EVALUATION OF INNOVATIONS AND INNOVATION POTENTIAL OF CZECH REGIONS AT THE NUTS 3 LEVEL

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Abstract: Innovation and innovation potential of the regions have played the key role for regional competitiveness. Hence the prime objective of the paper is to investigate evaluation of innovations using multi-criteria model, namely the Regional competitiveness Index (RCI) developed in 2010 by the Research Centre of European Commission for the purpose of regional competitiveness measurement of the EU regions at the NUTS 2 level. However, the model is still relatively unverified. Thus the paper finds out to what extend this measure is applicable in the regions at level NUTS 3. The indicators characterizing innovation potential of the region are revealed using multivariate analysis (namely principal component analysis). The evaluation compares mutual level of innovations in individual regions along with their development in years 2004 – 2009. The results of this paper will be used for construction of a holistic RCI model and for overall evaluation of competitiveness of regions in the Czech Republic.

Keywords: Czech Republic, innovation, innovation potential, region, regional competitiveness.

JEL classification: O31, O33, O47

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Introduction

The key objective solved in the frame of Cohesion policy, are the regional disparities and different level of development of the EU member states and their regions. The further the EU extends its borders, the more these disproportions grow. In the present programming period this negative effect should be suppressed through 3 goals: Convergence, Competitiveness and employment and European territorial cooperation. Regional disparities can be expressed in many forms, starting with different economic performance, unequal social conditions, level of health, education, innovation and technology, more or less developed business environment, institutional framework etc. All these areas and many others could be summarized into the group of factors determining the level of regional competitiveness. Wide range of new methods of its measurement emerged as this phenomenon has not been clearly and unambiguously defined yet These methods are predominantly multicriterial – based on aggregation of several indicators. Reaching the main objective of the paper the Regional Competitiveness Index (RCI) is used since it includes innovation as one of the crucial determinants of the overall competitiveness of the regions (Annoni and Kozovska, 2010).

1 Methodology

As noted the objective of the paper is the evaluation of disparities between the 14 Czech regions from the innovation point of view and development in the period 2004 – 2009. Although the RCI model is primarily aimed for evaluation of competitiveness of regions at the NUTS 2 level, the study of the Research centre published in 2010 creates suitable methodological framework also for application of the model on the regions at the level of NUTS 3. Therefore, the same technique is used consisting of following steps: selection of candidate indicators characterizing innovations, univariate analysis performance including data normalization and data transformation where necessary. Some values have to be reversed

to accomplish positive correlations to the level of competitiveness, i.e. the higher indicator value, the higher level of innovation and hereby competitiveness., Further, the principal component analysis is performed to reduce candidate indicators and ensure that the final evaluation will be based only on such indicators that unambiguously characterize innovations and innovation potential of the regions. Resulting scores of the innovation potential of individual regions are mutually compared and their development in time expressed using parallel line graph.

Data sources: Czech Statistical Office (CSO), Eurostat, Industrial property office, Czech national bibliography, Yearbook of education.

Measurement period: The value of indicators for the beginning period is calculated as a moving average of data collected in years 2004, 2005 and 2006. Ending period is again calculated as moving average of values measured in year 2006, 2007 and 2008. In cases where values were not available for all the years, we took only one-shot data.

2 Innovation and its linkage to growth and competitiveness of regions

The European Commission defines innovation as "*the renewal and enlargement of the range of products and services and associated markets; the establishment of new methods of production, supply and distribution; the introduction in changes in management, work organization, and the working conditions and skills of workforce*." The Commission of the European Communities (2005) also remarks that the main source of innovations is research and development (so called technological innovation). The differentiation of innovations is usually as follows: technological, material, product and organizational. According to National Innovation Strategy of CR (2004) *„innovation is more than just idea; it is implementation and bringing the idea to life."* The document notes that innovation have not to be confused with creativity. Creativity is a kind of human skill while innovation represents process beginning with an idea or thought, followed by different development stages, resulting into implementation itself. But for sure the idea as well as creativity represents integral parts of innovation.

