ASSESSMENT OF REGIONAL INNOVATION SYSTEMS AS AN ASSUMPTION FOR INNOVATION POLICY ADJUSTMENT

Vladimír ŽÍTEK
Viktorie KLÍMOVÁ
Maria KRÁLOVÁ

Vladimír ŽÍTEK (corresponding author)
Associate professor, Department of Regional Economics and Administration, Faculty of Economics and Administration, Masaryk University, Brno, Czech Republic
Tel.: 00420-549.49.8813
E-mail: zitek@econ.muni.cz

Viktorie KLÍMOVÁ
Assistant professor, Department of Regional Economics and Administration, Faculty of Economics and Administration, Masaryk University, Brno, Czech Republic
Tel.: 00420-549.49.4987
E-mail: klimova@econ.muni.cz

Maria KRÁLOVÁ
Assistant professor, Department of Applied Mathematics and Computer Science, Faculty of Economics and Administration, Masaryk University, Brno, Czech Republic
Tel.: 00420-549.49.5386
E-mail: kralova@econ.muni.cz

Abstract

The role of regions in promoting innovation is gaining increasing significance. For a policy to be efficient, it is first necessary to analyze the innovation performance and the character of the innovation system. The aim of this paper is to propose and implement a methodology for the evaluation of regional innovation systems using the index of the regional innovation system (I_{RIS}) devised by the authors. The analysis is performed using the example of Czech NUTS3 regions. The evaluated indicators were divided into five groups (factors): Knowledge, Businesses, Intellectual property, Political support, and Results. Based on the standardization and rescaling of the factors, the I_{RIS} was calculated. The regions were divided into groups by means of the cluster analysis. The highest value of the I_{RIS} was achieved by Capital City Prague, followed by the South Moravian region. The lowest value was achieved by the Karlovy Vary region.

Keywords: Czech Republic, innovation performance, innovation system, region.

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1. Introduction

The concept of innovation systems was designed in the 1980s and its purpose was to clarify the disparities within the innovation performance of industrial countries. Its adherents state that the differences among countries in the economic and technological performance are due to the combination of the existing institutions and their interactions, as they have an effect on the accumulation of capital, technologies and knowledge. According to them, the innovation performance of countries depends on the institutional differences in the ways of the implementation, improvement, development and dissemination of new technologies, products and processes (Metcalfe and Ramlogan, 2008).

Originally, the concept of innovation systems only focused on the national level, and it was pointed out that a specific research environment, system of education, finances, and regulations shape the innovation processes of some countries to a considerable extent (Tödtling and Kaufmann, 1999). Shortly, many authors applied it also to the multinational level, but the regional level became the primary field. This development was, among others, based on the idea that industries concentrate in certain areas and the existing decentralized policy can be applied to the regional level (Buesa *et al.*, 2006).

The concept of innovation system is a practical tool for the analysis of dependencies in the innovation process (Tödtling and Kaufmann, 1999) or a tool to propose an innovation policy (Lundvall, 2007). This tool is used to determine which alternative of the institutional arrangement supports the strong dynamic performance (national/regional) of the economy or a sector (Lundvall *et al.*, 2009). There are also differences in the individual authors' approaches. Taking into account two significant representatives, Lundvall and Nelson, Nelson's approach is rather based on empirical case studies, while Lundvall's approach is more theory-oriented and seeks to create alternatives to the traditional neoclassical economics by placing an emphasis on interactive learning, relationships between manufacturers and customers, and innovation in the center of analyses (Edquist, 2005). Empirical approaches are also used in the description and understanding of the structure, dynamics and performance of innovation systems (Bergek *et al.*, 2008).

The innovation system can be understood in a broader or a narrower sense (e.g., Freeman, 2002 or Asheim and Gertler, 2005). The narrower definition focuses on the institutions that promote the acquisition and dissemination of knowledge and are the main sources of innovation. This primarily includes companies and the research sector and adopts the top-down approach as well as the linear model of the innovation process. An example can be the triple-helix model (Leydesdorff, 2006; Etzkowitz, 2008). The broader concept of innovation systems encompasses all components and aspects of the economic structure and the institutional arrangement affecting learning, as well as exploration and discoveries. This broader definition includes elements of the bottom-up approach and the interactive model of the innovation process (Asheim and Gertler, 2005).

Just as states vary in their innovation performance, the ability of regions to innovate and develop their innovation system varies as well. This is due to the fact that regions differ in the sector specialization and in the functional and organizational characteristics. Additionally, their ability of interaction, which depends on the presence of clusters and the approach to cooperation, differs. The problem of some regions can be an inadequate capacity to build relevant institutions as well as the absence of an effective management model (Tödtling and Kaufmann, 1999).

