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Competitiveness, Innovation and Regional Development. The Case of the Visegrad Group Countries**

Summary: The article examines the competitiveness and innovativeness of 35 NUTS-2 Visegrad regions from 2001 to 2008, with a focus on the existence of clusters. The author undertakes to identify the most competitive and innovative clusters. She also looks at the impact of nationality and checks if high competitiveness was in each case accompanied by high innovativeness.

The author applies two classical methods of cluster analysis: the non-hierarchical k-means clustering algorithm and Ward's hierarchical method.

The results show that capital regions tend to develop faster and that there is a significant diversity of regional competitiveness and innovativeness across the Visegrad Group, which brings together four Central European countries, Poland, the Czech Republic, Hungary and Slovakia.

The main conclusion from the cluster analysis is that the development of regions in Visegrad Group countries depends on their "nationality" – regions tend to cluster within national borders, according to Golejewska. The analysis shows that this process intensified in 2008, so it is not a vestige of the previous system, the author says.

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The correlation analysis found that innovative inputs were transformed into innovative outputs and that innovations had a positive and growing impact on regional competitiveness across the Visegrad Group. However, further input-output analysis and econometric research are needed to confirm these findings, the author says.

Keywords: regional competitiveness, innovation, cluster analysis, Central and Eastern European countries

JEL classification codes: R11, C38, 033, P25

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Introduction

One of the most important determinants of national and regional competitiveness are innovations. Innovations treated as the process of building, development and exploitation of new ideas, methods and technologies influence competitiveness in two ways. Firstly, they change organizational structures, production methods and marketing strategies and in effect improve productivity. Secondly, they introduce new or remarkably improved products. Innovative economies are better able to adjust to the rapid changes in the global economy and best able to sustain their competitiveness. There are numerous analyses based on the production function of Cobb-Douglas which confirm positive effect of innovation on labour productivity and total factor productivity [Parisi et al., 2005], [Criscuolo, Haskel, 2003], [Gu, Tang, 2003]. The comprehensive empirical econometric framework on the relation between productivity and innovation presents [Vieira et al., 2010, pp. 7].

Innovation has a spatial distribution. Many researchers studied the spatial distribution and concentration of innovation tried to understand the mechanisms by which innovation occurs and spreads/concentrates. Although limited data available at regional level is an important obstacle to studying innovation geography. Inadequate theoretical models weaken the ability of analysts to construct empirical indicators, tests and analyses of innovation. To sum up, measurement of innovation on national, regional and local level requires precise concepts and definitions [Ratanawaraha, Polenske, 2007].

The objective of the analysis is to compare competitiveness and innovativeness of 35 NUTS-2 Visegrad regions in the years 2001 and 2008. The choice of the analysed countries results from their geographical proximity, similarity in socioeconomic changes, common interests and similar level of their development. However the group is not homogenous. There are still wide disparities between them caused among others by cultural factors, different systems of law and dissimilar spatial structures. The paper is organised as follows. The study starts from a comprehensive survey of the literature on regional competitiveness and the potential effects of innovation. The theoretical section is supplemented by empirical one (section 2) based on Eurostat Regional Statistics. The analysed period is the 4th stage of transformation process in

CEECs, characterised by visible uniformity in development paths. The author's intention was to compare the first and the last (available) year of the mention stage, but the lack of complete, actual and comparable regional data for the whole group of regions at the moment of preparing this article, caused the choice of analysed years.

Innovation and regional competitiveness

Competitiveness means different things to different authors [Budd, Hirmis, 2006]. According to Dunning [1998], competitiveness is "the way of discussing the relative performance of economies in a benchmarking sense. It can help identify areas of the economy that are lagging behind but not the reasons for those lags". Applying this definition, the most common measure of competitiveness is GDP *per capita*. For Porter [2000] "the only meaningful concept of competitiveness is productivity" and that "productivity is the prime determinant in the long run of a nation's standard of living. For it is the root cause of per capita income". Krugman [1996], states that "nations compete for world markets in the same way that corporations do" and "that a nation which fails to match other nations productivity or technology will face the same kind of crisis as a company that cannot match the costs or products of its rivals."

Conceptualizing regional competitiveness is rather hard task. It has been defined more poorly than micro- and macroeconomic competitiveness. Regional competitiveness, seems to be a concept that is "stuck in the middle" because it appears to be neither the simple aggregation of firms nor a weighted disaggregation of the national economy [Golejewska, 2012a]. In my opinion, one of the most comprehensive definitions of macroeconomic competitiveness, often quoted in the literature are the definition given by the President's Commission on Competitiveness [1984, pp. 2] and the European Commission [1999, pp. 4]. According to the first one a nation's competitiveness is "the degree to which it can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously expanding the real incomes of its citizens. Competitiveness at the national level is based on superior productivity performance and the economy's ability to shift output to high productivity activities which in turn can generate high levels of real wages. Competitiveness is associated with rising living standards, expanding employment opportunities, and the ability of a nation to maintain its international obligations. It is not just a measure of the nation's ability to sell abroad, and to maintain a trade equilibrium." According to the European Commission, competitiveness may be defined as "the ability to produce goods and services which meet the test of international markets, while at the same time maintaining high and sustainable levels of income or, more generally, the ability to generate, while being exposed to external competition, relatively high income and employment. At the microeconomic level, competitiveness means "the ability of firms to consistently and profitably produce products that meet the requirements of an open market in terms of price, quality, etc." [Martin, 2003].

There exist numerous definitions of place and territorial competitiveness, but there is still no accepted consensus on this topic [Steinle, 1992, Storper, 1997, Camagni, 2002, Kitson, Martin, Tyler, 2004, Krugman, 2003, Porter, 2000, 2001, 2003, Bristow, 2005, Martin, 2005]. European Commission [1999] emphasises that, though productivity is very important for regional competitiveness, the focus on it should not obscure the need of its transposition into higher wages and profits. An interesting definition of regional competitiveness presents Meyer-Stamer [2008, pp. 3]. The author defines (systemic) competitiveness of a territory as "the ability of a locality or region to generate high and rising incomes and improve livelihoods of the people living there." In contrast to the definition of the World Economic Forum [2002], which is focused on productivity, this definition stresses the benefits to people living in a region. According to the author, competitive regions are not only these which are productive. They should also be characterized by sustained or improved level of comparative prosperity. Dijkstra et al. [2011, pp. 3] integrate the perspective of both firms and residents. They define regional competitiveness as "the ability (of a region) to offer an attractive and sustainable environment for firms and residents to live and work". Krugman suggests that regional competitiveness has more to do with absolute advantage than with comparative advantage. If a region is more productive, it attracts labour and capital from other regions, which tends to consolidate its "absolute productivity lead". According to Krugman, the starting point of comparative regional analysis should be relative aggregated productivity measured as: GDP *per capita*, GDP per worker and labour market indicators. The relative changes of economic performance should in turn reveal dynamic competitive advantages of regions. However it is questionable if a region is highly productive because it is competitive or it is competitive because it is productive. In reality, regional competitiveness should be regarded as "an evolving complex self-reinforcing process, in which outputs themselves become inputs, and thus influence future outputs" [Krugman, 2003, pp. 17-20]. Implementing the assumptions of Krugman [2003], regional competitiveness of the Visegrad Group was measured using GDP *per capita* and labour market indicators: employment and unemployment rate.

