SPATIAL DIVERSIFICATION OF INNOVATIVENESS OF THE VISEGRAD GROUP REGIONS

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Abstract

A feature that characterizes the spatial structure of each country's economy is the disproportion in the level of the economic development of the regions, whose determinants may be the innumerable range of conditions – stimulating or inhibiting. The scientific and technical progress has created new conditions for the economic development in the regional systems. Modern innovation factors include innovation. It is the catalyst for the development and economic growth of the countries. The regions of the Visegrad Group are diverse in terms of the level of innovation. Bearing in mind these discrepancies, it is extremely reasonable to constantly study and monitor this matter. The study has decided to use one of the numerical taxonomy methods, namely Hellwig's pattern of development. The subject of the study is the regions of the Visegrad Group, which as objects have been characterized by the selection of appropriate features describing the state of innovation. This is also the purpose of these considerations to measure innovation in the V4 regions. The statistical analysis, which, thanks to the use of appropriate tools allowed to collect, analyze and interpret the studied phenomenon, turned out to be an indispensable research method in achieving the set objective. The data on selected innovation indicators characterizing the thirty-five territorial units of the Visegrad Group were used.

Key words: innovation, NUTS 2 regions, Visegrad Group, Hellwig's development pattern

JEL Code: C1, O31, R12

Introduction

Despite strong efforts, the countries of the Visegrad Group are still diversified in terms of the level of economic development. Therefore, they also have different positions even in relation to competitiveness (more on Maráková et al., 2016) or innovative policy. Bearing in mind these discrepancies, a continuous multi-aspect study of this matter is justified or even desirable. However, the level of innovation of individual regions is a complex phenomenon,

conditioned by the various factors. Quantitative methods, above all statistical and econometric ones, turn out to be an extremely helpful tool. They enable the objectivity and inference of the conducted research.

The subject of innovation is constantly a frequent topic of scientific inquiry. Among contemporary researchers dealing with this issue, we should even mention: (Cavagnoli, 2011), (Gorakhova et al., 2015), (Harmancioglu et al., 2010), (Lyasnikov et al., 2014), (Merickova, 2015). The scientific achievements of Polish researchers in this field are also rich and diverse: (Duda & Gąsior, 2014), (Firlej, 2013), (Nowacki & Bachnik, 2016), (Sieradzka, 2013), (Wolak-Tuzimek, 2016).

The general objective of the research was defined as: the measurement of innovation in the V4 regions. The selected method of numerical taxonomy was used to achieve this goal. Such a selection of a research tool was made, because these methods are particularly applicable, where there is a need to divide objects/phenomena according to strictly defined rules and to select classes. In the proposed study that can be considered as detailed objectives of the analysis being carried out.

Two research hypotheses have emerged from research studies:

H1: The development pattern method is a useful tool for solving problems related to the quantification of the innovation level diversity in the V4 regions;

H2: Most regions of the Visegrad Group are weak or the weakest regions in terms of the level of innovation.

1 Methodology

The study decided to use one of the methods of numerical taxonomy, and more precisely, the method of Z. Hellwig's development pattern. The subject of the study turned out to be the regions of the Visegrad Group, which as objects were characterized by the selection of appropriate features describing the state of innovation.

The main objective was achieved by: selecting a set of statistical features defining the development of the Visegrad Group regions in the field of innovation; application of Hellwig's development pattern method; building synthetic measures for the development of innovation of NUTS 2 regions; preparation of the ranking of V4 regions; grouping of V4 regions by means of the selected classification method.

The use of Z. Hellwig's development measure made it possible to organize the examined objects, in this case, NUTS 2 regions in terms of the level of innovation. In other

words, the calculation of the synthetic measure allowed to organize the objects in a linear way and divide the analyzed regions into four groups.