Doloreux (2002) stated that the regional innovation systems consist of four basic interrelated elements, which are the businesses, institutions, knowledge infrastructure, and the policy. Businesses must be understood as learning organizations which are in interaction with other companies and institutions forming their environment. Institutions are, for example, the governments and other institutions which are key players in the creation and transfer of knowledge. Institutions reduce uncertainty, coordinate the use of knowledge, settle conflicts, and provide incentives. They can be formal or informal and they are significantly affected by the national innovation system. The knowledge infrastructure represents the physical and organizational infrastructure for the promotion of innovation. It also includes research institutes, laboratories, and universities. A policy focused on regional innovation is a policy oriented to the improvement of the interactions among the knowledge infrastructure, businesses, and institutions. Policies are to develop the endogenous potential of regions by encouraging the spread of technologies at the regional level. General regional policy is influenced by the idea that innovations play a crucial role within competitiveness enhancement. Due to that the regional policy is often connected with the innovation policy (Klímová and Žítek, 2015).

Successful economies can be characterized by a compact and integrated system for the conversion of new knowledge and innovation into profitable (productive) economic values. A successful economic development is thus closely linked to the ability of the country to acquire, absorb, spread and apply modern technologies, i.e., the ability represented by the national innovation system (Metcalfe and Ramlogan, 2008). Successful regional innovation systems have several features in common (Skokan, 2005):

- economic activities (high GDP, export, high representation of businesses, presence of knowledge-intensive industries, skilled workers);
- research activities (private R&D expenditures, emergence of new technologies in the region);
- research infrastructure (strong and diversified R&D institutions meeting the requirements of businesses);
- policy (political awareness, relevant objectives, appropriate strategy); and
- social networks (interactions between entities, relations between businesses and research representatives, cooperation of the businesses).

However, it is also necessary to pay attention to the regions with system failures and dysfunctions, because it is the only way to understand better the factors forming the regional innovation performance (Bathelt, 2003; Asheim, Smith and Oughton, 2011).

2. Evaluation of territorial innovation performance

The literature contains a wide range of studies that deal with the issue of regional competitiveness using various methodologies. Incomparably fewer authors elaborate more specifically on the evaluation of the regional innovation potential or directly regional innovation systems. The following text briefly summarizes the selected studies which evaluate the Czech environment.

The European Commission evaluates the innovation performance of countries using the Summary Innovation Index (IUS). It consists of 25 indicators representing three main areas (enablers, firm activities, outputs). This study investigates, for example, human resources, expenditures on research and development, research publications, intellectual property rights, innovative companies, cooperation in innovation and economic effects. Based on the composite index, the countries are divided into four groups: innovation leaders, innovation followers, moderate innovators, and modest innovators. The Czech Republic is a moderate innovator (European Union, 2014a). On the regional level (NUTS2), the European Commission evaluates the innovation performance in the same way (RIUS) at two-year intervals. However, not all data are available at the regional level so the index only uses 11 out of the 25 indicators. Furthermore, not all of these 11 indicators are available for each region. In our opinion, this significantly reduces the information value of the innovation index. As a result, all the Czech regions fall among moderate innovators, which is not correct, because we can find big differences among them (European Union, 2014b).

Poledníková and Kashi (2014) in their evaluation of the innovation performance of the Czech NUTS2 regions in 2011 used the European Commission methodology (European Union, 2014a), but with a smaller number of indicators (5 indicators – employees with a university degree, public and private expenditures on R&D, EPO patents, and employment in high-tech sector) complemented by two more (the use of structural funds and technically innovative businesses). Their calculation methodology was based on the analytic hierarchy process method AHP and the optimization method VIKOR. The South-East cohesion region (i.e., South Moravian region + Vysocina region) was evaluated as the most innovative region. It was followed by Prague. The Northwest cohesion region (Usti region + Karlovy Vary region) was marked as the least innovative region.

Quite a different approach to the evaluation of the innovation performance of NUTS2 regions in the European Union was adopted by Capello and Lenzi (2013). They used 25 indicators divided into four areas. Some of these indicators were taken from various statistical resources; some of them were calculated by the authors (for the list of indicators see Capello and Lenzi, 2013, pp. 130-134). Based on the cluster analysis (method of k-means) they created the taxonomy of five groups of European regions. The Northwest cohesion region and the Central Bohemia cohesion region belong to the forth cluster (smart and creative diversification area) and the rest of them belong to the third cluster (smart technological application area). In our opinion, the Northwest and Central Bohemia cohesion regions should not fall within the same

cluster, because they differ significantly as regards to the structure of economy, economic performance, standard of living and others.