The relativity of competitiveness causes the need of comparative regional analysis and search for the best practice [Golejewska, 2012b]. Consequently, the number of analysis and measures implemented for indicating "the winner" is still increasing. The main determinants of economic growth together with their main literature sources present Van Hemert and Nijkamp [2011, pp. 65-66]. Berger [2010] presents detailed survey of almost 50 analysis of regional competitiveness, where number of indicators ranges from 3 to 246. According to Tsounis [2007], factors influencing regional competitiveness can be divided into five groups:

1. cost factors (labour cost, cost of intermediates),
2. factors related to the neoclassical growth theory (investment, human capital, technology -exogenous variable),
3. factors related to new growth theories (technology -endogenous variable),

4. factors related to economic geography and the new international trade theories (urbanization, agglomeration effects, economies of scale) and
5. factors related to knowledge (number of researchers, infrastructure for Research and Development (R&D), R&D expenditure, patents, innovation activity)[1].

Nowadays, regional competitiveness depends more on the level of creativity and creation, circulation and absorption of knowledge. In the long run, improved institutions, human capital, proper infrastructure or efficient financial and goods markets can't assure an enhancement of standards of living. Technological innovation is the only one determinant which can manage it. Unfortunately, there is no single theory that explains the impact of innovation on regional growth [Golejewska, 2012c]. In the endogenous growth theory, the key determinant of productivity advance and local economic growth is the accumulation of skilled human capital (via its effect on technological progress). Well educated and skilled employees promote knowledge creation and spillovers, and as result-innovation. According to the neo-Schumpeterian theory the crucial factors of regional competitiveness are: innovation, technological advance and entrepreneurship. The theory argues that the local innovation can be stimulated by two opposite processes: local economic specialisation (through rivalry between similar and competing firms), or local economic diversity (through the greater scope for novelty and market opportunities). In cluster theories, clustering stimulates inter-firm rivalry and knowledge spillovers, innovation, investment, and a local pool of specialised skilled labour, all of which increase local productivity [Martin, 2005, pp. 17]. Innovation is especially important for those economies/regions which approach the frontiers of knowledge and have no more possibility of adapting exogenous technologies [WEF 2010, pp. 8].

To understand the meaning of innovation we must specify its definition and measures. The first approaches defined innovations as great leaps of knowledge accomplished by talented individuals or research groups. They were perceived as a linear processes from the research to the market applications. The theories of innovation initiated important changes. Innovations were no more seen only as technological but also as social and organisational changes. Consequently, they are created not only in a laboratory but also, and maybe first of all, in networks "where actors of different backgrounds are involved in the process". The most important determinant of innovation is no more the science push effect but the ability to learn collectively and build solid relationships between the partners participated in the process of innovation.

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[1] According to other authors, there are two contrasting bodies of theory which explain the processes of regional economic change: endogenous growth theory, drawn essentially from economics; and the "new regionalism" that focuses on institutions, the agency of individuals, and social regulation connected with such notions as: learning regions, innovative milieu, regional innovation systems, knowledge economies, and the "creative class" [Rainnie, Grobbelaar, 2005]. New regionalist suggest that economic growth depends not only on market conditions, but also on repeated inter-firm interaction and knowledge exchange, the creation of social capital and local institutional thickness.

First measures of innovativeness, developed in the 1950s and 1960s, included R&D expenditures and other inputs of the innovation activities of the firms. Next measures contained outputs, especially patent data. Significant contribution to the development of measures of innovations had the work of Pavitt [Pavitt et al., 1987]. Generally, the measures of innovativeness can be divided into two groups: output-type and input-type measures[2]. The first group of measures is connected to the results of successful utilisation of innovation capability in firms and organisations, the second is related to the ways, in which innovation process is supported and resourced by firms and institutions. The most common output-type (intermediate) measures are patents and licences. Although they have some shortcomings, namely they do not measure the economic value of the developed technologies [Hall et al., 2001]. The output-type measures are also problematic because of the fact that they usually apply only to certain types of innovations and firms, ignoring small enterprises and service firms [Romijn, Albaladejo, 2002, pp. 3-4]. Input-type measures such as R&D expenditures, R&D personnel or resources on training and education are also a subject of criticism. Firstly, input measures like R&D expenditures measure only the budgeted resources assigned to innovation activities [Acs et al., 2002, pp. 1070]. Secondly, they also underrate less significant innovation activities and innovations of less R&D intensive sectors. Thirdly, it is controversial whether they measure “real” innovativeness, or maybe rather some internal and external support activities of innovation processes [Romijn, Albaladejo, 2002, pp. 4]. Both measures neglect the aspect of the dynamics of the innovation processes. While the resources involved in the process of innovation, as well as its results, are broadly considered, the factors between them are still largely unstudied [Tura, Harmaakorpi, 2005, pp. 8-9]. Despite awareness of their shortcomings, both measures are widely applied in empirical studies [Markowska, Strahl, 2007]. In the paper, I followed the approach of Regional Innovation Scoreboard [Hollanders et al., 2009], in which input-type and output-type measures are used simultaneously.

Empirical analysis

In terms of economy, there have been both similarities and wide disparities between the Visegrad Countries. Similarities result from socialist economy, which form their economic and social systems for several decades. Differences are caused among others by cultural factors, different systems of law and

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[2] Sirilli [1998] and Godin [2002a, 2000b] categorize innovation data into three groups, representing the traditional concept of the innovation production process: namely, innovative inputs, innovative outputs, and innovative agents. Ratanawaraha and Polenske [2007] present data used in measuring spatial dispersion of innovation adding a fourth group: innovative networks (patent citations, knowledge sourcing, technological overlap and interfirm co-operation).

dissimilar spatial structures. Generally, the transformation process in CEE countries can be divided into four periods [Gorzelak, Smętkowski, 2010]:

1. the years 1989-1991: initiation of transformation followed by an economic crisis (as a result),
2. the years 1991-1994: overcoming of the crisis and return to a development path,
3. the years 1995-1998: when some countries suffered further crises, which resulted in disparities in development paths,
4. the period after 1999: visible uniformity in development paths (except Baltic States, whose economies experienced the greatest changes, due to the highest degree of liberalization).

Transformation and regional development are closely related. Changes in regional economic structure depend to a considerable extent on structural changes in the whole economy. There are some similarities in the regional development of CEE countries. To these belong:

– an increase in regional disparities in the level of income, investment and employment,
– fastest development rate of capital city regions and other big agglomerations, due to reasons such as the emergence of new companies, development of the service sector and concentration of FDIs, with relatively lesser differences in the development levels between other regions of individual countries,
– positive influence of location at the border with EU countries, and negative of location at the eastern (external) border of the EU,
– weak position of old industrial regions as a result of the restructuring process, which involved privatisation and employment downsizing [Gorzelak, Smętkowski, 2010].

The group of analysed regions consist of 16 Polish, 8 Czech, 7 Hungarian and 4 Slovak regions. Table 1 presents area, population density, GDP per capita and its growth rate in the NUTS-2 regions. Between 2001 and 2008 the dispersion of regional GDP at NUTS level 2 rose in all the countries of the Visegrad Group (see graph 1). An inverse tendency was observed in the European Union. Despite its growth, the coefficient of dispersion in Poland still remains lower than the EU average. The highest regional diversity characterizes Hungary (more than 38 per cent in 2008).

