Approaches to Regional Competitiveness Evaluation in the Visegrad Four Countries

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Abstract: The aim of the paper is to investigate and evaluate the regional competitiveness on the case of Visegrad Four (V4) countries. Furthermore the purpose is to compare using two alternative research methods based on relevant hypotheses. The theoretical part explains the basic concept of regional competitiveness. Particularly it identifies and compares two selected methodological approaches to evaluating competitiveness: macro econometric modelling and Data Envelopment Analysis (DEA). The empirical part is based on the estimation of regional competitiveness econometric panel data model and analysis of efficiency by application of DEA method in V4 NUTS2 regions. Both approaches include a comparison of results for all explanatory variables in V4 NUTS 2 regions, which are cross-sectional and used over referenced period. Econometric panel data regression model determine the order of impact of each V4 NUTS 2 region on overall competitiveness of the European Union. DEA method provides a different view of regional competitiveness assuming that efficiency mirrors competitiveness. The final part of the paper offers a comprehensive look at the results of used approaches to regional competitiveness evaluation.

Key-Words: Competitiveness, Visegrad Four, NUTS 2, evaluation, macro econometric modelling, econometric panel data model, Data Envelopment Analysis, BCC input oriented model VRS, index of efficiency

1 Introduction
Competitiveness and its evaluation play a significant role in the European Union (EU) and all over the world. Recently the interest in competitiveness has risen on three levels: firms, nations and regions. Generally speaking, we have to strive to be competitive in order to survive in the new marketplace which is being affected by globalization and the new information technologies. Despite that, the definition of competitiveness is associated with several difficulties. Competitiveness still remains a concept that can be understood in different ways, especially at the microeconomic and the macroeconomic level.

The concept of competitiveness has quickly spread to the regional, urban and local level, but the idea of regional competitiveness still remains controversial. Current economic fundamentals are threatened by the shifting of production activities to places with better conditions. In global economy, regions are becoming the drivers of economy. In general, one of the most significant features of regional economies is the presence of clusters, or geographic concentrations of linked industries [8]. The regional competitiveness is also affected by the regionalization of public policy because of shifting of decision-making and coordination of activities at regional level. 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 the competitiveness of every region and major city, and hence the national economy as a whole [6].

Evaluating competitiveness is as complex as the definition and understanding of the concept itself. Regional competitiveness and its evaluation are issues constantly in the forefront of economic sciences, which lacks a mainstream approach. Decomposition of aggregate macroeconomic indicators is the most common approach of evaluation used at the regional level, as well as comprehensive (mostly descriptive) analysis aimed at identifying the key factors of regional development, productivity and economic growth; see e.g. [9, 10]. Another approach presents competitiveness evaluation by EU Structural indicators.

Finally, regional competitiveness can be explored by another alternative approaches, e.g. macro econometric modelling with creation of an
econometric panel data regression model; see [1, 5, 7] and DEA method measuring regional efficiency and subsequently measuring regional competitive potential; see [2, 4, 10].

2 Selected Approaches to Regional Competitiveness Evaluation

Creating competitiveness evaluation system in terms of the EU is complicated by the heterogeneity of countries and regions. What is more, the countries have their individual approach to the original concept of competitiveness. Looking for sources of national competitiveness we focus primarily on lower territorial units. On the contrary, accepting growing importance of EU regions is necessary because it deserves increasing attention especially regarding the fact that the economic performance of the regions is crucial for the EU competitiveness.

Evaluation of regional competitiveness in the EU is determined by the chosen territorial region level, especially in terms of Nomenclature of Territorial Units Statistics (NUTS). Reference period, availability and periodicity of data and selection of convenient specific indicators that reflect the degree of competitiveness potential are of no less importance.

2.1 Theoretical Background of Macro econometric modelling

Macro econometric modelling as a scientific discipline has more than fifty years of history and it is an important source of research interest on (alternative) models in terms of regional competitiveness. For evaluating the degree of regional competitiveness or searching for sources of competitiveness on regional level, it is appropriate to use the formulation of regional econometric panel data models. Regional panel data models form a link between micro and macro components and are constructed mostly ad hoc. The explanatory and interpretive ability is mainly dependent on the fulfilment of the appropriate model and especially the availability of data and specification of the applied model.