Drahošová and Bednář (2014) evaluated the innovation potential of Czech NUTS3 regions using 11 selected statistical indicators. Some of the indicators were not always appropriate for the Czech environment (scientific publications) and often were not available for the whole period (EPO patents). This study puts a strong emphasis on indicators related to intellectual property rights (5 out of 11 indicators). Nevertheless, we consider some findings of this study quite interesting. The position of Prague is strong and exceptional. It is followed by the Central Bohemian, Liberec, South Moravian, Olomouc and Pardubice regions. The worst innovation potential has been observed in the Karlovy Vary, Usti and Vysocina regions.

A comprehensive analysis of the innovation potential of the Czech regions was carried out in 2008 by the Technological Centre of the Academy of Sciences of the Czech Republic (Pokorný *et al.*, 2008). For the evaluation, the authors used a total of 39 indicators grouped into 14 factors which represented 5 groups of indicators (innovation drivers, knowledge creation, business and innovation, application, intellectual property). In the framework of this evaluation, the Capital City Prague was marked as highly above-average region and two regions (the South Moravian and the Hradec Kralove regions) were marked as above-average. The Karlovy Vary and the Vysocina regions were in the group of highly below-average regions. Particularly, the good position of the Hradec Kralove region is not usual in similar studies.

The article by Matatkova and Stejskal (2011) represents a specific example of studies whose research of regional innovation systems is qualitative in character. They perceive the regional innovation system as a set of four layers: enterprises, supporting organizations, environment and infrastructure, and relations and connections. Several features were defined for each of these layers and using numerical data or verbal comments these features were applied on the example of two regions. Based on this evaluation, the Pardubice region was identified as a non-functional regional innovation system and the Moravian-Silesian region as a functional one.

3. Data and methods

One of the ways to evaluate regional innovation systems (RIS) is to analyze indicators characterizing them. Although there are several partial studies dealing with this issue, none of them can be seen as providing generally valid methodological instructions. The aim of this paper is to propose and implement a methodology using the index of the regional innovation system (I_{RIS}) devised by the authors. The analysis is performed using the example of Czech NUTS3 regions. However, should the results be credible, it has to be well considered what indicators are included in the evaluation. The limiting factor is their availability. A number of potentially suitable indicators recommended by literature are either not monitored at all, or not at the regional level (and often it is not possible to decipher them due to the individuality of the data), or they stopped being monitored in the past. In addition to the ranking

of the regions based on their innovation potential, it is also interesting to see which Czech regions are similar to each other in terms of the parameters rated. Following up on these findings, specific requirements for the setting or the modification of the innovation policy can be formulated.

When selecting the indicators, we followed theoretical knowledge provided in scientific literature and indicators applied in empirical studies. We needed to encompass the characteristics of successful regional innovation systems. We searched for indicators that express the presence of knowledge (e.g., well-educated people and investment in research and development). We also needed to evaluate the presence of innovative companies and their innovation activity (expenditures on innovation, cooperation, companies' own research activity, intellectual property rights). Special attention was paid to technical innovations. These innovations often exploit knowledge of technical and natural sciences and can be protected by patents. In general, technical innovations are expected to bring higher economic effects than non-technical ones. We are aware of the fact that political support can be very important for innovation development and so it was necessary to find some indicators characterizing it. And last but not least, there was the fact that innovations in regions have to lead to positive economic results. At the same time, all the indicators have to be accessible at the regional level.

The indicators selected can be categorized into groups (factors), the resulting values of which can be interpreted independently. The evaluation uses the following five RIS factors:

- *Knowledge* – the basic features of the environment, in particular the area of training and education, and the area of research and development, predetermine the capacities for innovation in the region;
- *Businesses* – the businesses are the basic building block of the innovation system, in particular innovative businesses or businesses with their own R&D play a key role, because they put innovation into practice and generate the positive economic effects;
- *Intellectual property* – the results of R&D are often ideas that need to be protected due to the competition under intellectual property rights;
- *Political support* – the RIS also includes institutions and instruments of the economic policy, which act as a stimulus to the innovation creation in the region;
- *Results* – performance indicators showing how both the economic and the innovation environments are also important prerequisites for the innovation performance.

The indicators are mostly not simple, but they either consist of multiple values, or they are converted so as to best reflect the general characteristics of the RIS and also be suitable for the comparison of Czech regions. The absolute values are used in the cases when the absolute value of the indicator reveals the true meaning of the phenomenon and the conversion would not make sense (Zbranek and Fišer, 2010). Indicators use data obtained from various sources. The sources are provided in Table 1.