Table 1

NUTS 2 regions in the Visegrad Group countries

Country	NUTS2 region	Area (square kilometre), 2008	Population density 2008	GDP *per capita* 2008 (PPS)	GDP *per capita* growth rate 2001-2008 (average)*
The Czech Republic					
	Praha	496,0	2 519,4	43 200	0,058
	Strední Cechy	11 014,8	112,5	18 600	0,052
	Jihozápad	17 618	70,3	17 100	0,041
	Severozápad	8 649	134,7	15 600	0,050
	Severovýchod	12 440,1	122,6	16 200	0,039
	Jihovýchod	13 991,3	120,9	18 400	0,053
	Strední Morava	9 230,4	135,2	16 100	0,052
	Moravskoslezsko	5 427	235,3	17 400	0,068
Hungary					
	Közép-Magyarország	6 915,8	421,0	26 800	0,053
	Közép-Dunántúl	11 116	99,3	14 500	0,041
	Nyugat-Dunántúl	11 328,4	88,1	15 700	0,036
	Dél-Dunántúl	14 168,7	67,5	11 100	0,036
	Észak-Magyarország	13 432,8	91,6	10 000	0,041
	Észak-Alföld	17 728,8	85,1	10 000	0,035
	Dél-Alföld	18 337,2	72,5	10 800	0,038
Poland					
	Łódzkie	18 219	140,1	13 100	0,062
	Mazowieckie	35 559	146,1	22 200	0,059
	Małopolskie	15 190	216,1	12 200	0,062
	Śląskie	12 331	377,1	15 200	0,058
	Lubelskie	25 121	86,1	9 800	0,054
	Podkarpackie	17 844	117,6	9 700	0,055
	Świętokrzyskie	11 708	108,8	11 300	0,064
	Podlaskie	20 187	59,1	10 300	0,049
	Wielkopolskie	29 826	113,7	14 700	0,055
	Zachodniopomorskie	22 896	73,9	12 800	0,044
	Lubuskie	13 989	72,1	12 100	0,054
	Dolnośląskie	19 948	144,3	15 200	0,067
	Opolskie	9 412	110,0	12 000	0,063
	Kujawsko-Pomorskie	17 970	115,0	12 200	0,050
	Warmińsko-Mazurskie	24 192	59,0	10 500	0,056
	Pomorskie	18 293	121,1	13 400	0,054

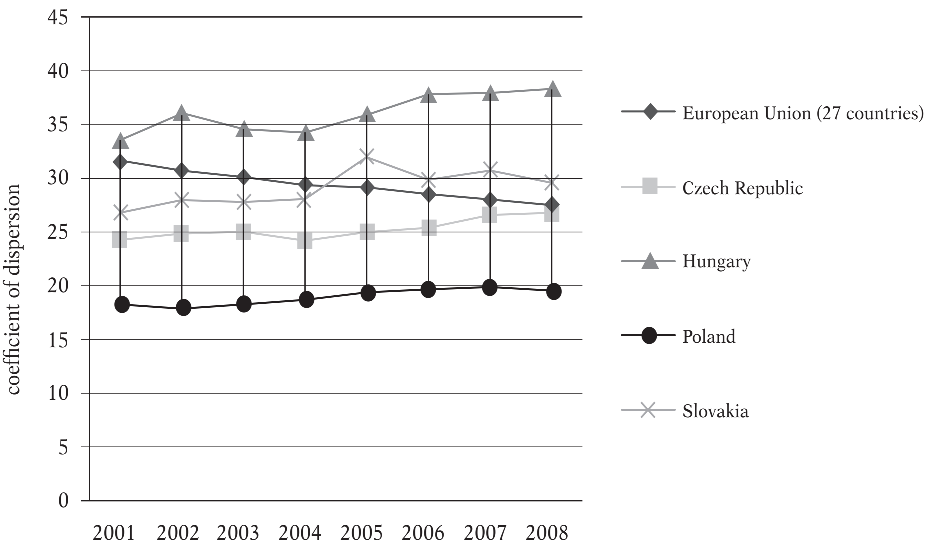
Country	NUTS2 region	Area (square kilometre), 2008	Population density 2008	GDP *per capita* 2008 (PPS)	GDP *per capita* growth rate 2001-2008 (average)*
Slovakia					
	Bratislavský kraj	2 053	298,9	41 800	0,086
	Západné Slovensko	14 993	124,4	17 400	0,085
	Stredné Slovensko	16 263	83,0	14 800	0,076
	Východné Slovensko	15 726	100,3	12 700	0,068

* average growth rate calculated as ln(Yn/Yo)/n

Source: Eurostat Regional Statistics, own calculations

Graph 1

Dispersion of regional GDP*, NUTS-2 level, 2001-2008



* The dispersion of regional GDP is measured by the sum of the absolute differences between regional and national GDP per inhabitant, weighted with regional share of population and expressed in per cent of the national GDP per inhabitant.

Source: Eurostat Regional Statistics, own calculations

Interpreting regional diversity we should consider territorial division of a country [Golejewska, 2012b]. Division into small and few regions causes higher concentration. This explains the smallest dispersion of regional GDP at NUTS 2 in Poland. A very important factor of regional diversity is a delimitation of capital region, especially when capital region dominates economically in a country, where the number of regions is not numerous. An extreme example is Slovakia, where the contrast between the capital region and the rest of the country is exceptionally big. The predominance of Praha is also visible, but because of higher level of development of the country, it is not as big as in case of Bratislava in Slovakia. The predominance of Mazowieckie in Poland is definitely the smallest. The analysis of dispersion of GDP *per capita* between the first and the second region and the second and the last region of each of the countries analysed shows that regional diversity, in case of exclusion of capital region, is not big. In the Visegrad Group, similarly to the rest of the EU countries, there is no relationship between the level of regional diversity and economic development of a country [Domański et al., 2003].

Results of cluster analysis

The objective of cluster analysis is to compare competitiveness and innovativeness of 35 NUTS-2 Visegrad regions in the years 2001 and 2008 and verify existence of clusters. I try to find the most competitive and the most innovative clusters, test the impact of nationality and verify, if in every case high competitiveness must be accompanied by high innovativeness. The group of analysed regions consist of 16 Polish, 8 Czech, 7 Hungarian and 4 Slovak regions. I applied two classical methods of cluster analysis [Golejewska, 2012b]. The results of non-hierarchical k-means clustering algorithm were compared with the results of hierarchical Ward's method. I applied two methods of cluster analysis, which is reasonable from statistical point of view. The results of non-hierarchical k-means clustering algorithm were compared with the results of hierarchical Ward's method. Application of two methods was caused by methodological differences between them. The Ward's method is effective in building homogenous clusters with the lowest inter-group variance [Grabiński, 2003, pp. 110]. Its characteristic is creation of clusters with similar numerical amount [Balicki, 2009, pp. 278]. The advantage of the k-means algorithm is that it produces the exact k different clusters of greatest possible distinction [Strahl, 1998, pp. 81]. Application of two methods enabled the comparison (and confirmation) of results and explanation of differences. The analysis comprises two groups of indicators. The first group consist of indicators describing competitiveness. To these belong: GDP *per capita* (PPS), employment- and unemployment rate (among 15 years or over). The second group is composed of four measures of innovativeness: patent applications to the EPO per million labour force, R&D expenditure as percentage of GDP, R&D personnel as percentage of total employment – (in full time equivalents) and core Human Resources in Science and Technology as percentage of active population. According to the definition, HR in S&T are people who fulfil one or other of the following conditions:

a) successfully completed education at the third level in an S&T field of study;
b) not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required.