Innovation is a special kind of factor that is not subjected to the law of diminishing returns, as it is in case of labor, capital, land and other basic production factors. All investments and expansion of production capital, building infrastructure or enhancing the quality of human resources has impact on the development of regions only within a limited time horizon. On the other hand, in the long run we identify one real resource of economic growth and growth of competitiveness of regions – it is already mentioned technological innovation (Sala-i-Martin et al., 2007). This phenomenon is clearly described by Neoclassical theory of exogenous growth by Solow (1956) claiming that only technological progress and technological innovations help to overcome steady state towards which each economy heads (theory of convergence). On contrary Romer (1994) and Lucas (1988) in their New theory of growth, integrate technology and innovation inside the model as endogenous variable. They claim that among the important factors leading to technological progress belong state and private business investments into the science and development, support of education and labor force training, since only educated and experienced people can be also innovative. Innovation and new technological processes require high level of savings that is, however, typical only for regions with high levels of income and production. Therefore, with respect to this theory, divergence among territories are commonly occurred. Innovations are also stressed by Joseph Schumpeter (1911) in his theory of creative destruction. He claims that only entrepreneurs and their entrepreneurial ideas can bring innovations leading to technological progress. It is

just firm´s innovativeness that creates new products, improves technologies, develops more effective business models and shifts those of poor quality, underdeveloped and unproductive backwards. He adds that innovations are concentrated in larger cities that form the most suitable conditions for innovation activity. Similar conviction is held also by Grossmann and Helpmann (1991). They note that firms start innovative activities with a vision of dominating the market and reaching monopoly profits coming out from technological progress. Firms and analogically also regional or national economies climb so called "quality ladder". By continuous improvement of products and production processes they themselves get to the higher level. They can offer better products for their clients / inhabitants and provide higher wages to their employees / residents.

Innovations are also closely connected with the theory of creative class introduced by Florida (2002) arguing that the "creative class" (represented by highly educated people working in science and technology, architecture and arts, business and juridical sphere) is significant for creation of dynamic and innovative environment suitable for business. Through creativity we are getting to the current phenomenon – knowledge economy – that should become the primary aim of the EU member states economies according to the Lisbon strategy (2000). The knowledge economy is such economy that is built on knowledge and experience, on creative activity and high qualification. No doubt the crucial task is played by education, research, development and innovation. In Lisbon (2000), new process was started stressing competitiveness, information society and creation of European space for research and innovation and creation of suitable environment for setting up and development of innovative firms, especially small and medium enterprises (SME). On 19. March 2003 the Czech Government accepted the Lisbon process through decision nr. 282 and in 2004 issued National Innovation Strategy expressing that the problem of innovation is one of its future priorities (National Innovation Strategy of CR, 2004).

3 Why innovation

While the less developed regions increase their productivity by adopting new technologies from others, those regions that already reached high stage of the development have to dedicate much effort and resources into science and research that form the essential precondition for innovation. Moreover, cooperation in science between universities and individual industries as well as intellectual property protection forms very important base for successful innovation policy (National Innovation Strategy of ČR, 2004). Innovation is the only way enabling regions to get over their already reached limits. In such economies it is necessary to develop cutting-edge products and new production processes in order to keep their competitive advantage. This, however, requires appropriate environment for innovation activities as well as support of public and private sector (Sala-i-Martin et al., 2007, Annoni and Kozovska, 2010). According to the OECD (1992) and Martin (2003) innovation is considered to be an interactive learning process that requires mutual actions among wide range of private and public regional actors. This process is influenced by many internal and external factors, starting with business partners, customers, competitors, over the disposable human capital, regional knowledge infrastructure, ending with institutions, regulations and legislation. These factors together create so called Regional Innovation System (RIS). Cooke (2002) defines RIS as a "systemic linkage that enables transfer of knowledge and innovations within and beyond the regional economy". Annoni and Kozovska (2010) stated that innovations and technological progress is strongly influenced by spatial proximity. From experience it is known that knowledge creation is spatially highly concentrated and the level of regional innovation ability directly influences way of the technology diffusion in the region.

4 Univariate analysis of indicators describing innovations in regions

The Research Centre of the European Commission selected 11 candidate indicators representing innovation competitiveness of the regions that enter the application part. The selection was primarily based on experts estimation, literature search and data availability. The candidate indicators are: patents awards, patent applications, core creativity class employment, research workers, scientific publications, R&D expenditures, human resources in science and technology, employment in technology and knowledge-intensive sectors, high-tech inventors, ICT inventors and biotechnology inventors.