To summarize, we point out the benefits of panel data model compared to conventional simple linear regression models. The panel data model supports cross-sectional analysis compared to a simple regression model. It can affect the dynamics of change thanks to cross-sectional analysis. It can also better capture the dynamic changes and fixed or stochastic effects that occurred in proposed explanatory variables. Another advantage is to design and test the complex models with an appropriate number of degrees of freedom. See [8] for other advantages and disadvantages of macro econometric modelling. Panel data model, used in our empirical analysis, is based on assumption of partial positive effect of each V4 NUTS 2 to overall competitiveness of EU27. Panel data model generally eliminates variations caused by aggregation of data sets used. Panel model can be used in microeconomics and macroeconomics as well as for mezzo-economic applications. It is also suitable for the analysis of competitiveness [1].

2.2 Theoretical Background of DEA Method

There are economic, social and territorial disparities among the EU Member States and their regions. They have a negative impact on the balanced development across the EU countries and their regions. The differences in regional productivity and efficiency are the topics of intense research. The performance analysis is used for evaluating regional development quality and potential (with respect to the regional factor endowment). DEA method becomes a suitable tool for setting a competitive/uncompetitive position of each NUTS 2 region within the group of V4 countries. To evaluate regions, we define a number of similar indicators, which are based on different data. That is why the results usually are not consistent. A larger number of inputs and outputs can be used for measuring and evaluating the overall effectiveness of regions as well. Application of DEA method is based on hypothesis that efficiency of regions calculated by DEA can be seen as the source of regional competitiveness/competitive potential.

DEA was first proposed by Charnes et al. in 1978. Since that time, DEA is a subject of a number of research activities. DEA is based on original Farrel model, which expanded Charnes, Cooper and Rhodes (CCR model) and later Banker, Charnes and Cooper (BCC model); for more details see [2].

DEA is gaining importance as a tool for evaluating and improving the performance of so-called decision-making units (DMUs). DEA is a multi-factor productivity analysis model for measuring relative efficiency and providing comparison of a homogenous set of DMUs. The definition of a DMU is generic and flexible, but there are comparable. The DMUs are usually characterized by several inputs that are utilized for producing several outputs. DMU is efficient if the observed data correspond to testing whether the DMU is on the imaginary 'production possibility
frontier’. All other DMUs are simply inefficient. The best-practice units are used as a reference for the evaluation of the other group units. The aim of this method is to divide DMUs effective and not effective by amount of consumed inputs and produced outputs [10].

2.3 Methodological Background of Empirical Analysis

We used two above mentioned methodological approaches to evaluate regional competitiveness – macro econometric modelling and DEA method, which are based on comparable elements. Both models are applied to 35 NUTS 2 regions of V4 countries. Database for measuring regional competitiveness in 35 NUTS 2 regions of V4 countries is based on regional data provided by European Statistical Office – module Regional Statistics [3]. Under regional data, we have used time series of indicators all expressed in volumes per inhabitant. The data analysis cover reference period 2000 – 2008. For the research analysis, we used annual basis regional data sheets that include: Gross Domestic Product (GDP), Gross Fixed Capital Formation (GFCF), Gross Expenditure on Research and Development (GERD), Net Disposable Income of Households (NDI), Employment Rate (ER) and Number of Students in Tertiary Education (NSTE). 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 (NUTS 2). GFCF due to international accounting is a basic part of gross capital formation (capital investments), in which is also the change of inventories and net acquisition of valuables included. GFCF presents an index of innovating competitiveness which enables to increase production on modern technical base. 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. NDI is the result of current receipts and expenditures, primary and secondary disposal of incomes. 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. Next represented explaining variable is ER. From the economic relevance, employment rate is important in accordance to number of economic active people in above mentioned age group. The last variable is NSTE. It will assume that increasing number of university educated people will contribute to the growth of country competitiveness and finally to increasing productivity of work in fields generating higher added value, as it proposed in [7].

2.3.1 The Specification of the Econometric Panel Data Model for V4 Regions

The logging for the estimate of panel non-linear regression model using technique of dummy variables for NUTS 2 regions of V4 countries (1) is, with using above specified data, following [7]:

\[
\ln GDP_{r,t} = \hat{\alpha} + \hat{\beta}_1 \ln GFCF_{r,t} + \hat{\beta}_2 \ln GERD_{r,t} + \hat{\beta}_3 \ln NDI_{r,t} + \hat{\beta}_4 \ln ER_{r,t} + \hat{\beta}_5 \ln NSTE_{r,t} + \sum_{i=1}^{35} \gamma_i D_{r,t} + \hat{\epsilon}_{r,t}
\]

(1)

where:

