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Evaluation of Czech NUTS 2 Competitiveness Using AHP and Group Decision Making

Abstract

The contribution solves the problem of alternative access towards evaluating of competitiveness of NUTS 2 regions in the Czech Republic. In the absence of mainstream views on the assessment of competitiveness, there is sample room for the presentation of individual approaches to its evaluation. The basic aim of the contribution is due to the method of analytic hierarchy process (AHP) and aggregation of individual priorities 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, which are employment rate, gross domestic product, gross domestic expenditures on research and development, gross fixed capital formation, knowledge intensive services, net disposable income and patents indicators. We can obtain the idea of mutual competitive position of these regions by applying the method. The analytic hierarchy process is a concrete method for multicriteria decision making which uses pair-wise comparison matrices to calculate weights (priorities) of given objects (criteria or alternatives to be evaluated). These individually determined priorities will be aggregated into group priority vector which will serve as basis for further computations of our problem. The macro-regional indicators are 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 European Union.

Key Words

competitiveness, macroeconomic indicator, pair-wise comparison, AHP, aggregation

JEL Classification: C61, D79, 018, P25, R11

Introduction

The competitiveness has become quite a common term used in many professional and non-specialized publications. Nevertheless, evaluation of the competitiveness issue is not less complicated. Effectively analysed 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. 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 the Czech Republic at NUTS 2 level in terms of analytic hierarchy process [1] using group decision making. 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 [11] and regional competitiveness it is necessary to suggest not only difficult but also simple methods which enable quick evaluation of competitiveness by accessible tools. Database for our paper has been taken from OECD Regional Statistics – eLibrary system. Paper analysis includes last programming period (from 2000 to 2006) of European Union – in case of the Czech Republic

1. Approaches to Competitiveness Evaluation

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 [4]. 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. 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, but we can also apply different NUTS level – e.g. NUTS 3 level.

First 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 [1;3]. 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 [5]. 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. This aspect is also crucial in this paper, where we present AHP to gain more detailed view on competitiveness of regions by way of quantitative characteristics. Second 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. Another and also specific approach is macro econometric modelling and creation of an econometric panel data model [2].

2. Evaluation criteria

First represented entrance criteria is **rate of employment** in age group 20 – 64 years (ER). From the economic relevance rate of employment is important in accordance to

number of economic active people in above mentioned age group. Employed population consists of those persons who during the reference week did any work for pay or profit for at least one hour, or were not working but had jobs from which they were temporarily absent.

Gross domestic product (GDP) was chosen as it is one of the most important macroeconomic aggregates 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 [10] (i.e. increasing efficiency of regions) also the rate of obtained competitiveness/competition advantage grows.

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.

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. It is estimated in purchase price including costs connected with instalment 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. It is an index of innovating competitiveness which enables to increase production on modern technical base.

Knowledge intensive services (KIS) as % of total employment are among the fastest growing and dynamic sectors of the economy. Knowledge intensive services are characterized by high degrees of contact intensity and a high number of variants. Typical examples are professional business services like consulting, IT and marketing. Knowledge-intensive services are supplied mainly to final consumers, as public services (e.g. health) or private professional ones (consumer financial advice [9] or computer repair).

Net disposable income (NDI) is the result of current incomes [8] 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.

Patents (PAT) are a key measure of innovation output, as patent indicators reflect the inventive performance of regions. Patent indicators can serve to measure the output of R&D, its productivity, structure and the development of a specific technology/industry. Among the few available indicators of technology output, patent indicators are probably the most frequently used. Patents are often interpreted as an output indicator; however, they could also be viewed as an input indicator, as patents are used as a source of information by subsequent inventors.

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 (weights). Pair-wise comparisons matrices which entries are results of pair-wise comparisons are characteristic for this method.

The essence of pair-wise comparison is mutual measure of all pairs of considered elements. 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 [7], where 1 means equality and 9 extreme difference of importance.

Data obtained through pair-wise comparisons are inserted into the pair-wise comparison matrix A, its entries are signed generally a_{ij}. An $n \times n$ (square) matrix is created, see Fig. 1.

Fig. 1 General multiplicative pair-wise comparison matrix

	element x_1	element x_2	…	element x_k
element x_1	a_{11}	a_{12}	$\cdots$	a_{1k}
element x_2	a_{21}	a_{22}	$\cdots$	a_{2k}
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
element x_k	a_{k1}	a_{k2}	$\cdots$	a_{kk}

Entries of the pair-wise comparison matrix represent *estimation of weight ratio* of two compared elements, i.e. of criteria or alternatives with respect to qualitative criterion. These weights are not known, they are calculated in the analytic hierarchy process. If a_{ij} is an element of pair-wise 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:

$$a_{ij} = \frac{w_i}{w_j},\ a_{ij} \in \{1,2,3,4,5,6,7,8,9\}. \tag{1}$$

$$a_{ji} = \frac{1}{a_{ij}},\ a_{ji} \in \{1,2,3,4,5,6,7,8,9\}, \tag{2}$$

$$a_{ij} \cdot a_{ji} = 1,\ \text{for all } i,j = 1,2,\ldots,n. \tag{'2}$$

Formula (2) corresponds to one of the pair-wise comparison matrix characteristic – the reciprocity.