First of all, univariate analysis of the 11 indicators involved in innovation pillar is performed. It was performed separately for both beginning and ending period. The detailed results of the descriptive analysis are summarized in the attachments 1 and 2. With respect to mean value there is 50 % success that patent applications become real patents The most inventors of EPO[1] patents are in the field of ICT, then in high technology and the least in biotechnology. The development of these indicators is rather random and has no single tendency. Only amount of high-tech inventions increased while the other types of inventions are declining. However the growth in employment of creative class and other human resources in science, technology and knowledge intensive sectors was confirmed, The average number of scientific workers in the Czech Republic increased nearly by 25 % in time. This might be a reaction on growth of Czech economy in years 2006 – 2008 and Lisbon strategy promoting conversion of EU regions into knowledge economies based on creative activity and high qualification of people. Positive, but still insufficient is also the development in R&D expenditures. The expenditures do not reach the target 3 % of GDP (as stated in Lisbon strategy) in any Czech region. As demonstrated in the attachments 1 and 2 the coefficient of variation of many indicators exceeds 50 %. This indicates heterogeneity of the data and differences among values. The capital of the Czech Republic, Prague, reaches the highest values in most of the indicators. Furthermore, these extremes have increasing tendency in time. On the other side, the minimal values are related mostly to the Karlovarský region. These values indicate decreasing trend, so the disparity of Karlovarský region is deepening.

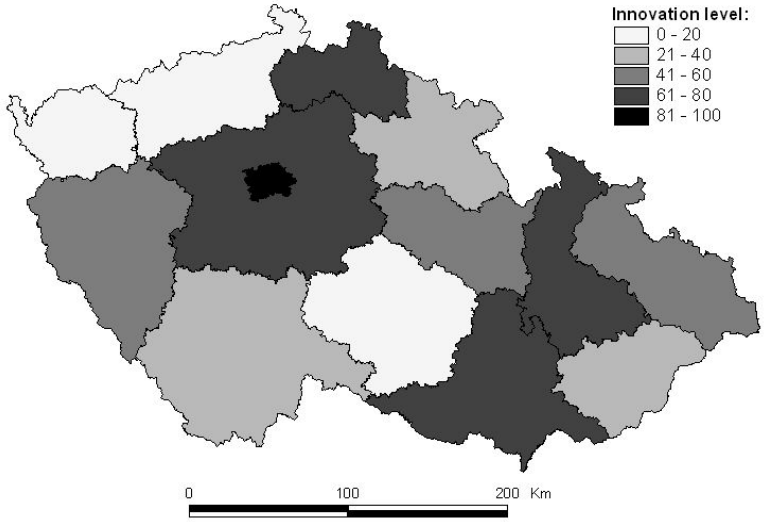
In the frame of univariate analysis a skewness testing was performed to confirm normal distribution. Several variables evince skew values exceeding the RCI range (i.e. <-1,5;1,5>) in both periods. Therefore, a logarithmic transformation was employed together with inverse transformation in order to fit the data into the given range where necessary. The result of the transformation was elimination of the indicator Employment in technology and knowledge intensive sectors since none of the above mentioned transformations led to the required level of skewness. Thus. only 10 from original 11 indicators were normalized and underwent the multivariate analysis. None of the indicators was reversed as all of them keep positive relationship to the level of innovation competitiveness.

5 Multivariate analysis and innovation score evaluation

The multivariate analysis was performed separately for both beginning and ending period. Using this analysis 3 indicators were eliminated. Biotechnology and high-technology inventions indicators were removed in the beginning period and biotechnology, high-technology and also ICT inventions were eliminated in the ending period. Overall 7 indicators were involved in the innovation competitiveness measurement. The results are demonstrated in the Figure 1 and Figure 2.