The selection of diagnostic features that characterize the described phenomenon was extremely important for the results of the study. The substantive selection of diagnostic variables was based on literature studies on innovation and checking the differentiation of individual variables. Then, it was considered whether they met the criteria of measurability, accessibility, completeness and comparability. A set of diagnostic variables with 5 variables was qualified for the next stage of the study, which were then used in the synthetic evaluation of conditions for the development of innovation in the V4 regions. It should be noted that all selected variables met the indicated criteria, so there was no problem of eliminating variables.

In the measurement of innovation, indicators from the key area: Science, Technology and Innovation was taken into account. The study group constituted indicators in percentage terms. The attributes are assigned numbers from 1 to 5. The distribution of variables is presented in tab. 1.

Tab. 1: List of features accepted for the study

Area	Indicators
Science, Technology and Innovation	$\mathbf{X_1}$ – Employed in the high technology sector in 2017 [% of all employees]
	$\mathbf{X_2}$ – Number of researchers in 2015 [% of all employees]
	$\mathbf{X_3}$ – Internal R & D expenditure (GERD) in 2015 [% of GDP]
	$\mathbf{X_4}$ – People with higher education and / or employed in science and technology in 2017 [% of active population]
	$\mathbf{X_5}$ – Expenditure on research and development of the enterprise sector in 2015 [% of GDP]

Source: Own study.

Bearing in mind the substantive meaning of the feature as well as its correlation relationships, the character of each variable should be determined. It is worth noting that among selected five indicators, all these are stimulants – (low values are undesirable from the point of view of a given phenomenon), and therefore there is a positive correlation with the explained variable. In other words, an increase in the value of the explanatory variable leads to an increase in the explained variable. Another very important issue that often arises in this type of cases is the problem of weighing variables. In order to remedy this, the assumption about the equal importance of each examined feature was accepted; unit weighing system.

2 Results

2.1 Evaluation of spatial diversity using the Hellwig method

The analysis was based on the previously presented research procedure. The arithmetic mean, standard deviation, coefficient of variation and maximum and minimum value were calculated first. Then, on the basis of the obtained calculations, they were standardized, the Euclidean value and the synthetic meter was calculated – tab. 2.