We only included businesses with 10 and more employees in our analysis.[1] All data are as of the end of 2012; if not, this is pointed out.

The chosen characteristics of the factor *Knowledge* are these four indicators:

[1] the number of students of technical and natural sciences (bachelor's, master's and doctoral programs);
[2] the total expenditure on research and development conducted in the Czech regions (the government, university, corporate, and non-profit sectors are included) expressed as a share of GDP (%);
[3] the number of all research and development institutes;
[4] the share of employees with university degrees in the total number of employees in the national economy (%);

The following five indicators have been chosen as the characteristics of the factor *Businesses*:

[5] the share of businesses with 250 or more employees (large enterprises) in all businesses with 10 and more employees (%);
[6] the share of businesses cooperating on technical innovations with other entities in all businesses with 10 and more employees (%);
[7] the businesses' costs of technical innovations, converted to one technically innovative business with 10 or more employees (mil. CZK);
[8] the share of businesses whose business activity incorporates research and development in all businesses with 10 and more employees (%);
[9] the share of businesses that deduce expenditures on R&D from the tax base in their tax report and thus gain indirect support for research and development in all businesses with 10 and more employees (data of 2011, %).

The chosen characteristics of the factor *Intellectual property* are these four indicators:

[10] the number of applications submitted for European patents EPO per one million inhabitants (data of 2010);
[11] the number of patents granted (Czech and European) per one million inhabitants;
[12] the number of utility models granted (Czech) per one million inhabitants.

The following five indicators have been chosen as the characteristics of the factor *Political support*:

[13] the quality of the regional innovation strategy in the given region (points 1-5);[2]

1 This is given by the guidelines for statistical surveys (OECD, 2005), which results in the fact that most of European statistical offices do not collect data for smaller enterprises. Furthermore, this group of enterprises is formed by a large number of individual self-employed persons with no employees, in particular, and it could influence our evaluation in an unacceptable way.

2 The point evaluation of Regional innovation (RI) strategies (as of the end of 2012) was carried out by authors. The criteria for point assignment was as follows: 1 – RI strategy does not exist; 2 – RI

[14] the number of business incubators and science and technology parks;
[15] the amount of subsidy gained from the Operational Programme Research and Development for Innovation (mill. CZK);
[16] the amount of subsidy gained from the Operational Programme Enterprise and Innovation (mill. CZK);
[17] the share of technically innovative businesses that have received public support in all businesses with 10 and more employees (%).

The following five indicators have been chosen as the characteristics of the factor *Results*:

[18] the regional gross domestic product (in CZK per an inhabitant);
[19] the general unemployment rate as calculated by the Czech Statistical Office based on the Selective Survey of the Labour Force (%);
[20] the value of exports of technological services per an employee (in CZK);
[21] the share of businesses that have implemented a technical innovation in all businesses with 10 and more employees (%);
[22] the value of revenues from technically innovated products converted to a technically innovative business with 10 or more employees (in mill. CZK).

All of these indicators can be interpreted so that a higher value means a better ranking of the region's innovation system in the given territory. The only exception is the indicator 'general unemployment rate', which is measured in percentages, where a higher value means a worse ranking of the region. Therefore, for the reason of a uniform interpretation, this indicator was transformed into the employment rate (using 100 minus the unemployment rate). All indicators are quantitative in character, only the quality of the regional innovation strategy has an ordinal character.

The index of the regional innovation system, I_{RIS}, is designed so that:

- its higher value means a better ranking of the overall innovation system of the region;[3]
- based on its value, it is possible to rank the regions from the best to the worst;
- all the RIS factors considered have the same effect on its value;
- each indicator from the group of indicators related to a particular factor contributes to the value of the factor with the same weight.

The last requirement is related to the fact that the indicators of a factor considered are measured in different units, therefore, their numeric values are not comparable. For this reason, standardization was used to convert these indicators to dimension-

strategy existed in the past, it had low quality and it is not valid anymore; 3 – RI strategy exists, it has unlimited time validity and it is rather a formal document; 4 – RI strategy exists, it has limited time validity and it is not so much formal; 5 – RI strategy exists, it is regularly updated and it has good quality.

3 The index proposed by the authors takes values from 0 to 50. It can also be modified by adding other factors, then the value would be from 0 to (10 x the number of factors).