- GDP<sub>r,t</sub> Gross Domestic Product;
- GFCF<sub>r,t</sub> Gross Fixed Capital Formation;
- GERD<sub>r,t</sub> Gross Domestic Expenditures on Research and Development;
- NDI<sub>r,t</sub> Net Disposable Income;
- ER<sub>r,t</sub> Employment Rate by Age;
- NSTE<sub>r,t</sub> Number of Students in Tertiary Education;
- \(\hat{\alpha}\) Constant;
- \(\beta_1, \ldots, 5\) Slope Parameter of regression model (e.g. J. Fan - Q. Yao 2005);
- \(\gamma_r\) Differences Parameter of fixed effects;
- \(\epsilon_{r,t}\) Random error;
- \(D_{r,t}\) Binary Variable for region specification;
- \(D_{r,t} = 1\) if it takes data of the region “r“ in time “t“; \(D_{r,t} = 0\) otherwise;
- \(r\) indexes sectional characteristics – in our case NUTS 2 regions of V4 (basic „region“ is average of EU-27 regions);
- \(r = 1, 2, \ldots, 35\) (in this case 35 Visegrad Group regions);
- \(t\) indexes time; \(t = 2000, 2001, \ldots, 2008\).

From the explanation of non-linear regression model of panel data theorem is clear that it is
necessary to assign dummy variable \( D_{ij} \) for each NUTS 2 region of V4 before estimate of the model is provided. The model will content 35 dummy variables corresponding with 35 V4 NUTS 2 regions.

The model conception unambiguously determines which regions contribute by selected explored indicators of competitiveness to total average output of EU27, which is approximated in endogenous variable by GDP aggregate. Average value like an ideal region then presents arithmetic regional GDP average calculated from 271 NUTS 2 regions of EU27. According to the hypothesis, that regional average of EU27 GDP stands for ideal region – the most competitive region, it will be valid: the higher value of \( \gamma \), the higher contribution of each NUTS 2 region to average level of economic output of whole EU27. The regions with the highest contribution will be currently considered as the most competitive. This aspect is crucial for the model.

### 2.3.2 DEA Analysis

For calculations of economic efficiency of 35 NUTS 2 regions of V4 countries is used BCC input oriented model (with multiple inputs and outputs), assuming variable returns to scale (VRS). CCR model assumes constant returns to scale (CRS). In 1984, Banker, Charnes and Cooper suggested a modification of CCR model, which considers VRS (decreasing, increasing or constant). VRS enable identify more efficient units (in our case regions). The assumption of variable returns to scale provides a more realistic expression of economic reality and factual relations, events and activities existing in the regions.

The efficiency coefficient is the ratio between the weighted sum of outputs and the weighted sum of inputs. Each region selects input and output weights that maximize its efficiency score. The coefficient of efficiency takes values in the interval \( <0,1> \). In DEA models aimed at inputs the efficiency coefficient of efficient regions always equals 1, while the efficiency coefficient of inefficient regions is less than 1.

Mathematical formulation of primary BCC input oriented model VRS show the equation (2) [4]:

\[
\max \quad z = \sum_{i} u_{i} y_{iq} + \mu ,
\]

on conditions:

\[
\sum_{i} u_{i} y_{iq} + \mu \leq \sum_{j} v_{j} x_{jk} , \quad k = 1,2,\ldots,n ,
\]

\[
\sum_{j} v_{j} x_{jq} = 1 ,
\]

\[
u_{i} \geq \varepsilon ; \quad i = 1,2,\ldots,r ,
\]

\[
v_{j} \geq \varepsilon ; \quad j = 1,2,\ldots,m ,
\]

\[
\mu - \text{arbitrary} .
\]

where: 
- \( z \) optimal efficiency score;
- \( y_{iq} \) amount of output \( i \) produced by country \( q \);
- \( x_{jq} \) amount of input \( j \) utilized by country \( q \);
- \( u_{i} \) weight given to output \( i \);
- \( v_{j} \) weight given to input \( j \);
- \( \varepsilon \) infinitesimal constant;
- \( \mu \) dual variable.

### 3 Application of Selected Method for Regional Competitiveness Evaluation of V4

We can state, based on calculation and results of panel data non-linear regression model using dummy variables for V4 NUTS 2 regions, that following regions have the most significant contribution to GDP formation and thus to the position-effect of V4 NUTS 2 regions on the overall competitiveness of EU27: CZ01 Praha, SK01 Bratislavský kraj, HU22 Nyugat-Dunántúl and HU10 Közép-Magyarország. Economically powerful regions in agglomeration of major cities achieve the best results. On the other hand, four Polish regions – PL31 Lubelskie, PL21 Malopolskie, PL11 Łódzkie and PL32 Podkarpackie contribute to overall EU27 competitiveness the least. The top and bottom three regions are bold and in italics placed in Annex. We can consider these regions as most/least competitive in relation to EU27 GDP average. Let us remind that the above mentioned model is not an economic growth model. In contrast to model of competitiveness, it has explicitly defined form of input variables. Annex includes the final order of all 35 NUTS regions of V4 and their influence on global competitiveness of EU27 measured by average GDP level.