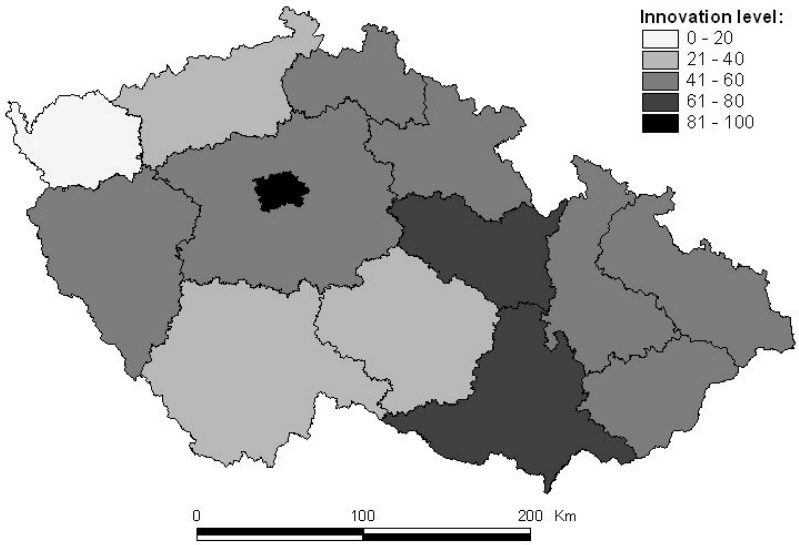
[1] EPO – European Patent Office

Figure 1: Spatial distribution of min-max normalized innovation score (2004 - 2006)



Source: own elaboration based on Eurostat, Czech Statistical Office et al. (2004 - 2006)

Figure 2: Spatial distribution of min-max normalized innovation score (2007 - 2009)