HR described as core are qualified and employed in S&T [OECD, 1995].

The analysed variables and their descriptive statistics presents table 2.

Table 2

Descriptive statistics of the analysed variables

Variables	n	Mean	Median	Min.	Max.	Lower quartile	Upper quartile	Standard deviation	Coefficient of variation
	2001								
GDP per capita, PPS	35	10 688,57	9 400,00	6 600,00	28 700,00	7 900,00	12 200,00	4 594,29	42,98
Employment rate	35	48,42	47,90	40,70	60,00	43,90	51,70	5,31	10,96
Unemployment rate	35	13,77	14,60	3,90	24,30	7,80	19,70	6,78	49,24
Patents per million labour force*	35	8,27	4,02	0,33	68,30	2,02	12,86	12,23	147,80
R&D expenditure, percentage of GDP	35	0,65	0,50	0,10	3,00	0,34	0,78	0,55	84,76
R&D personnel, percentage of employment	35	0,51	0,39	0,05	2,29	0,29	0,54	0,46	91,14
HR (core), percentage of active population	35	9,05	8,10	5,10	20,10	7,10	9,90	3,20	35,41
	2008								
GDP per capita, PPS	35	15 854,29	14 500,00	9 700,00	43 200,00	11 300,00	17 100,00	7 605,78	47,97
Employment rate	35	50,87	50,40	40,10	62,90	48,10	54,60	5,06	9,94
Unemployment rate	35	7,11	6,50	1,90	13,40	4,90	8,80	2,94	41,26
Patents per million labour force	35	19,40	12,07	2,40	77,81	9,04	22,30	16,52	85,14
R&D expenditure, percentage of GDP	35	0,68	0,52	0,10	2,47	0,27	0,94	0,56	81,73
R&D personnel, percentage of employment	35	0,60	0,42	0,15	3,24	0,31	0,62	0,62	103,01
HR (core), percentage of active population	35	13,25	12,40	5,50	24,80	10,10	14,60	4,08	30,80

* the value for the year 2001 is estimated as the mean value for the period 1999-2001, for the year 2008: as the mean value for the period 2006-2008

Source: Eurostat Regional Statistics, own calculations

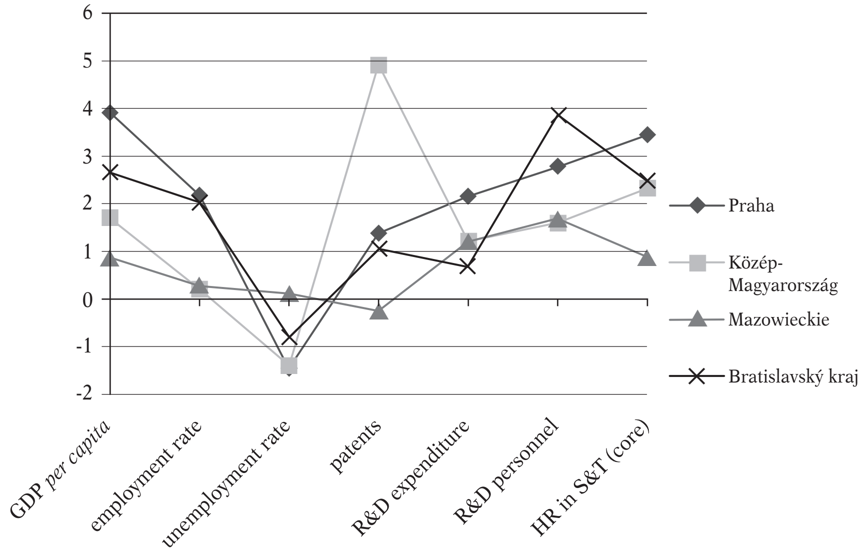
The results of mean and median analysis show, that in the whole group of regions there are some units, which raise the average values of the variables (with the exception of unemployment rate). In 2001 the most numerous group form regions, where GDP *per capita* was lower than 10 000 PPS (21 regions). The employment rate above 50 per cent was recorded hardly in 11 regions, whereas the unemployment rate above 14 per cent – in 19 regions. The highest variation characterizes patent applications. In 25 regions their number didn't exceed 10 per million labour force. Only in 5 regions the R&D expenditure exceeded 1 per cent (capital regions and Strední Cechy). The HR indicator was characterized by the lowest variation among innovativeness indicators. In 2008, in comparison to 2001, all the mean values of the analysed variables improved. The most numerous group form regions, in which GDP *per capita* didn't exceed 15 000 PPS (20 regions). In 19 regions the employment rate was higher than 50 per cent and in 20 regions the unemployment rate was lower than 7 per cent. In merely 12 regions the number of patent applications was over 20 per million of labour force and in 4 regions it exceeded 40 (capital regions of Hungary, Czech Republic and Slovakia and Stredni Cechy). More than 1 per cent of GDP was assigned for R&D activity in 8 regions: capital regions of Poland, Czech Republic and Hungary, 4 Czech regions: Stredni Cechy, Jihozapad, Severovychod and Jihovychod and one Hungarian region: Észak-Alföld. In 23 regions the share of R&D personnel in total employment was lower than 0.5 per cent. The highest share was recorded in Praha (3.2 per cent), Bratislavský kraj (2.3 per cent) and Közép-Magyarország (1.4 per cent). Only in 4 capital regions the share of core HR in active population amounted to over 20 per cent.

Because of visible differences between four capital regions and the rest of the analysed regions, I decided to eliminate "the outliers". However the group of them is not homogenous. The leader in competitiveness is the region of Praha with GDP per capita at 43 200 PPS, unemployment rate at 60 per cent and unemployment rate at 2 per cent. In 2008 the most similar to the capital region of the Czech Republic was Bratislavský kraj. Mazowieckie was closer to Strední Cechy than to the rest of the capital regions. The variables in the group of "the outliers" present graphs 1 and 2. There is also a big diversity in innovativeness between these regions. The highest number of patent applications, both at the beginning and the end of the analysed period was in the capital region of Hungary. In case of the rest of the measures the leader remains the region of Praha. Mazowieckie was characterized by the lowest innovativeness[3].

[3] The author also decided to abandon more detailed comparison of capital regions because of their significant territorial differentiation. Czech capital region is only a city, Slovak capital region is a city with suburban zone, Hungarian capital region is metropolitan region and Polish capital region is metropolitan macro-region as big as a half of territory of whole Slovakia. Such territorial differentiation strongly influences results: region Strední Cechy is the best, because this region contains Prague vicinity, but Warsaw seems to be the weakest because of large agricultural areas incorporated to this administrative unit.