Tab. 2: Statistical characteristics of diagnostic variables

Region NUTS 2	X_1	X_2	X_3	X_4	X_5	Standardization					Eucidean Distance	Synthetic meter M
Praha	9.2	2.13	2.97	60.2	1	2.63	3.34	2.82	2.77	0.98	1.56	0.846
Strední Cechy	4.7	0.54	1.89	38	1.6	0.51	0.01	1.21	0.01	2.39	5.42	0.465
Jihozápad	3.8	0.46	1.57	34.1	0.98	0.08	-0.15	0.73	-0.48	0.93	6.32	0.376
Severozápad	1.8	0.12	0.36	29.3	0.31	-0.86	-0.86	-1.07	-1.08	-0.64	8.63	0.148
Severovýchod	4.9	0.44	1.34	35.4	1.04	0.60	-0.19	0.39	-0.32	1.07	6.11	0.397
Jihovýchod	4.6	1.08	2.83	39.3	1.53	0.46	1.14	2.61	0.17	2.23	4.47	0.559
Strední Morava	3.8	0.55	1.26	33.3	0.82	0.08	0.04	0.27	-0.58	0.56	6.53	0.355
Moravskoslezsko	3.7	0.44	1.19	37.2	0.76	0.04	-0.19	0.16	-0.09	0.41	6.53	0.355
Közép-Magyarország	7.7	1.3	1.88	48.3	1.41	1.92	1.60	1.19	1.29	1.94	3.18	0.686
Közép-Dunántúl	3.8	0.37	0.97	31.1	0.73	0.08	-0.34	-0.16	-0.85	0.34	7.10	0.299
Nyugat-Dunántúl	3.8	0.23	0.58	31.4	0.45	0.08	-0.63	-0.74	-0.81	-0.31	7.71	0.239
Dél-Dunántúl	2.9	0.2	0.42	28.3	0.16	-0.34	-0.70	-0.98	-1.20	-1.00	8.46	0.164
Észak-Magyarország	5.2	0.18	0.5	29.7	0.41	0.74	-0.74	-0.86	-1.03	-0.41	7.71	0.239
Észak-Alföld	3.3	0.27	1.1	27	0.8	-0.15	-0.55	0.03	-1.36	0.51	7.47	0.262
Dél-Alföld	1.7	0.36	1.69	29.1	1.24	-0.91	-0.36	0.91	-1.10	1.54	7.15	0.294
Lodz	2.9	0.34	0.67	39.6	0.27	-0.34	-0.40	-0.61	0.21	-0.74	7.47	0.263
Mazowieckie	5.5	0.89	1.74	52.2	0.75	0.88	0.75	0.98	1.78	0.39	4.60	0.546
Malopolska	3.6	0.93	1.49	45.3	0.66	-0.01	0.83	0.61	0.92	0.18	5.54	0.453
Silesian	2.5	0.4	0.61	44.9	0.33	-0.53	-0.28	-0.70	0.87	-0.60	7.28	0.281
Lublin	1.6	0.31	1.07	35.8	0.26	-0.95	-0.47	-0.01	-0.27	-0.76	7.75	0.235
Subcarpathian	1.4	0.49	1.29	38.4	0.96	-1.05	-0.09	0.31	0.06	0.89	6.85	0.324
Swietokrzyskie	1	0.19	0.61	36	0.27	-1.24	-0.72	-0.70	-0.24	-0.74	8.29	0.182
Podlasie	1.4	0.32	0.76	41.1	0.23	-1.05	-0.44	-0.48	0.39	-0.83	7.78	0.232
Wielkopolskie	2.1	0.41	0.74	36.3	0.27	-0.72	-0.26	-0.51	-0.20	-0.74	7.69	0.241
West Pomeranian	2	0.33	0.33	41.3	0.13	-0.77	-0.42	-1.12	0.42	-1.07	8.00	0.210
Lubusz	2.4	0.18	0.22	36.2	0.14	-0.58	-0.74	-1.28	-0.22	-1.04	8.34	0.177
Dolnoslaskie	4.1	0.61	0.85	44.2	0.49	0.22	0.16	-0.34	0.78	-0.22	6.38	0.371
Opole	1.9	0.23	0.32	36.4	0.14	-0.81	-0.63	-1.13	-0.19	-1.04	8.32	0.179
Kuyavian-Pomeranian	2.7	0.33	0.46	36.8	0.3	-0.44	-0.42	-0.92	-0.14	-0.67	7.77	0.233
Warmia-Mazury	1.5	0.23	0.32	36.2	0.06	-1.00	-0.63	-1.13	-0.22	-1.23	8.50	0.161
Pomeranian	4.4	0.55	1.12	45.5	0.68	0.37	0.04	0.06	0.94	0.23	5.96	0.412
Bratislavský kraj	10.6	2.16	1.84	58.1	0.49	3.29	3.40	1.13	2.51	-0.22	3.12	0.692
Západné Slovensko	4.1	0.34	0.88	31.7	0.35	0.22	-0.40	-0.30	-0.78	-0.55	7.40	0.269
Stredné Slovensko	3.2	0.34	1.16	30.7	0.3	-0.20	-0.40	0.12	-0.90	-0.67	7.53	0.256
Východné Slovensko	3	0.4	0.75	29.3	0.11	-0.29	-0.28	-0.49	-1.08	-1.11	8.03	0.208
Arithmetic average	3.62	0.53	1.08	37.9	0.58	0.00	0.00	0.00	0.00	0.00	6.77	0.33
Standard deviation	2.12	0.48	0.67	8.03	0.43	1	1	1	1	1	1.68	0.166
Coefficient of variation	59%	90%	62%	21%	73%							50%
Max	10.6	2.16	2.97	60.2	1.6	3.29	3.40	2.82	2.77	2.39	8.63	0.85
Min	1	0.12	0.22	27	0.06	-1.24	-0.86	-1.28	-1.36	-1.23	1.56	0.15

Source: Own study based on (Eurostat, 2019), own calculations.