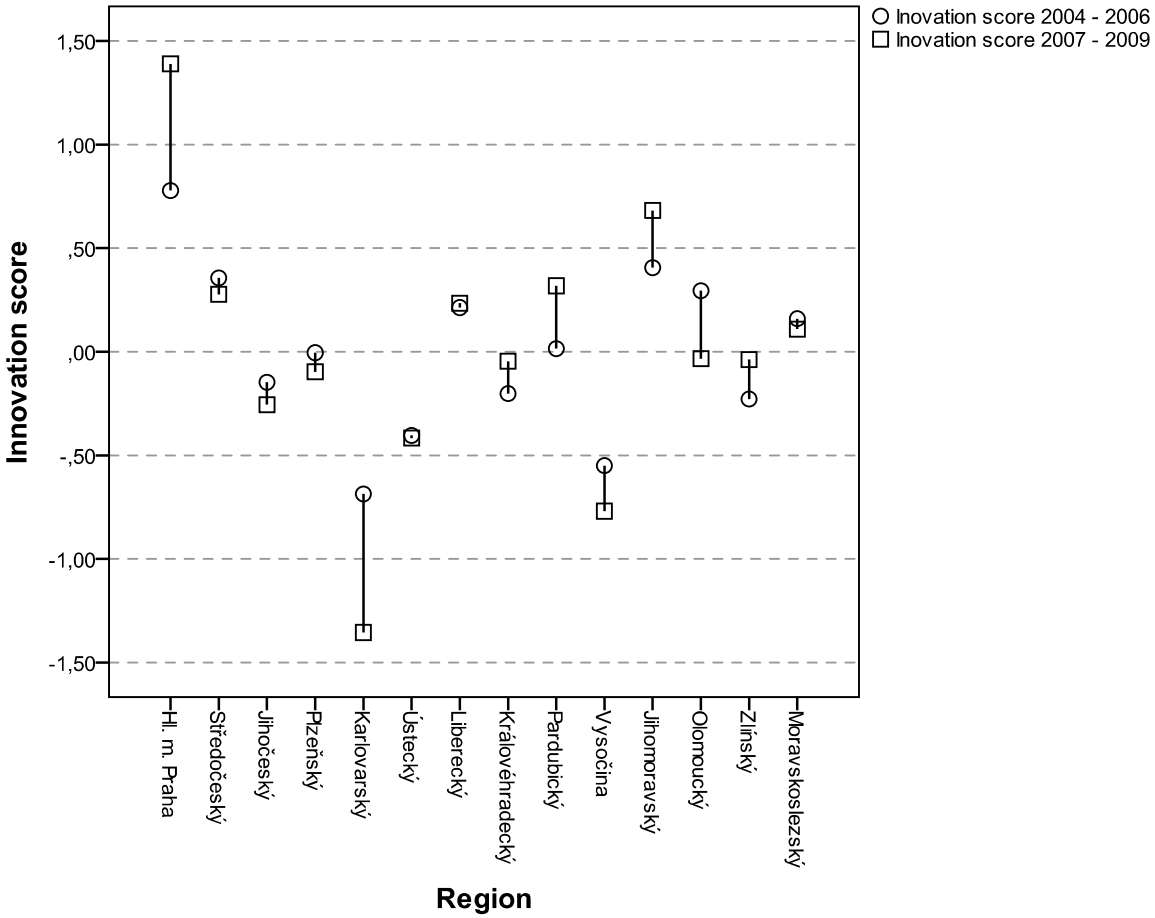


Source: own elaboration based on Eurostat, Czech Statistical Office et al. (2004 - 2006)

The figures depict the relative level of innovations and innovation capacity of Czech regions. According to the min-max transformed innovation score (see attachment 3) the regions were classified into five groups. Intensity of the color represents position of the region – the darker one indicates better innovation outcomes and innovation capacity of the region. The strongest position in innovation in both periods maintains Prague. However, Prague represents a national metropolis with high concentration of population, trade and industry, lacking the rural areas (typical for all other Czech regions) which are usually source of inefficiency. This gives Prague a unique position. Prague, as the capital city of the Czech Republic, concentrates majority of prosperous firms and institutions as well as educated and creative people from whole country. These firms and creative class employed in science, technology and knowledge-intensive sectors bring perfect score in patent applications, patent awards and scientific publications. Innovations and new technology inventions are supported by relatively high R&D expenditures.

In beginning period, the second best position is occupied by regions: Středočeský, Liberecký, Jihomoravský and Olomoucký. However during the time 3 of them (Středočeský, Liberecký and Olomoucký region) fell to the third level. All other relative changes in time have increasing tendencies. In the third (middle) category, there were originally 3 regions: Plzeňský, Pardubický and Moravskoslezský. At the end, the number of regions in this category more than doubled, so it covered: Středočeský, Plzeňský, Liberecký Královéhradecký, Olomoucký, Zlínský and Moravskoslezský region. Positive tendencies are visible also in case of Ústecký region and region Vysočina that moved from last position one level up. The relatively worst performing region remains Karlovarský region in both periods.

Figure 3: Innovation score development in Czech regions 2004-2009



Source: own elaboration based on Eurostat, Czech statistical office data et al.

The drop-line chart (see Figure 3) revealed various tendencies in the development of innovations throughout the Czech regions. The following ones: Prague, Jihomoravský, Pardubický, Zlínský and Královéhradecký improved their innovation competitiveness during the monitored period. The common characteristics of these regions, contributing to the high level of innovation competitiveness, are diversified economies with strong engineering, chemical and also electronic industry (particularly in Jihomoravský region). Significant role received expanding number of scientific workers and human resources working in knowledge intensive sphere. The significant decline occurred in hereinafter regions: Olomoucký, Vysočina and Karlovarský. Olomoucký region is partially disadvantaged by its rural peripheral area on the north and by emigration of population. The slow innovation development of the region Vysočina may be connected with its location in the internal periphery of the Czech Republic, no strong industrial centre and sparse population.

Karlovarský region is a typical structurally disadvantaged region with declining mining, chemical and ceramic industry, degraded environment in Sokolov district, declining social structure and migration of population into neighboring region. To sum it up, regions with the most divergent development are Prague and Karlovarský region where in the first case innovation score increased from 0,78 to 1,39 and in the second case dropped from –0,69 to –1,36 units. In this short period results of innovation score development indicate that neither the European nor any other national or regional activities supporting innovations have significant and positive influence on the regions. To evaluate efficiency of the above mentioned tools it is necessary to consider data describing situation of the development in long run where also fixed resources e.g. innovation infrastructure, university education and traditions in industries can be changed.