Table 1: Selected indicators and source of data

Indicator	Source of data
[1] students of technical and natural sciences	CZSO (2013a)
[2] expenditure on research and development	CZSO (2013b)
[3] research institutes	CZSO (2013b)
[4] employees with university degrees	CZSO 2013a)
[5] large enterprises	CZSO (2014), Bisnode (2014), authors' own calculations
[6] businesses cooperating on technical innovations	CZSO (2014), Bisnode (2014), authors' own calculations
[7] businesses' costs of technical innovations	CZSO (2014), Bisnode (2014), authors' own calculations
[8] businesses with own research and development	CZSO (2014), Bisnode (2014), authors' own calculations
[9] tax deduction	RVVI (2014), Bisnode (2014), authors' own calculations
[10] applications of EPO patents	Eurostat (2014), CZSO (2013a), authors' own calculations
[11] Czech patents granted	RVVI (2014), CZSO (2013a), authors' own calculations
[12] Czech utility models granted	RVVI (2014), CZSO (2013a), authors' own calculations
[13] quality of the regional innovation strategy	authors' own evaluation
[14] business incubators and science parks	SVTP (2014)
[15] subsidy gained from the OP RDI	MŠMT (2014), authors' own calculations
[16] subsidy gained from the OP EI	CzechInvest (2014)
[17] innovative businesses with public support	CZSO (2014), Bisnode (2014), authors' own calculations
[18] regional gross domestic product	CZSO (2013a)
[19] unemployment rate	CZSO (2013a)
[20] export of technological services	RVVI (2014)
[21] businesses with technical innovation	CZSO (2014), Bisnode (2014), authors' own calculations
[22] revenues from technically innovated products	CZSO (2014), Bisnode (2014), authors' own calculations

Source: Authors' processing

less, and thus comparable, quantities. The value of a standardized indicator is thus given by

$$Z = \frac{X - m}{s}$$

where Z stands for a standardized indicator, X for a raw indicator, m represents the mean value of the considered indicator in the sample of regions, and s represents the standard deviation of the considered indicator in the sample of regions.

After all the indicators within a factor considered are standardized, their values for each region can be added up. However, a simple sum of standardized indicators as a representative of an individual factor is not sufficient to meet the requirement that all RIS factors have the same effect on the I_{RIS}. Therefore, the simple sum of standardized indicators is rescaled so that the worst region regarding the given factor gains a value of zero and the best region gains 10. The rescaling is done by formula

$$F^* = \frac{F - F_{min}}{(F_{max} - F_{min})} \times 10$$

where F^* stands for a rescaled factor, F for a raw RIS factor (the sum of related standardized indicators), F_{min} represents the minimum value of the considered F factor

in the sample of regions, and F_{max} represents the maximum value of the considered factor in the sample of regions.

The index of the regional innovation system is then the sum of the rescaled factors, i.e.,

$$I_{RIS} = \sum_{j=1}^{5} F_j^*$$

where F_1^* stands for rescaled factor *Knowledge*, …, F_5^* stands for rescaled factor *Results*.

The interpretation of I_{RIS} follows: the higher the value, the better the region's potential to create innovation, or the higher quality of the regional innovation system. Therefore, on the basis of the value of the I_{RIS} the regions can be ranked from the best to the worst.

The rescaled factors F_i^* allow for the calculation of the index of the regional innovation system, but it can be used for other purposes as well, e.g., for grouping the regions into clusters. The cluster method of k-means is used and presented in the Results and discussion and the number of clusters is set to k = 5.

4. Results and discussion

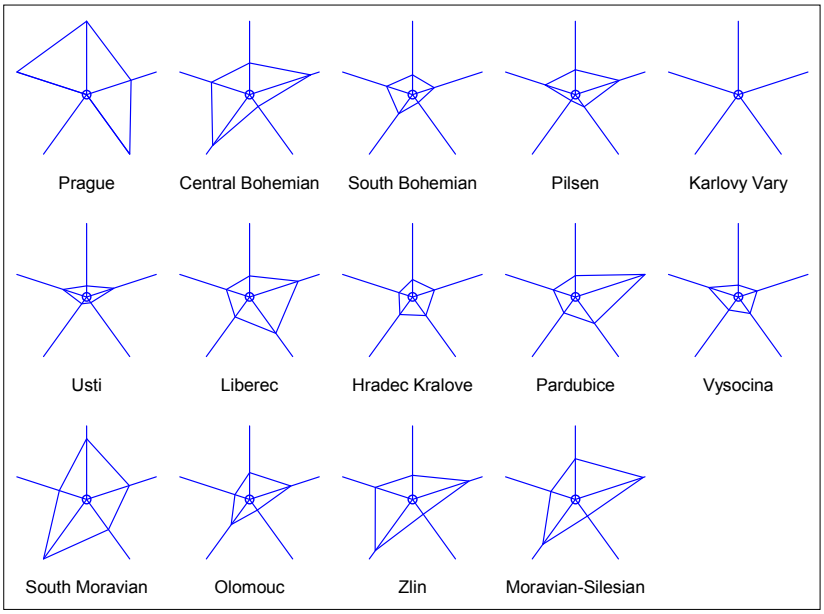
Table 2 lists the values of rescaled RIS factors F_1^* to F_5^* for each region, the value of the index of the innovation system, and for better clarity, the regions are already ranked from the best (with the highest I_{RIS}) to the worst (the lowest I_{RIS}). The values of the total score can range in interval <0;50>.