For all selected innovation indicators, the maximum standardized values were selected. Detailed distribution is presented in tab. 3.

Tab. 3: Maximum standardized values

Diagnostic variables	Region V4
X_1 – Employed in the high technology sector in 2017 [% of all employees]	Bratislavský kraj
X_2 – Number of researchers in 2015 [% of all employees]	Bratislavský kraj
X_3 – Internal R & D expenditure (GERD) in 2015 [% of GDP]	Praha
X_4 – People with higher education and / or employed in science and technology in 2017 [% active population]	Praha
X_5 – Expenditure on research and development of the enterprise sector in 2015 [% of GDP]	Střední Cechy

Source: Own study.

Among the countries with maximum index values, the Slovak region – Bratislavský kraj and two Czech regions – Prague and Střední Cechy were the leaders. In this group, the regions of Slovakia and Czech Republic dominated the remaining surveyed territorial units of the V4.

After analyzing the maximum values, it was also decided to examine the minimum standardized values – a thorough distribution is presented in tab. 4.

Tab. 4: Minimum standardized values

Diagnostic variables	Region V4
X_1 – Employed in the high technology sector in 2017 [% of all employees]	Swietokrzyskie
X_2 – Number of researchers in 2015 [% of all employees]	Severozápad
X_3 – Internal R & D expenditure (GERD) in 2015 [% of GDP]	Lubusz
X_4 – People with higher education and / or employed in science and technology in 2017 [% active population]	Észak-Alföld
X_5 – Expenditure on research and development of the enterprise sector in 2015 [% of GDP]	Warmia-Mazury

Source: Own study.

In the examined group of indicators, the three Polish voivodships fared the worst, namely Swietokrzyskie, Lubusz and Warmia-Mazury. Their fate was also shared by one Czech region – Severozápad and one Hungarian – Észak-Alföld.

Then, the synthetic value of individual variables was analyzed – tab. 5.

Tab. 5: Maximum and minimum values of the synthetic meter M

Synthetic meter	MAX	MIN
	Praha	Severozápad

Source: Own study.

The maximum value of the synthetic meter was obtained by Prague, while the minimum values of this meter were described by Severozápad.

The next stage of the analysis was to take the following five steps: sorting by decreasing M measure; determining the average; division into two groups, depending on whether smaller or larger than the average; determination of intermediate averages; division into four groups designated by three averages.

The analysis of the taxonomic value of the development meter enables grouping of objects into homogeneous classes. The study divided the regions into four typological groups according to the method of three averages. In the assumption of this method, the studied set of features is divided into 2 subsets. So that in the first there are only objects whose values of the meter are larger than the general average, while in the second – all the others. The next step is to define the intermediate averages for each group. Following this line of thinking, the following groups can be distinguished: the best, good, weak, the weakest regions. Thus, the following ranking of V4 regions – tab. 6. For the sake of clarity of the analysis, it was decided, after measuring the innovation, to present a map of spatial diversity – this is presented in Figure 1.