Graph 2

Capital regions in 2001*

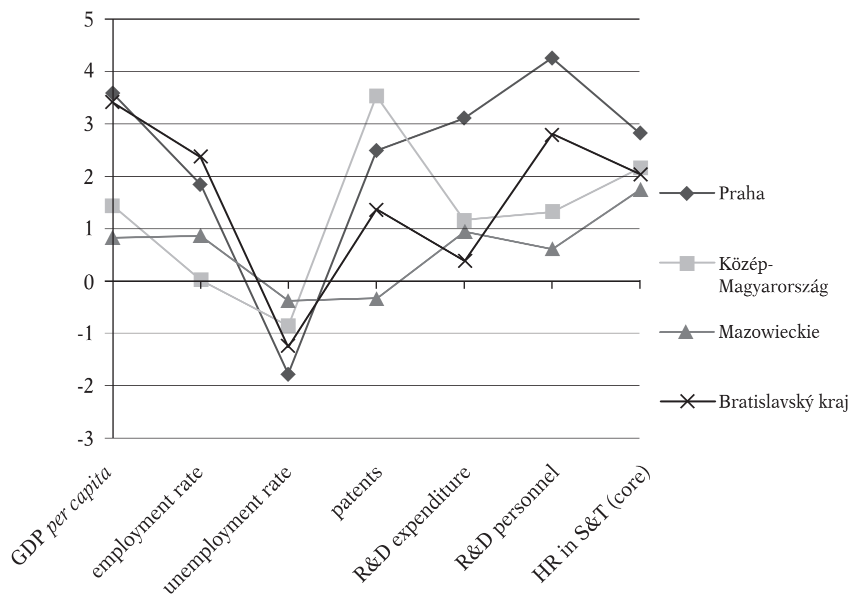


* standardised variables

Source: Eurostat Regional Statistics, own calculations

Graph 3

Capital regions in 2008*



* standardised variables

Source: Eurostat Regional Statistics, own calculations

Correlation matrix of the variables used in the cluster analysis for the year 2001 and 2008 present tables 3 and 4. In 2001 the strongest positive correlation show GDP *per capita* with employment rate and the strongest negative correlation – unemployment rate with patent applications. According to the latter result, one can suppose – according to research assumption-, that innovations had positive impact on employment and thereby regional competitiveness. In 2008 the strongest and positive correlation was found between R&D expenditure and patent applications, patent applications and R&D personnel, R&D expenditure and R&D personnel. This can indicate, that higher levels of R&D expenditures lead to more R&D personnel and to more patented (practical) innovations. They also confirm that the more R&D personnel the more innovations. Thereby, the result suggest that innovative inputs were transformed in innovative outputs. The correlation between GDP *per capita* and innovativeness variables, except for R&D expenditure, rose in the analysed period. This can mean, that the positive impact of innovations on competitiveness increased in 2001-2008. Surprising is the negative, though low, correlation between GDP *per capita* and HR in S&T**.** In 2008, the results of the analysis confirmed negative correlation between HR in S&T and the rest of the variables, with the exception of unemployment rate (very low positive correlation). This may be caused, on the one hand by overeducation, which does not transform into productivity growth and innovativeness [McGuinness, 2006], and on the other hand by the broad definition of HR in S&T implemented by OECD, according to which S&T includes many fields of studies, which are often not the main subject of R&D interest. However to confirm the assumptions resulted from correlation analysis, further econometric research is still needed.

Table 3

Correlation matrix for the analysed variables, 2001

Variable	2001						
	GDP *per capita*	Employment rate	Unemployment rate	Patents	R&D expenditure	R&D personnel	HR in S&T (core)
GDP *per capita*	*1,000*	0,692	-0,527	0,401	0,510	0,228	-0,109
Employment rate	0,692	*1,000*	-0,548	0,283	0,515	0,138	-0,240
Unemployment rate	-0,527	-0,548	*1,000*	-0,636	-0,384	0,014	-0,176
Patents	0,401	0,283	-0,636	*1,000*	0,282	0,082	0,111
R&D expenditure	0,510	0,515	-0,384	0,282	*1,000*	0,473	-0,048
R&D personnel	0,228	0,138	0,014	0,082	0,473	*1,000*	0,291
HR in S&T (core)	-0,109	-0,240	-0,176	0,111	-0,048	0,291	*1,000*

Source: Eurostat Regional Statistics, own calculations

Table 4

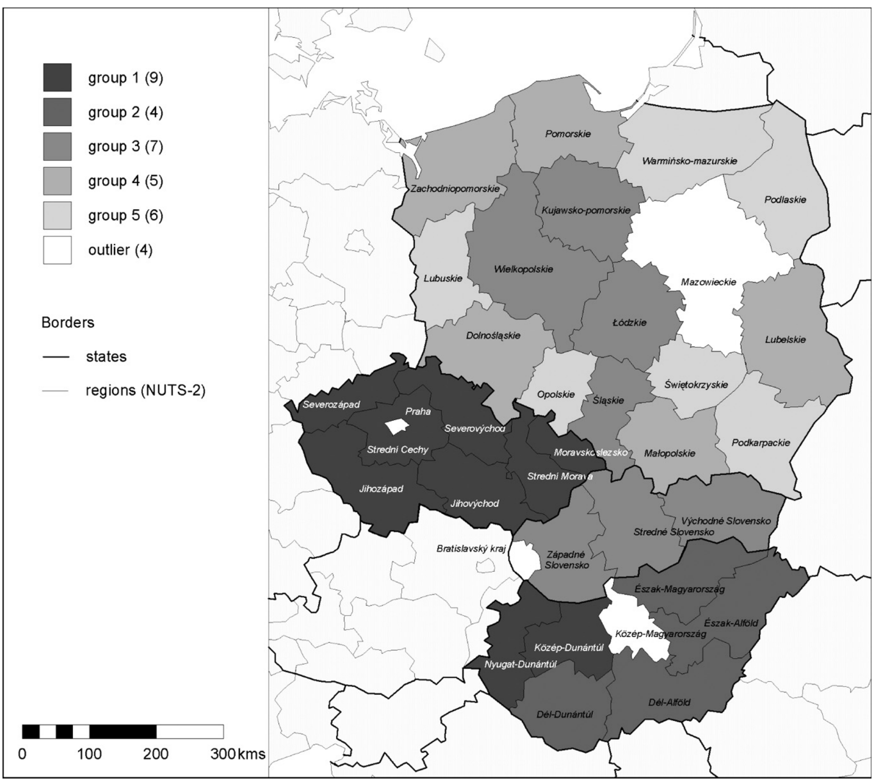
Correlation matrix for the analysed variables, 2008

Variable	2001						
	GDP *per capita*	Employment rate	Unemployment rate	Patents	R&D expenditure	R&D personnel	HR in S&T (core)
GDP *per capita*	*1,000*	0,740	-0,582	0,442	0,507	0,633	-0,482
Employment rate	0,740	*1,000*	-0,710	0,206	0,431	0,450	-0,424
Unemployment rate	-0,582	-0,710	*1,000*	-0,381	-0,500	-0,475	0,030
Patents	0,442	0,206	-0,381	*1,000*	0,826	0,810	-0,318
R&D expenditure	0,507	0,431	-0,500	0,826	*1,000*	0,804	-0,269
R&D personnel	0,633	0,450	-0,475	0,810	0,804	*1,000*	-0,158
HR in S&T (core)	-0,482	-0,424	0,030	-0,318	-0,269	-0,158	*1,000*