Consistency is characteristic of pair-wise comparison matrix which expresses how much individual pair-wise comparisons are mutually consistent. This characteristic can be expressed by the following formula illustrating transitivity of pair-wise comparisons:

$$a_{ij} = a_{ik} \cdot a_{kj},\ i,j,k = 1,2,\ldots,n \tag{3}$$

We have to compute the eigenvector $w = (w_1, w_2, \ldots, w_n), \sum_{i=1}^{n} w_i = 1$ corresponding to the maximal eigenvalue $\lambda_{\max}$ of the pair-wise comparison matrix A to determine result element priorities of the given matrix. Eigenvector w contents information about result priorities.

$$Aw = \lambda_{\max} w \tag{4}$$

Pair-wise comparison matrix is square, nonnegative and irreducible. These characteristics ensure existence of maximal eigenvalue $\lambda_{\max}$ and corresponding positive eigenvector [6]. The Wielandt theorem is used to compute the eigenvector, where e is unit vector and c is constant.

$$cw = \lim_{k \to \infty} \frac{A^k e}{e^T A^k e} \tag{5}$$

It is possible to measure the consistency, respective inconsistency of multiplicative pair-wise comparisons using multiplicative consistency index $I_{mc}(A)$ of pair-wise comparison matrix A:

$$I_{mc}(A) = \frac{\lambda_{\max} - n}{n-1}. \tag{6}$$

In case of consistent pair-wise comparison matrix $I_{mc}(A) = 0$. As it follows from formula (6) the multiplicative consistency index $I_{mc}(A)$ depends on dimension of the matrix. Therefore the multiplicative consistency ratio $CR_{mc}(A)$ was implemented. It is defined as ratio of multiplicative consistency index $I_{mc}(A)$ and its mean value $R_{mc}(n)$ calculated for randomly generated reciprocal matrices satisfying characteristics of multiplicative pair-wise comparison matrices. Values of $R_{mc}(n)$ are published e.g. in [7]. It is formulated as follows:

$$CR_{mc}(A) = \frac{I_{mc}(A)}{R_{mc}(n)}. \tag{7}$$

Generally the maximal acceptable value of the multiplicative consistency ratio is 10 %.

4. Aggregation of individual assessments and synthesis

Let us have group of n decision-makers evaluating m criteria $c_1, c_2, ..., c_m$. The evaluation of the i-th criterion performed by the j-th decision-maker is signed as h_{ij} considering $h_{ij} > 0$, $\sum_{i=1}^{m} h_{ij} = 1$, $j = 1,2,...,n$, i.e. evaluations are normalized. Evaluation of i-th criterion performed by all decision-makers is obtained by [6]:

$$h_i = \prod_{j=1}^{n} h_{ij} = h_{i1} \cdot h_{i2} \cdot ... \cdot h_{in}, \; i = 1,2,...,m. \tag{8}$$

The group evaluation of the i-th criterion is determined by:

$$H_i = \frac{h_i}{\sum_{i=1}^{m} h_i}. \tag{8}$$

satisfying condition of normalization $\sum_{i=1}^{m} H_i = 1$. We gain the group priority vector $w_G = (H_i), i = 1,2,..., m$. The required result, i.e. weights of alternatives, we obtain through synthesis of these information. If weight of i-th criterion is H_i and weight of j-th alternative with respect to criterion f_i is $v_j(f_i)$, the overall weight E_j of j-th alternative with respect to the goal is:

$$E_j = \sum_{i=1}^{m} H_i \cdot v_j(f_i). \tag{10}$$

where $j = 1,2,...,n$. 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.

5. Application

The analytic hierarchy process is used to compute priorities of indicators which are determined by each evaluator/decision-maker separately and independently on each other. Afterwards, these priorities are aggregated and overall priorities of indicators are

gained. This procedure enables to rank Czech NUTS 2 regions according to achieved competitiveness.

Pair-wise comparison matrices based on expert estimations of decision-makers K, L, M (indicators are in order: ER, GDP, GERD, GFCF, KIS, NDI, PAT) are following:

$$K = \begin{bmatrix} 1 & 1/2 & 6 & 5 & 7 & 3 & 8 \\ 2 & 1 & 5 & 4 & 7 & 3 & 9 \\ 1/6 & 1/5 & 1 & 1/2 & 2 & 1/4 & 3 \\ 1/5 & 1/4 & 2 & 1 & 4 & 1/3 & 6 \\ 1/7 & 1/7 & 1/2 & 1/4 & 1 & 1/6 & 3 \\ 1/3 & 1/3 & 4 & 3 & 6 & 1 & 7 \\ 1/8 & 1/9 & 1/3 & 1/6 & 1/3 & 1/7 & 1 \end{bmatrix}, \quad L = \begin{bmatrix} 1 & 1/8 & 1/3 & 1/5 & 1/3 & 1/4 & 3 \\ 8 & 1 & 7 & 5 & 8 & 3 & 9 \\ 3 & 1/7 & 1 & 1/3 & 2 & 1/2 & 5 \\ 5 & 1/5 & 3 & 1 & 4 & 1/2 & 5 \\ 3 & 1/8 & 1/2 & 1/4 & 1 & 1/3 & 4 \\ 4 & 1/3 & 2 & 2 & 3 & 1 & 5 \\ 1/3 & 1/9 & 1/5 & 1/5 & 1/4 & 1/5 & 1 \end{bmatrix},$$