Tab. 6: Division of the Visegrad Group regions due to the level of innovation

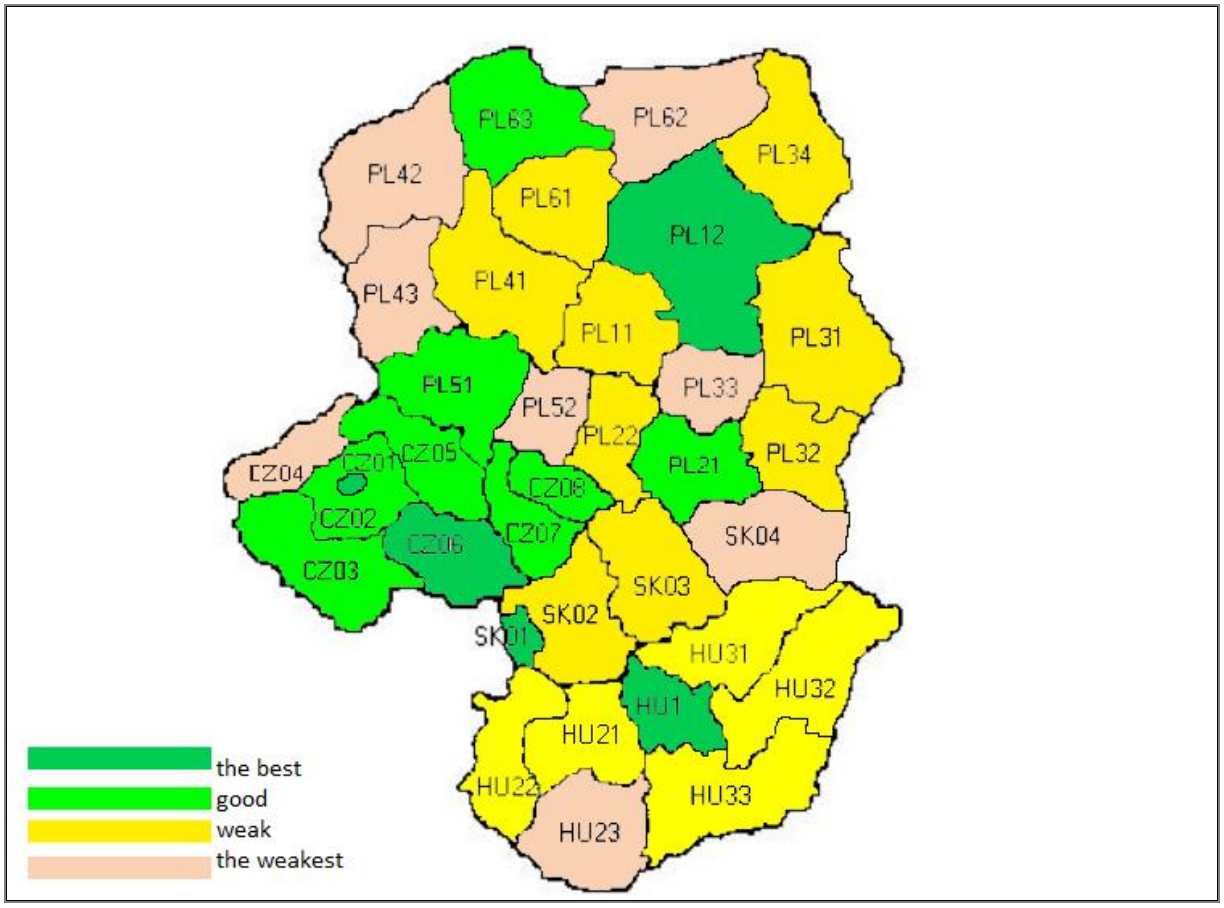
Region NUTS 2	Synthetic meter M1	Synthetic meter M1	Rating
Praha	**0.846**	**0.846**	THE BEST
Bratislavský kraj	**0.692**	**0.692**	
Közép-Magyarország	**0.686**	**0.686**	
Jihovýchod	**0.559**	**0.559**	
Mazowieckie	**0.546**	**0.546**	
Strední Cechy	**0.464**	**0.464**	GOOD
Malopolska	**0.453**	**0.453**	
Pomeranian	**0.412**	**0.412**	
Severovýchod	**0.397**	**0.397**	
Jihozápad	**0.376**	**0.376**	
Dolnoslaskie	**0.371**	**0.371**	
Moravskoslezsko	**0.355**	**0.355**	
Strední Morava	**0.355**	**0.355**	
Subcarpathian	0.324	0.324	WEAK
Közép-Dunántúl	0.299	0.299	
Dél-Alföld	0.294	0.294	
Silesian	0.281	0.281	
Západné Slovensko	0.269	0.269	
Lodz	0.263	0.263	
Észak-Alföld	0.262	0.262	
Stredné Slovensko	0.256	0.256	
Wielkopolskie	0.241	0.241	
Nyugat-Dunántúl	0.239	0.239	
Észak-Magyarország	0.239	0.239	
Lublin	0.235	0.235	
Kuyavian-Pomeranian	0.233	0.233	
Podlasie	0.232	0.232	
West Pomeranian	0.210	0.210	THE WEAKEST
Východné Slovensko	0.208	0.208	
Swietokrzyskie	0.182	0.182	
Opole	0.178	0.178	