Table 2: The values of rescaled RIS factors of the Czech regions and the index of the regional innovation system

Code	Region	RIS factors					I_{RIS}
		Knowledge	Businesses	Intellectual property	Political support	Results	
CZ010	Prague	10.000	6.362	10.000	0.000	10.000	36.362
CZ064	South Moravian	8.267	6.122	5.070	10.000	3.915	33.374
CZ080	Moravian-Silesian	5.535	9.725	2.796	7.544	3.497	29.097
CZ020	Central Bohemian	4.323	8.752	1.975	8.560	5.458	29.067
CZ072	Zlin	3.288	8.127	2.495	8.624	5.324	27.859
CZ053	Pardubice	2.916	10.000	4.406	2.646	3.152	23.121
CZ051	Liberec	2.878	6.953	6.109	3.331	3.308	22.580
CZ071	Olomouc	3.659	5.926	1.786	4.239	2.098	17.708
CZ032	Pilsen	3.389	6.280	2.050	0.994	4.322	17.036
CZ031	South Bohemian	2.700	3.129	1.332	3.209	3.687	14.058
CZ052	Hradec Kralove	2.393	3.140	3.111	2.920	1.917	13.480
CZ063	Vysocina	1.634	2.683	2.759	2.191	4.213	13.480
CZ042	Usti	1.523	3.914	0.951	1.122	3.379	10.890
CZ041	Karlovy Vary	0.000	0.000	0.000	0.076	0.000	0.076

Source: Authors' elaboration

Some of the results of the evaluation could have been intuitively assumed, for example the best position of the Capital City Prague or the worst position of the Karlovy Vary region. The information contained in the heart of the sample is far more interesting. With the selected RIS factors of Czech regions, the Capital City Prague is significantly approached by the South Moravian region, with a gap followed by the Moravian-Silesian, Central Bohemian, and Zlin regions. At the other end of this imaginary ranking, there are the Usti region, followed by the Vysocina, Hradec Kralove, and South Bohemian regions. It is also worth pointing out that the average value of the total I_{RIS} (20.585) divides the regions exactly in half. The situation in the individual regions can be graphically presented using the icon graph (see Figure 1). The icon graph of Prague seems deformed due to the zero value of *Political support*.[4] If we excluded this RIS factor, the position of the Capital City Prague would be stronger and the position of the other regions would not change significantly.



Note: The five rays represent the individual factors, the 12 o'clock position is occupied by *Knowledge*, the other factors (*Businesses*, *Intellectual property*, *Political support*, *Results*) are ordered clockwise.

Figure 1: The evaluation of the regions based on the rescaled RIS factors

Source: Authors' elaboration

In order to divide the regions into groups based on the total I_{RIS}, taking into account the differences in the internal structure of each region at the same time, it is necessary

4 The zero value of Political support is caused by the fact that Prague has limited access to the European Structural funds due to the rules of the EU Cohesion policy.

to conduct still another analysis. For this purpose, the cluster analysis seems to be suitable. It is able, to an extent, to reliably distribute the regions into clusters based on their similarities. The non-hierarchical method of k-means[5] is used with the number of clusters set to k = 5.

For the complex evaluation of I_{RIS} of Czech regions based on all rescaled factors, the situation is as follows:

- 1st cluster (can be interpreted as highly above average) – Capital City Prague;
- 2nd cluster (can be interpreted as above average), the South Moravian, Moravian-Silesian, Central Bohemian, and Zlin regions;
- 3rd cluster (can be interpreted as average) – the Pardubice, Liberec, Olomouc, and Pilsen regions;
- 4th cluster (can be interpreted as below average) – the South Bohemian, Hradec Kralove, Vysocina, and Usti regions;
- 5th cluster (can be interpreted as deeply below average) – the Karlovy Vary region.

A detailed examination of the properties of the clusters showed that even the clusters obtained by the method of k-means can be ranked from the best to the worst. For example, if the cluster centroid reached an above-average result for one factor, it reached above-average results for all the other factors as well. This arrangement relation applies to nearly all the factors and centroids. The only exception is the *Intellectual property*, where the value for cluster 2 is slightly lower than for cluster 3, and the zero value of *Political support* in the otherwise highly above-average cluster of Prague. This fact can be freely interpreted that if the region has a higher innovation potential, then it is higher thanks to all RIS factors. The spatial distribution of the overall evaluation result of the RIS parameters of Czech regions based on the k-means method is presented in Figure 2.