Source: Eurostat Regional Statistics, own calculations

Map 1

Results of cluster analysis, 2001

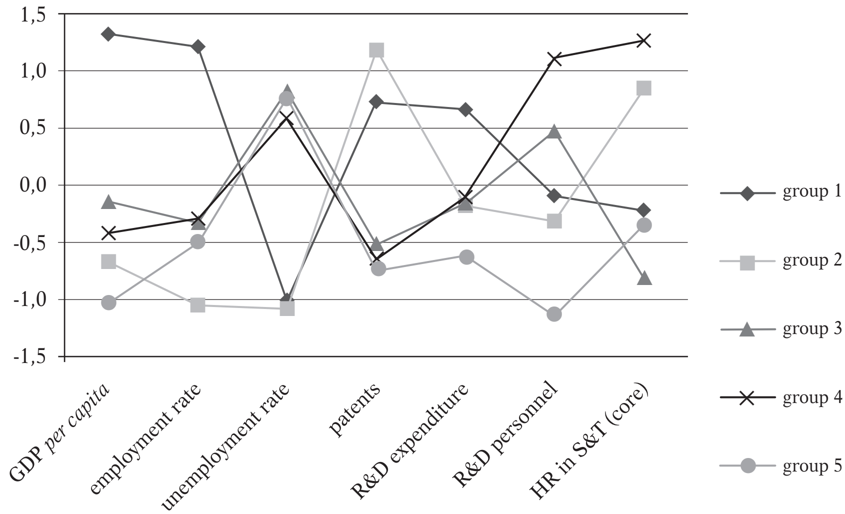


Source: Eurostat Regional Statistics, own calculations

The structure of set of objects is known, so the first method applied in cluster analysis was k-means clustering algorithm. As a result, in 2001, 31 regions of Visegrad Group were divided into 5 groups. Map 1 presents composition of the groups. The most numerous group 1 consist of 9, mainly Czech regions. The most homogenous is group 2 composed of 4 Hungarian regions. Group 3 consist of 7 regions: all the Slovak regions and four Polish regions: Wielkopolskie, Śląskie, Kujawsko-Pomorskie i Łódzkie. Two last groups form Polish regions. The differences among groups can be analysed using mean values of the standardised variables (see graph 4).

Graph 4

Mean values of variables by groups of regions, 2001



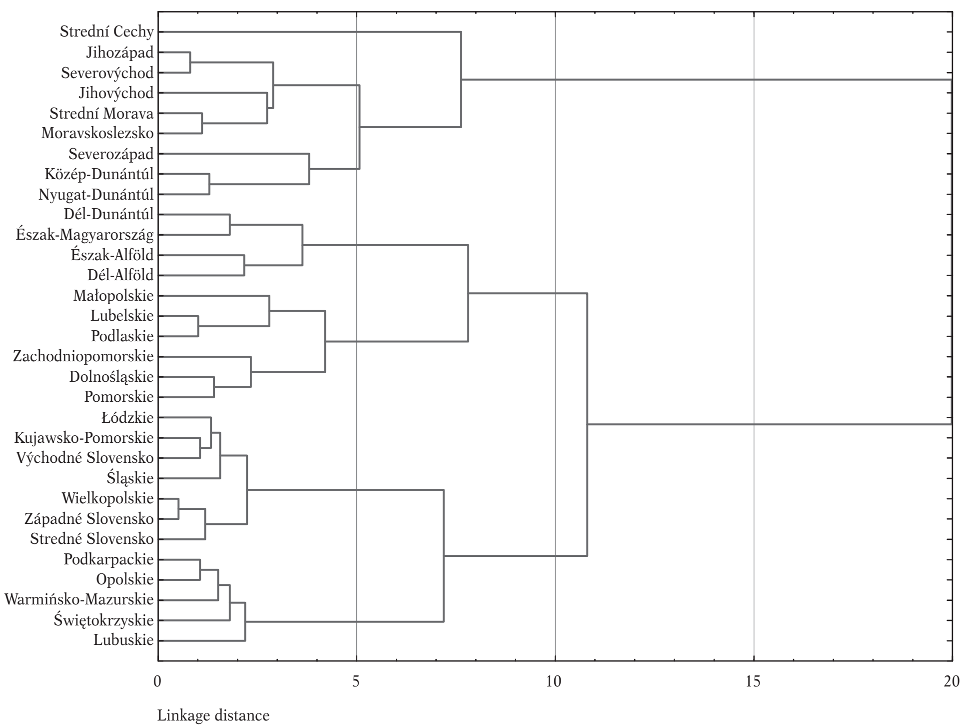
Source: Eurostat Regional Statistics, own calculations

The first group is characterised by the highest GDP *per capita*, good situation on the labour market, high R&D expenditure and patent applications and medium level of R&D personnel and HR. The second group contains low competitive but medium-innovative regions. Characteristic for groups 3, 4 and 5 is disadvantageous situation on the labour market and low number of patent applications, and in case of group 3 and 4 also medium R&D expenditure. In case of the other innovativeness variables there is a big diversity among these three groups. The lowest GDP *per capita* and innovativeness indicators have Polish regions belonging to the last group. The most innovative among them is group 4, composed of 5 Polish regions, characterised by medium level of GDP *per capita*.

The second method applied in cluster analysis was agglomeration. I carried out a hierarchical cluster analysis using Ward's method applying Euclidean Distance [Balicki, 2009, pp. 215]. This method is distinct from other methods because it uses an analysis of variance to evaluate the distances between clusters. On the basis of dendrogram we can see similarities among regions of the Visegrad Group. The results of agglomeration are similar to result received by k-means algorithm. Also in this case regions were divided into 5 groups. Group 1, 2 and 3 remained unchanged in comparison to the results of k-means method. Group 1 is internally differentiated. Region Strední Cechy visibly stands out with respect to economic development. One of the explanations could be the fact, that region Sredni Cechy contains Prague vicinity. The least differentiated are groups 5 and 3. The only changes were observed in the composition of 2 Polish groups. Podlaskie left the fifth group for the benefit of the forth one. In case of this region came out disadvantage of Ward's method (sometimes regarded as advantage), namely tendency to build groups of equal number of objects [Pielou, 1984]. Podlaskie is between two groups, but because the forth group is less numerous, it was added to this group. Finally the composition of groups corresponds with the results of k-means method. The dendrogram shows also that in case of building three clusters, group 3 would join group 5 and group 2 would be attached to group 4.

Graph 5

Dendrogram, Ward's method applying Euclidean Distance, 2001



Source: Eurostat Regional Statistics, own calculations

The results of cluster analysis for the year 2008, carried out similarly using firstly k-means clustering algorithm, presents table 5. The results show that composition of clusters is similar to composition of countries. The most homogenous is the second group composed of Hungarian regions. The most numerous is group 4, which contains almost exclusively Polish regions. Group 3 is dominated by Slovak regions, and group 4 by Czech regions. As in 2001 region Strední Cechy is an "outlier" in group 1. One of the main disadvantages of k-means method is low level of resistance to outliers. This method also tends to build clusters of different number of objects [Anderberg, 1973]. Precise analysis demands applying the second method – hierarchical cluster analysis. Similarly to the year 2001, I used Ward's method applying Euclidean Distance. The results presents graph 6. They are similar to the results obtained by using k-means method. 31 regions were divided into 4 groups, however only 2 of them – group 1 and 2 – remained unchanged in comparison to results of k-means method. As in 2001, the first group is internally differentiated. The second one is characterised by visible similarity of analysed variables. Group 4 was reduced to 14 Polish regions, which, according to the dendrogram can be divided into 2 groups of better (4a) and worse (4b) performed regions. The composition of group 3 has changed. The group consisting of 6 regions joined Közép-Dunántúl and Wielkopolskie. These 2 regions are actually between groups 3 and 4a, and in some aspects like indicators of labour market, R&D expenditures and R&D personnel even closer to group 4a. Differences between finally received groups presents graph 7.