Lubusz	0.177	0.177	
Dél-Dunántúl	0.164	0.164	
Warmia-Mazury	0.161	0.161	
Severozápad	0.148	0.148	

Source: Own study.

After conducting an in-depth analysis of the studied group of indicators, it should be noted that five areas are among the most innovative V4 regions, including: Praha, Bratislavský kraj, Közép-Magyarország, Jihovýchod, and Mazowieckie. The Střední Cechy, Malopolska, Pomeranian, Severovýchod, Jihozápad, Dolnoslaskie, Moravskoslezsko and Střední Morava well came out well too.

Fig. 1: Spatial diversification of the level of innovation in the V4 regions



Source: Own study.

The most numerous group turned out to be the one concerning weak innovators. It included fourteen V4 regions, half of which were Polish NUTS 2 regions, including: Subcarpathian, Silesian, Lodz, Wielkopolskie, Lublin, Kuyavian-Pomeranian and Podlasie.

The weakest regions in terms of the level of innovation in this group of indicators turned out to be eight areas – one Czech: Severozápad, one Hungarian: Dél-Dunántúl, one

Slovak: Východné Slovensko and as many as five Polish voivodships: Warmian-Masurian, Lubusz, Opole, Swietokrzyskie and West-Pomeranian.

The spatial diversity of the level of innovation in the Visegrad Group regions is a fact. This has been proven by examining the determinants of innovation from two key areas: employment in the science and high technology and expenditure on R&D. This indicates, therefore, that the main reasons for the low and very low level of innovation in most V4 regions are the lack of qualified personnel, and the insufficient level of financial resources allocated to research and development, which is also indirectly related to too high costs of introducing innovations.

These considerations do not fully cover the scope of the reasons for this state of affairs, but only constitute a kind of incentive for further research. Undoubtedly, it is worth expanding the scope of diagnostic variables, for example those specifying the export of the high technology production or intellectual property rights (number of patent applications, number of EU trademark applications, number of registered Community designs). Undoubtedly, unsatisfactory cooperation between science and business, and in particular the relatively low innovation of the SME sector in the Visegrad Group regions is not without significance, on the contrary – these aspects constitute fundamental barriers to the development of regions' innovation, and thus also of entire economies.

Conclusion

The aim of the research was to measure innovation in the NUTS 2 regions of the Visegrad Group. The conducted research procedure using the development pattern method showed significant spatial differentiation in the studied area. The selected detailed objectives were also achieved, i.e. the regions were divided and four groups of regions were selected: the best, good, weak, the weakest.

Prague turned out to be an undisputed leader in innovation, followed by the Bratislavský kraj. Another Közép-Magyarország region was on the podium.

The diametrically opposite situation concerned the Severozápad region, which placed it on the last placement.

The implementation of the assumptions allowed to verify the research hypotheses:

H1: The development pattern method is a useful tool for solving problems related to the quantification of the innovation level diversity in the V4 regions.

The hypothesis was confirmed because the applied method allowed to construct synthetic indicators of the innovation development of the V4 regions, which in turn allowed to precisely determine the spatial diversity of the innovation level of the V4 regions.

H2: Most regions of the Visegrad Group are weak or the weakest regions in terms of the level of innovation.

The hypothesis was verified positively, as 22 out of 35 regions were qualified to the group of weak and the weakest regions, therefore the group of weak and the weakest regions accounted for 63% of all NUTS 2 regions of the Visegrad Group.

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