There is no need to interpret the distribution of regions into the clusters. However, some of the results can be pointed out:

- Capital City Prague has an exceptional position;
- the South Moravian region is becoming the innovation leader among the regions;
- Moravian (eastern) regions generally apparently devote considerable attention to innovation, which is manifested in their good ranking;
- the RIS factors of most Czech regions are only average or below-average; and
- the Karlovy Vary region is deeply below average, and this concerns all the RIS factors.

Big attention to innovation is paid in the eastern part of the country (the South Moravian, Zlin and Moravian-Silesian regions). Let us explain and comment their position.

5 Initial cluster centers were based on the 'sort distances and take observations at constant intervals' approach; number of iterations were set to be 10, the solution was obtained after 2 iterations.

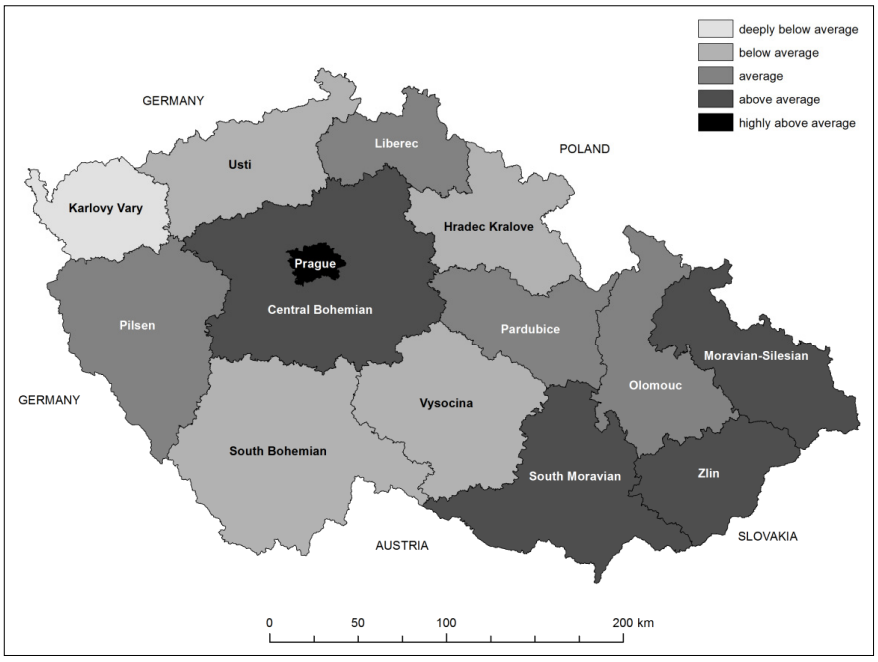


Figure 2: The overall evaluation of I_{RIS} of Czech regions

Source: Authors' elaboration

The capital of the South Moravian region is Brno, the second biggest city in the Czech Republic. It has a good geographical position, because it lies near three capitals (130 km from Vienna, 130 km from Bratislava and 200 km from Prague). In the field of education and research this region is characterized by a concentration of universities into the regional capital, we can find six public universities there. The large number of students corresponds to the high number of students that study natural sciences and technical branches, which are crucial for innovations. This region has also quite a good industrial tradition and it has a sophisticated institutional framework for innovation support. Innovation is perceived as a key topic by regional politicians and authorities. The capital of the Moravian-Silesian regions, Ostrava, is the 3rd biggest Czech city. This region has a very strong industrial tradition, but it has to modernize its structure of the economy (heavy industry used to be the cornerstone in the past). Nevertheless, regional authorities are aware of the importance of innovation and make efforts to improve conditions for innovation. There are three public universities located in the region. Although they have a lower number of students than universities in the South Moravian region, they have a higher share of students of natural sciences and technical branches. The Zlin region can be characterized by a strong industrial tradition as well. It has only one public university with a shorter history. Although innovation performance is not as high as in the two previous regions, the support of innovations is important for regional authorities. We should also describe the specific situation of the Central Bohemian region which has a high

value of total I_{RIS} too. This region has a beneficial geographical position, it is closely connected to Prague so many businesses and research institutes are located there and take advantage of it.