Table 5

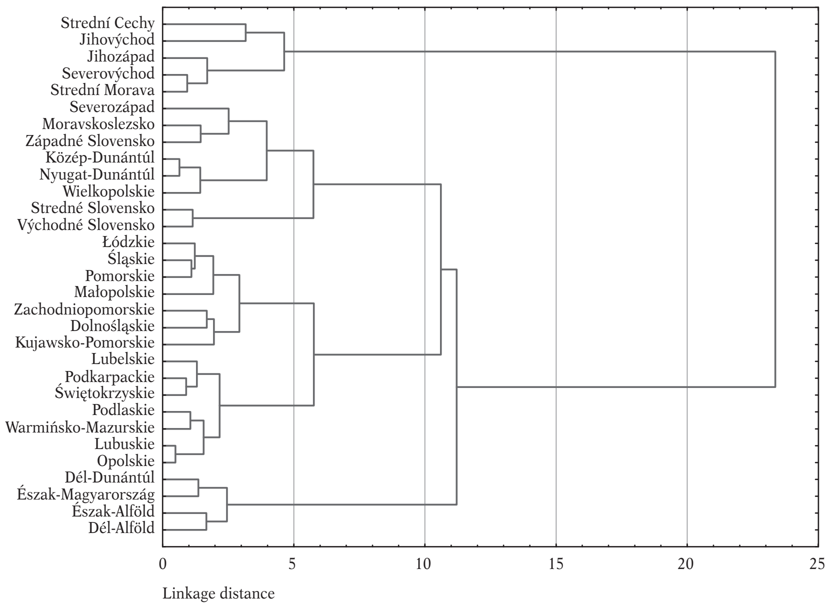
Results of cluster analysis, k-means algorithm, 2008

Group 1	Group 2	Group 3	Group 4
Strední Cechy Jihozápad Severovýchod Jihovýchod Strední Morava	Dél-Dunántúl Észak-Magyarország Észak-Alföld Dél-Alföld	Severozápad Moravskoslezsko Nyugat-Dunántúl Západné Slovensko Stredné Slovensko Východné Slovensko	Közép-Dunántúl Łódzkie Małopolskie Śląskie Lubelskie Podkarpackie Świętokrzyskie Podlaskie Wielkopolskie Zachodniopomorskie Lubuskie Dolnośląskie Opolskie Kujawsko-Pomorskie Warmińsko-Mazurskie Pomorskie

Source: Eurostat Regional Statistics, own calculations

G r a p h 6

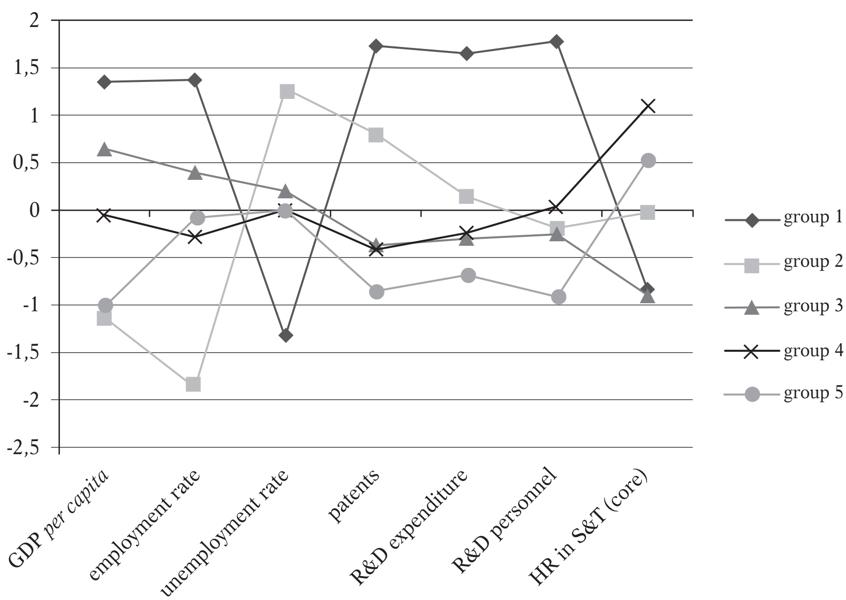
Dendrogram, Ward's method applying Euclidean Distance, 2008



Source: Eurostat Regional Statistics, own calculations

G r a p h 7

Mean values of variables by groups of regions

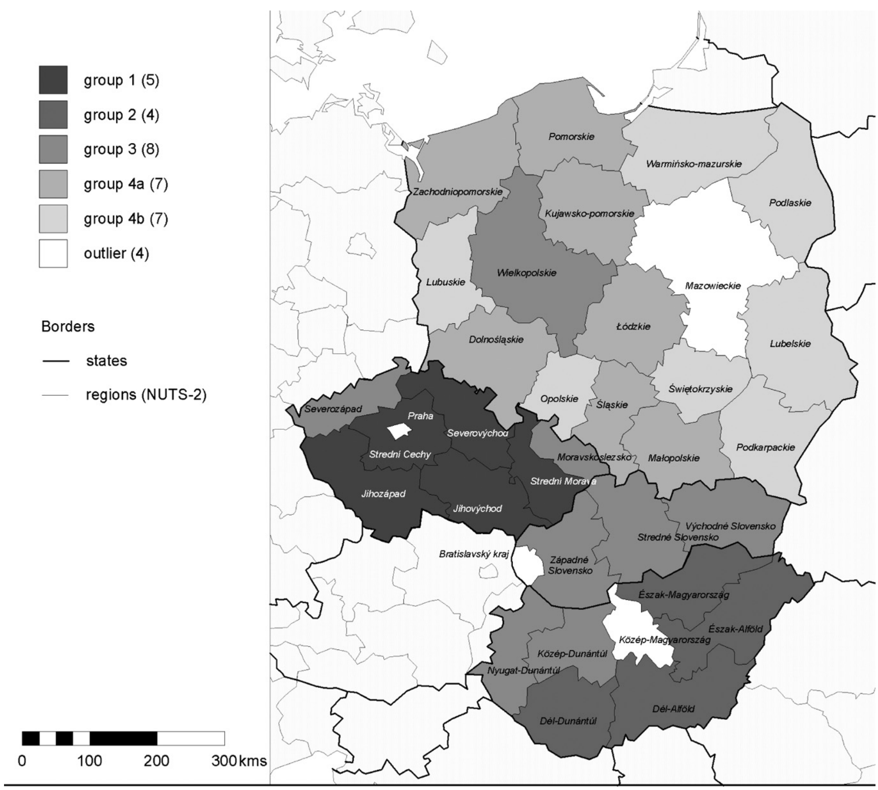


Source: Eurostat Regional Statistics, own calculations

According to the graph, the first group reached the highest GDP *per capita*, the best indicators of labour market and the highest innovativeness among analysed regions. The least competitive group consist of 4 Hungarian regions, which recorded the lowest GDP *per capita*, the worst situation on the market and, surprisingly, medium-high level of innovativeness. The third group is characterised on the one side by high GDP *per capita*, on the other side by high – in comparison to the other groups – unemployment rate. This group is composed of regions with the level of innovativeness similar to the Polish better performed group 4a. Polish regions have similar situation on their labour markets, but diverse level of innovativeness. Group 4b composed mainly of the poorest eastern regions is characterised by very low (similar to the second group) standard of living and the lowest innovativeness. The final composition of groups in 2008 presents map 2.