Evaluation by application of DEA method – BCC input oriented model VRS indicates similar results as the previous econometric approach. The best results are traditionally achieved by economically powerful regions (in most cases) which were ‘efficient’ during the whole referred period, so the resulting efficiency index is equal to 1. This means that the outputs achieved were greater than those incurred inputs. ‘Efficient’ V4 NUTS 2 regions are mentioned by dark grey colour in Annex. Totally 7 NUTS 2 regions belong among the most efficient.
regions in V4 countries. There is only one most efficient region in the Czech Republic – CZ01 Praha. In Hungary, the most efficient NUTS 2 region is HU10 Közép-Magyarország. NUTS 2 regions PL31 Lubelskie, PL32 Podkarpackie, PL33 Świętokrzyskie and PL52 Opolskie belong among the most efficient NUTS 2 regions in Poland. In Slovakia, the most efficient NUTS 2 region is SK01 Bratislavský kraj.

The above listed efficient V4 NUTS 2 regions are followed by a group of 17 NUTS 2 regions which are ‘highly efficient’. These regions achieved relative efficiency equal to 1 at least in one year of the referred period (illuminated in light grey colour in Annex). These regions are: CZ04 Severozápad in the Czech Republic; HU22 Nyugat-Dunántúl, HU23 Dél-Dunántúl, HU31 Észak-Magyarország, HU32 Észak-Alföld and HU33 Dél-Alföld in Hungary; PL12 Mazowieckie, PL22 Ślaskie, PL34 Podlaskie, PL42 Zachodniopomorskie, PL43 Lubuskie, PL51 Dolnoslaskie, PL61 Kujawsko-Pomorskie and PL62 Warmińsko-Mazurskie in Poland; and regions SK02 Západné Slovensko and SK03 Stredné Slovensko in Slovakia.

Other regions with efficiency index less than 1 are classified as ‘ineffective’, i.e. these regions are considered as non-competitive or regions with the lowest competitive potential. ‘Inefficient’ regions are highlighted by italics in Annex. Regions CZ02 Střední Čechy, PL11 Lódzkie and PL21 Małopolskie belong among these regions.

4 Conclusion
We have observed contributions of V4 NUTS 2 regions to the average level of total EU27 economic performance approximated by GDP. The regions with highest contribution to average EU27 GDP where considered as the most competitive regions. On the other hand, the regions with the lowest impact to GDP formation where considered the least competitive. Applying DEA method we found out the rat of efficiency in V4 NUTS 2 regions within the whole referred time period.

Both used research methods provide relatively comparable results therefore they seem to be a suitable alternative methodological approach for evaluation of regional competitiveness and setting a competitive or uncompetitive position of V4 NUTS 2 region in reference period.

It is necessary to mentioned that DEA efficiency model indicated several ‘anomalies’ in the final classification of V4 NUTS 2 regions in the values of efficient coefficients, essentially in Polish regions PL31 Lubelskie and PL32 Podkarpackie. These regions were evaluated as the least competitive in relation to EU27 average in macro econometric approach but in DEA approach they seem to be effective. In these cases we cannot completely confirm the general hypothesis of efficiency as a reflection of competitive potential. In this paper DEA method evaluates relative rate of efficiency, i.e. the ratio between several outputs and several inputs of each V4 NUTS 2 regions. The ratio between weighted sum of outputs and inputs could be efficient even though the volume of inputs and outputs of DMUs is low, which seems to be case of these two Polish regions.

