	6648.4	97.3
CZ 08	11 100	1700.3	6420.2	63.2

Year 2003	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	31 900	4460.8	10427.5	573.7
CZ 02	14 400	2039.9	8113.6	346.8
CZ 03	13 900	2004.1	7417.0	83.3
CZ 04	12 400	1977.3	6780.1	34.8
CZ 05	13 000	1698.0	7087.6	108.7
CZ 06	13 800	2105.4	7152.4	133.8
CZ 07	12 100	1515.4	7008.0	83.0
CZ 08	11 800	1341.0	6702.0	107.6

Year 2004	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	33 400	5505.2	10577.8	613.5
CZ 02	15 400	2260.8	8341.8	342.6
CZ 03	15 100	2061.9	7636.5	90.6
CZ 04	13 200	1640.4	6876.3	29.0
CZ 05	13 800	1801.4	7338.2	123.8
CZ 06	14 600	1857.0	7473.8	147.3
CZ 07	12 900	1654.3	7129.5	80.6
CZ 08	13 300	1430.6	6881.4	94.4

Year 2005	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	35 600	5864.4	11225.0	729.9
CZ 02	15 700	2591.6	8823.4	403.8
CZ 03	15 700	2241.1	8175.4	125.8
CZ 04	13 600	1713.9	7362.3	31.9
CZ 05	14 500	1645.2	7939.9	142.6
CZ 06	15 200	2485.5	8012.2	176.3
CZ 07	13 300	1548.6	7641.1	129.6
CZ 08	14 400	1674.4	7559.7	93.6

Year 2006	**GDP**	**GFCF**	**NDI**	**GERD**
CZ 01	38 300	6766.8	12246.7	866.2
CZ 02	17 200	2453.1	9546.0	392.7
CZ 03	16 700	2603.0	8778.6	137.8
CZ 04	14 300	1967.5	7945.8	31.2
CZ 05	15 200	1754.8	8473.9	158.2
CZ 06	16 300	2169.1	8478.9	181.2
CZ 07	14 100	2192.9	8356.8	129.0
CZ 08	15 200	2378.2	7962.1	236.1

Table 2 Pairwise comparison matrix for criteria and data base

MS Excel and complement DAME are used to compute overall priorities. Resulting weights of criteria and positions of particular regions in years 2000 – 2006 are presented in Table 3.

Criterion	**Weight**
GDP	0.5763
NDI	0.2429
GFCF	0.1185
GERD	0.0623

a)

Region/Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
CZ 01	1.	1.	1.	1.	1.	1.	1.
CZ 02	2.	2.	2.	2.	2.	2.	2.
CZ 03	3.	3.	3.	4.	3.	4.	3.
CZ 04	7.	8.	7.	6.	8.	8.	8.
CZ 05	5.	5.	5.	5.	5.	5.	6.
CZ 06	4.	4.	4.	3.	4.	3.	4.
CZ 07	6.	6.	6.	7.	6.	7.	7.
CZ 08	8.	7.	8.	8.	7.	6.	5.

b)

Table 3 a) Weights of criteria, b) rank of regions in years 2000 - 2006

5 Conclusion

In this paper we have dealt with some approach for evaluation of regional competitiveness in the Czech Republic. The final rank of NUTS 2 regions has been presented on the basis of selected macro-regional data using analytic hierarchy process. In Table 3 b) presents final ranks of NUTS 2 regions in the Czech Republic applying 4 criteria (presented by GDP, GFCF, NDI and GERD) and 8 alternatives (presented by 8 NUTS 2 regions). For example the rank of extreme cases – CZ 01 and CZ 02 region remain unchanged. For example region CZ 08 indicates change in rank during evaluated period (8th position in 2000 and 5th position in 2006). On the other hand, each technique is specific so we can not say that some leads to more (or less) credible result than the others. Table 3 a) also shows weights of 4 criteria. The highest impact has GDP – the most importance macroeconomic aggregate. GERD has the lowest impact to final rank of regions. Consequently, our approach presented here could be considered as a suitable alternative for the evaluation of regional competitiveness not only in the Czech Republic. We intend to apply approach of AHP in case of Visegrad four in future.

Acknowledgements

This paper was created in the students' grant project "Seeking Factors and Barriers of the Competitiveness by Using of Selected Quantitative Methods". Project registration number is SGS/1/2012.

References

[1] Hančlová, J.: Panel Modelling of Globalization on Government Expenditures for the Selected New EU Countries. In: *Liberec Economics Forum 2011*. Technical university of Liberec, Faculty of economics, Liberec, 2011, 161-170.

[2] Mazurek, J.: Comparison of impacts of the financial crisis on the Czech Republic regions by cluster analysis. In: *Proceedings of the 13th International conference on finance and banking*. Silesian University, School of Business Administration, Karviná, 2011, 396-404.

[3] Nevima, J., and Melecký L.: Regional competitiveness evaluation of Visegrad Four countries through econometric panel data model. In: *Liberec Economics Forum 2011*. Technical university of Liberec, Faculty of economics, Liberec, 2011, 348-361.

[4] Nevima, J., and Ramík, J.: Application of multicriteria decision making for evaluation of regional competitiveness. In: *Mathematical Methods in Economics 2009*. Czech University of Life Sciences Prague, Kostelec nad Černými lesy, 2009, 239-244.

[5] Nevima, J., and Ramík, J.: Application of DEA for evaluation of regional efficiency of EU regions. In: *Mathematical Methods in Economics 2010*. University of South Bohemia, České Budějovice, 2010, 477-482.

[6] Porter, M. E.: The Economic performance of regions. *Regional Studies* **37** (2003), 549-578.

[7] Pražák, P.: On a dynamic model of revenue maximizing firm. In: *Mathematical Methods in Economics 2010*, University of South Bohemia, České Budějovice, 2010, 542-547.

[8] Ramík, J., and Hančlová, J.: Multicriteria methods for evaluating competitiveness of regions in V4 countries. In: *Trzaskalik. T. Multiple Criteria Decision Making'12*. Katowice: The Karol Adamiecki University of Economics, 2012.

[9] Ramík, J., Perzina, R.: *Modern methods of evaluation and decision making* (*Moderní metody hodnocení a rozhodování)*. OPF SU, Karviná, 2008.

[10] Saaty, T. L.: *The analytic hierarchy process: Planning, priority setting, resource allocation*. McGraw Hill, New York, 1980.

[11] Tuleja, P., and Tvrdoň, M.: The Czech labour market after the crisis of a real economy: negative development or return to steady-state? *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* **LIX** (2011), 477-488.

[12] Tvrdoň, M., and Verner, T.: Examining the relationship between economic performance and unemployment: the case of Visegrad countries. In: *Mathematical Methods in Economics 2011*, University of Economics, Praha, 2011, 733-738.

[13] Viturka, M.: Competitiveness of regions and possibilities of its evaluation (Konkurenceschopnost regionů a možnosti jejího hodnocení). *Politická ekonomie* **5** (2007), 637-657.