Based on the evaluation of the economy and the innovation parameters of regions, recommendations for the regional innovation policy can be drawn. McCann and Ortega-Argilés (2013) formulated recommendations through three defined groups of regions: world-class performing regions, industrial employment focus, and science and service regions. For each group they defined the economic, innovation and political challenges. This recommendation is not easy to link with specific Czech regions unless a study focused on the mentioned criteria is available. Capital City Prague was only evaluated as the science and service region by this study. In our opinion, it is possible to classify the South Moravian region to this group as well. Subsequently, we can identify the recommendations drawn with them. The other Czech regions can be primarily classified to the second group with high employment in industry. Science and service regions should focus on building their strengths and development of region-specific innovation strategies. It is important to strengthen relations between the private and the public sectors, attract global leaders and talents, strengthen private research, as well as the transfer of knowledge and technology. Regions with high employment in industry should focus on increasing the number of innovative companies, the variety of activities, regional cooperation, and the strengthening of the knowledge exchange.

OECD (2011a, 2011b) formulated recommendations for the innovation policy based on the type of the regional economic profile. The regions are divided into three basic groups: knowledge hubs, industrial production zones and non-science & technology-driven regions. Basic strategies are designed for each of the groups. In some aspects, this typology could be compared to the incomplete types of RIS (Tödtling and Trippl, 2005). The division of regions into groups is performed at the level of NUTS2 regions; out of the Czech regions, the OECD only classifies Prague as a knowledge hub, the remaining seven regions are industrial production zones. The regions classified as knowledge hubs are the real economic leaders. The challenge for their future development is to strengthen their position as a leader in the relevant sectors and maintain their high standard of living. Industrial production zones represent regions that used to experience successful development but are facing bankruptcy in the current global economy. These regions must change their social economic profile and find new opportunities. Their transformation should include the attraction of human capital, strengthening of the productive use of regional traditions and knowledge or cooperation with superior innovation systems.

The EU Cohesion policy supports the lagging regions in particular. In connection with this fact it is necessary to take further steps towards the enhancement of its efficient implementation (Melecký and Skokan, 2011). The World Bank provides more general recommendations for the innovation policy (World Bank, 2010); they are derived from technological skills and the quality of the institutional framework and are

primarily intended for entire countries. However, they can be applied by analogy to the regional innovation policy. The countries with a medium level of technology capabilities (which accept and adapt technologies available in the world), which is the most likely classification of the territory of the Czech Republic (Czech regions), are primarily recommended to support the development of innovation clusters (so cooperation is important) and supplier links with a high added value.

5. Conclusion

Regions can be compared with each other based on various appropriately chosen indicators. The selection has to comply with the purpose intended and depends on the subject of the comparison. A comprehensive evaluation of the regional prerequisites for the creation of innovation is largely limited by the (non-)availability of indicators. Some relevant indicators are not available at the level of NUTS3 regions; others have never been or stopped being monitored. Still, data that reliably characterize the innovation environment of the regions can be found when various sources are used.

The selected indicators were used to form groups that can be considered the environment factors. These factors are *Knowledge*, *Businesses*, *Intellectual property*, *Political support*, and *Results*. All the data were standardized and subsequently rescaled for the purposes of the evaluation. On the basis of this procedure, it was possible to sum up the values of the factors and calculate the index I_{RIS} for the individual Czech regions.

The highest I_{RIS} values were achieved by the Capital City Prague. With a small gap, it is followed by the South Moravian region; also the Moravian-Silesian, Central Bohemian and Zlín regions reached high values. On the contrary, the situation is the worst in the Karlovy Vary region. It has a dramatic score distance from the four regions with a low I_{RIS} value, i.e., the Ústi, Vysocina, Hradec Kralove, and South Bohemian regions.

Finally, the evaluation results (point scores of the individual factors) were used as an input for the cluster analysis. The regions were divided into five clusters using the method of k-means, and a complex evaluation analysis was done. Capital City Prague, which can be considered highly above average, and the Karlovy Vary region, which is deeply below average, form separate clusters. The leader among the remaining regions is the South Moravian region, which is in both cases in the cluster of regions with above-average RIS.

We would like to emphasize that public authorities and public policy can influence the innovation ability of a region to some extent. The dynamic innovation capacity of a region can be intentionally developed. Individual regions differ in their characteristics and therefore their innovation policy cannot be unified, but it has to be tailor-made for their needs.

On the basis of the evaluation of the regional economy and the innovation factors, recommendations for the regional innovation policy can be drawn. A different innovation policy is suitable for regions with an above-average value of the RIS index,

such as Capital City Prague and the South Moravian region, where it is necessary to primarily focus on the area of excellent research and strengthening of links and co-operation. On the contrary, the industrial regions starting from lower levels need to strengthen support for quality improvement of human resources and the transfer of innovation from more developed areas.

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