Map 2

Results of cluster analysis, 2008



Source: Eurostat Regional Statistics, own calculations

Table 6

Changes in the composition of groups, 2001-2008

2001	2008
group 1	group 1
Nyugat-Dunántúl, Közép-Dunántúl Severozápad Moravskoslezsko Strední Morava Jihovýchod Severovýchod Jihozápad Strední Cechy	Strední Cechy Jihozápad Severovýchod Jihovýchod Strední Morava
group 2	group 2
Dél-Alföld Észak-Alföld Észak-Magyarország Dél-Dunántúl	Dél-Dunántúl Észak-Magyarország Észak-Alföld Dél-Alföld
group 3	group 3
Stredné Slovensko Západné Slovensko Wielkopolskie Śląskie Východné Slovensko Kujawsko-Pomorskie Łódzkie	Severozápad Moravskoslezsko Nyugat-Dunántúl Západné Slovensko Stredné Slovensko Východné Slovensko Wielkopolskie Közép-Dunántúl
group 4	group 4a
Pomorskie Dolnośląskie Zachodniopomorskie Lubelskie Małopolskie	Łódzkie Pomorskie Śląskie Małopolskie Zachodniopomorskie Dolnośląskie Kujawsko-Pomorskie
group 5	group 4b
Podlaskie Warmińsko-Mazurskie Lubuskie Świętokrzyskie Opolskie Podkarpackie	Lubelskie Podkarpackie Świętokrzyskie Podlaskie Lubuskie Opolskie Warmińsko-Mazurskie

Source: Eurostat Regional Statistics, own calculations

Results of changes in the composition of groups in the analysed period are presented in table 6. The leaders group left two Hungarian (Nyugat-Dunántúl and Közép-Dunántúl) and two Czech regions (Severozápad i Moravskoslezsko). They joined group 3, which is characterised by medium level of competitiveness and medium-low innovativeness. In case of two Hungarian regions, responsible for the changes was labour market deterioration, in Czech regions-stagnation, or as in Moravskoslezsko-reduction of R&D expenditures. Next changes concerned Polish regions. As a result of growth in living standards and improvement in labour markets conditions (unemployment rates declines), Śląskie, Kujawsko-Pomorskie and Łódzkie joined the group of better performed Polish regions. However they recorded declines in R&D expenditures and the share of R&D personnel in total employment (in case of the latter with the exception of Kujawsko-Pomorskie). The last change concerned Lubelskie, which was attached to the group of the worse performed regions. In 2008 Lubelskie had the second lowest GDP *per capita* and one of the highest unemployment rate (8.8 per cent).

Summary

The results of the analysis confirm the results of the work of other authors concerning particularly Polish regions [Gorzelak et al., 2006], [Domański et al., 2009], [Gorzelak et al., 2010], [Tucholska, 2010], [Smętkowski, Wójcik, 2009]. In the Visegrad Group, there have been and continue to be substantial differences among the regions as regards competitiveness and innovativeness. The differences are particularly visible in case of capital regions, which in this case were not subjects of detailed comparison because of their significant territorial differentiation. They were also treated as outliers in cluster analysis. According to the results of the correlation analysis, one can suppose that, especially at the end of the analysed period, innovative inputs were transformed in innovative outputs and that innovations had a positive and growing impact on regional competitiveness in the Visegrad Group. Questionable is the impact of HR in S&T on the rest of the variables, which can result from the overeducation phenomenon observed in the Visegrad countries (particularly in Poland), however further research is still needed.

The major conclusion of the cluster analysis is that the development of regions in the Visegrad Group depends on their nationality. Regions cluster within borders, which is a quite interesting conclusion. Additionally, the results confirmed that this process intensified in 2008. In 2001 the groups were more mixed with respect to nationality, so it is not a vestige of the previous system. There was a split in the group of the best developed regions. Stredni Cechy remains the leader with a considerable advantage in innovativeness, particularly in R&D expenditures. One of the explanations could be the fact, that region Sredni Cechy contains Prague vicinity. The Hungarian group differs remarkably from the other regions, because it presents a rare combination of low competitiveness and medium-high innovativeness. The only one mixed group remains the third group composed of 3 Slovak, 2 Hungarian, 1 Polish (Wielkopolskie) and 2 Czech regions. In case of 14 Polish regions, the results of cluster analysis carried out for the year 2008 are similar to those obtained for the year 2001. This suggests that they have underwent similar changes.

Analysing the results, one should not forget that they are based on seven selected variables, which are a resultant of –in some measure- random choice and data accessibility. Presumably, adding or subtracting one of the variables would lead to slightly different results. To confirm the results of analysis, further research is still needed. The author intends to apply two methods: an input-output analysis and an econometric model. The first one allows to investigate, if in all cases innovative inputs are transformed in innovative outputs and if it depends on nationality, the second one verifies the assumption of positive impact of innovation on regional competitiveness in the Visegrad Group.

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KONKURENCYJNOŚĆ, INNOWACJA I ROZWÓJ REGIONALNY PAŃSTW GRUPY WYSZEHRADZKIEJ

Streszczenie

Celem analizy przedstawionej w artykule jest porównanie konkurencyjności i innowacyjności 35 regionów Grupy Wyszehradzkiej (NUTS-2) w latach 2001 i 2008 oraz określenie grup regionów najbardziej zbliżonych pod względem analizowanych cech. Podjęto próbę wytypowania wiązek regionów o najwyższym poziomie konkurencyjności i innowacyjności oraz zweryfikowano wpływ przynależności państwowej i zależność między poziomem konkurencyjności i innowacyjności analizowanych regionów. W badaniu zastosowano dwie klasyczne metody analizy skupień: niehierarchiczne grupowanie metodą k-średnich i hierarchiczną metodę Warda. Rezultaty analizy potwierdziły szybszy rozwój regionów stołecznych i istotne zróżnicowanie konkurencyjności i innowacyjności regionów Grupy Wyszehradzkiej. Najważniejszym wnioskiem wynikającym z analizy skupień jest fakt, że poszczególne regiony łączą się według granic państwowych. Wyniki wskazują, że proces ten nasilił się w 2008 r. Może to świadczyć o tym, że obserwowane zjawisko nie jest pozostałością poprzedniego systemu. Bazując na wynikach korelacji, można przypuszczać, że nakłady przełożyły się na efekty innowacyjności i innowacje miały pozytywny i rosnący wpływ na konkurencyjność regionów Grupy Wyszehradzkiej. W celu potwierdzenia tych przypuszczeń, konieczne jest przeprowadzenie kolejnych analiz, w tym analizy innowacyjności typu *input-output* i analizy ekonometrycznej.

Słowa kluczowe: konkurencyjność regionalna, innowacje, analiza skupień, kraje Europy Środkowej i Wschodniej

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