References:
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Annex

Results of Two Selected Models for V4 Regional Competitiveness Evaluation

<table>
<thead>
<tr>
<th>Code</th>
<th>NUTS 2 Region/Time</th>
<th>Econometric Panel Data Model 2000 – 2008</th>
<th>Efficiency Model (BCC Input Oriented Model VRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU27</td>
<td>European Union</td>
<td>Ideal Region</td>
<td>1,000</td>
</tr>
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<td>CZ01</td>
<td>Praha</td>
<td>1.</td>
<td>1,000</td>
</tr>
<tr>
<td>CZ02</td>
<td>Střední Čechy</td>
<td>29.</td>
<td>0,808 0,801 0,854 0,799 0,808 0,796 0,826 0,817 0,796</td>
</tr>
<tr>
<td>CZ03</td>
<td>Jihozápad</td>
<td>18.</td>
<td>0,865 0,887 0,922 0,876 0,912 0,883 0,870 0,861 0,823</td>
</tr>
<tr>
<td>CZ04</td>
<td>Severozápad</td>
<td>9.</td>
<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000</td>
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<td>CZ05</td>
<td>Severovýchod</td>
<td>27.</td>
<td>0,881 0,904 0,908 0,874 0,871 0,915 0,902 0,873 0,854</td>
</tr>
<tr>
<td>CZ06</td>
<td>Jihovýchod</td>
<td>15.</td>
<td>0,865 0,896 0,921 0,888 0,886 0,867 0,898 0,866 0,872</td>
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<tr>
<td>CZ07</td>
<td>Střední Morava</td>
<td>26.</td>
<td>0,880 0,865 0,880 0,860 0,883 0,888 0,834 0,854 0,855</td>
</tr>
<tr>
<td>CZ08</td>
<td>Moravskoslezsko</td>
<td>11.</td>
<td>0,868 0,886 0,914 0,888 0,935 0,926 0,903 0,914 0,913</td>
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<td>Közép-Magyarország 4.</td>
<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000</td>
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<tr>
<td>HU21</td>
<td>Közép-Dunántúl 7.</td>
<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 0,969</td>
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<tr>
<td>HU22</td>
<td>Nyugat-Dunántúl 3.</td>
<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000</td>
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</tr>
<tr>
<td>HU23</td>
<td>Dél-Dunántúl 8.</td>
<td>1,000 1,000 0,950 0,937 0,979 0,926 0,896 0,984 0,938</td>
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<td>HU31</td>
<td>Észak-Magyarország 12.</td>
<td>1,000 1,000 0,981 1,000 0,884 1,000 0,963 1,000 1,000</td>
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<tr>
<td>HU32</td>
<td>Észak-Alföld 10.</td>
<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 0,977 1,000 1,000</td>
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<tr>
<td>HU33</td>
<td>Dél-Alföld 19.</td>
<td>1,000 1,000 0,960 0,954 0,965 0,951 0,935 0,993 0,959</td>
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<tr>
<td>PL11</td>
<td>Łódzkie 33.</td>
<td>0,871 0,885 0,964 0,960 0,911 0,876 0,874 0,855 0,863</td>
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<tr>
<td>PL12</td>
<td>Mazowieckie 22.</td>
<td>0,894 1,000 0,949 0,960 0,974 1,000 0,973 1,000 1,000</td>
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<td>PL21</td>
<td>Malopolskie 34.</td>
<td>0,842 0,894 0,905 0,914 0,918 0,940 0,941 1,000 0,942</td>
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<td>PL22</td>
<td>Śląskie 30.</td>
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<td>PL31</td>
<td>Lubelskie 35.</td>
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<tr>
<td>PL32</td>
<td>Podkarpackie 32.</td>
<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000</td>
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<tr>
<td>PL33</td>
<td>Świętokrzyskie 24.</td>
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<tr>
<td>PL34</td>
<td>Podlaskie 31.</td>
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<td>PL41</td>
<td>Wielkopolskie 28.</td>
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<td>PL42</td>
<td>Zachodniopomorskie 16.</td>
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<td>PL43</td>
<td>Lubuskie 5.</td>
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<td>PL51</td>
<td>Dolnoslaskie 17.</td>
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<tr>
<td>PL52</td>
<td>Opolskie 6.</td>
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<tr>
<td>PL61</td>
<td>Kujawsko-Pomorskie 25.</td>
<td>0,995 0,963 0,951 1,000 1,000 0,993 1,000 0,955 0,952</td>
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<tr>
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<td>Warmińsko-Mazurskie 20.</td>
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<td>Pomorskie 13.</td>
<td>0,997 1,000 1,000 1,000 0,966 1,000 1,000 1,000 0,993 1,000</td>
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<td>SK01</td>
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<td>1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000 1,000</td>
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<td>Západné Slovensko 14.</td>
<td>0,945 0,897 0,893 0,955 0,950 0,939 0,985 1,000 1,000 1,000 1,000</td>
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<td>Stredné Slovensko 21.</td>
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<td>SK04</td>
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<td>0,917 0,888 0,929 0,980 0,970 0,925 0,921 0,941 0,948</td>
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Source: Own calculation and elaboration, 2011