$$M = \begin{bmatrix} 1 & 1/2 & 1/7 & 1/6 & 1/8 & 1/4 & 3 \\ 2 & 1 & 1/6 & 1/5 & 1/5 & 1/3 & 4 \\ 7 & 6 & 1 & 4 & 3 & 5 & 8 \\ 6 & 5 & 1/4 & 1 & 1/2 & 2 & 7 \\ 8 & 5 & 1/3 & 2 & 1 & 4 & 9 \\ 4 & 3 & 1/5 & 1/2 & 1/4 & 1 & 5 \\ 1/3 & 1/4 & 1/8 & 1/7 & 1/9 & 1/5 & 1 \end{bmatrix}.$$

We compute the multiplicative consistency ratios of pair-wise comparison matrices K, L and M and corresponding priority vectors (where indicators are in order: ER, GDP, GERD, GFCF, KIS, NDI, PAT): $CR_{mc}(K)$ = 0.052 with priority vector w_K = (0.292, 0.338, 0.053, 0.091, 0.036, 0.167, 0.022), $CR_{mc}(L)$ = 0.063 and the priority vector w_L = (0.039, 0.456, 0.088, 0.157, 0.064, 0.171, 0.025) and $CR_{mc}(M)$ = 0.062 with priority vector w_M = (0.035, 0.052, 0.395, 0.159, 0.241, 0.096, 0.022). All consistency ratios are less than 0.1, i.e. all pair-wise comparison matrices are sufficiently consistent. According to (9) we obtain the group weights of indicators w_G = (0.026, 0.503, 0.118, 0.143, 0.036, 0.174, 0.001), which give these weights and rankings of Czech NUTS 2 regions (Tab. 1 and Tab 2.):

Tab. 1 Group weights of Czech NUTS 2 regions in years 2000 – 2006 and average weights

Region/Year	2000	2001	2002	2003	2004	2005	2006	Ø
Praha	0.244	0.249	0.255	0.254	0.259	0.260	0.263	0.255
Střední Čechy	0.139	0.139	0.138	0.134	0.134	0.133	0.127	0.135
Jihozápad	0.112	0.109	0.107	0.109	0.110	0.110	0.110	0.109
Severozápad	0.094	0.094	0.092	0.096	0.092	0.090	0.090	0.093
Severovýchod	0.107	0.104	0.105	0.104	0.104	0.102	0.100	0.104
Jihovýchod	0.111	0.109	0.109	0.113	0.110	0.113	0.108	0.110
Střední Morava	0.097	0.099	0.100	0.096	0.095	0.095	0.096	0.097
Moravskoslezsko	0.095	0.096	0.094	0.094	0.096	0.098	0.107	0.097

Source: Own computations

Tab. 2 Final ranking of Czech NUTS 2 regions in years 2000 – 2006 and average ranking

Region/Year	2000	2001	2002	2003	2004	2005	2006	Ø
Praha	1	1	1	1	1	1	1	1
Střední Čechy	2	2	2	2	2	2	2	2
Jihozápad	3	3	4	4	4	4	3	4
Severozápad	8	8	8	6	8	8	8	8
Severovýchod	5	5	5	5	5	5	6	5
Jihovýchod	4	4	3	3	3	3	4	3
Střední Morava	6	6	6	7	7	7	7	7
Moravskoslezsko	7	7	7	8	6	6	5	7

Source: Own computations

From Tab. 2 is obvious that first and second positions do not change through the 7-years period. Praha and Střední Čechy can be considered as two most competitive regions in the Czech Republic. Jihozápad and Jihovýchod alternate on the third and fourth position. Severovýchod is the fifth most competitive region. Střední Morava is alternated by Moravskoslezsko on the sixth and seventh position. Except the year 2003, Severozápad is the least competitive region. Moravskoslezsko has been changed own position during programming period very significantly (from seventh position in 2000 to fifth position in 2006). From the methodological point of view, we would like to stress that our paper doesn't seek reasons of these changes inside of regions. We don't work with contemporary programming period, because it has not been over yet. In our next research we would like to make comparison between both programming periods.

Conclusion

In this paper we applied one of multicriteria decision making method – the analytic hierarchy process – in evaluation of regional competitiveness on NUTS 2 level in the Czech Republic. This method was used to calculate weights of criteria determined by three evaluators individually. These three priority vectors were aggregated and final group weights of criteria (i.e. of macroeconomic indicators) were gained. This procedure enabled to take different experts' estimations into consideration.

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