Conclusion

The capital, Prague, achieves the most dominant position in all measured indicators and also in overall innovation score (in absolute as well as relative measures). However, being aware of Prague, the Jihomoravský region is considered as the best performing Czech region. On the other hand, Karlovarský region keeps the worst position in innovation evaluation in both time periods and its innovation competitiveness level is sharply declining in that time. Stagnation reaches 10 from total 14 regions within the innovation score from -0,5 to 0,5. Therefore, the level of innovation in most of the regions does not demonstrate significant change over time according to the absolute measure. The disparities in innovation among regions are diminishing. In the beginning period the spread of regions within the 4 categories (excluding the first category including only Prague) was indicated as balanced. However, regions concentrated on the third level. characterized by min-max innovation score, falling within interval <41;60> in the final period. Accordingly, convergence among regions can be detected (with exception of Prague) and the same tendency can be expected in following years.

The results of the analysis prove not favorable development of innovation and innovation capacity of the Czech regions. The aim declared by Lisbon strategy (2000) to convert EU and its regions by the year 2010 into most competitive knowledge-based and innovative territories will probably not be reached in the Czech Republic. Therefore, it is strongly recommended to focus on this matter and boost efficiency of all resources (EU, national, regional and also local) used to improve innovation competitiveness in the Czech regions. The future positive development could be strongly influenced by higher public and private investment in research and development (R&D), offers of tax incentives supporting private investments into innovations, foundation of technological development centers, focus on quality of university education and support of cooperation between research institutes and industries.

Method RCI is based on range of indicators describing clearly and unambiguously innovation and innovation potential of the regions. One of its disadvantages is the extensive data collection and necessity of data transformations This method is more relevant for innovation competitiveness measurement in long run. The used time series it could be also recommended as methodology for the public administration, especially for the Ministry of Industry and Trade, Ministry of regional development and Research and development council.

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Attachment 1: Innovation indicators in the Czech Republic 2004 – 2006

Innovation indicator	Patent awards	Patent applications	Core creativity class employment	Research workers	Scientific publications	R&D expenditures	Human resources in science and technology	Employment in technology and knowledge-intensive sectors	High-tech inventors	ICT inventors	Biotechnology inventors
Unit of measurement	Number of awarded patents per 1 mil. Inhabitants	Number of patent application per 1 mil. Inhabitants	Academic workers and employees in R&D (% labor force)	Research workers (recalculated persons)	Scientific publications per 1 mil. inhabitants	R&D expenditures (% GDP)	% labor force	% of total employment	Number of inventors of high-technology EPO patents per 1 mil. inhabitants	Number of inventors of ICT EPO patents per 1 mil. inhabitants	Number of inventors of biotechnology EPO patents per 1 mil. inhabitants
Source of data	CSO, calculation	Industrial property office, calculation	CSO, Yearbook of education, calculation	CSO	Czech national bibliography, calculation	CSO, calculation	Eurostat, CSO, calculation	Eurostat	Eurostat	Eurostat	Eurostat
Mean	27,06	52,14	1,01	1591,57	182,40	1,02	34,24	23,54	1,18	2,59	0,58
Std. Deviation	18,70	33,19	1,01	2537,38	163,72	0,74	7,94	5,30	1,44	2,40	0,62
Skewness	2,13	2,92	3,09	3,11	1,14	0,86	2,83	3,34	2,93	1,44	1,65
Region (min value)	VYS	KV	KV	KV	KV	ZL	KV, ÚST	OL, ZL	JHČ, PLZ	MS	KV, ÚST
Region (max value)	PHA	PHA	PHA	PHA	PHA	STČ	PHA	PHA	PHA	PHA	MS

Source: own calculation based on Eurostat, Czech statistical office, Industrial property office, Yearbook of education and Czech national bibliography (2004 - 2006)

Attachment 2: Innovation indicators in the Czech Republic 2007 – 2009

Innovation indicator	Patent awards	Patent applications	Core creativity class employment	Research workers	Scientific publications	R&D expenditures	Human resources in science and technology	Employment in technology and knowledge-intensive sectors	High-tech inventors	ICT inventors	Biotechnology inventors
Unit of measurement	Number of awarded patents per 1 mil. Inhabitants	Number of patent application per 1 mil. inhabitants	Academic workers and employees in R&D (% labor force)	Research workers (recalculated persons)	Scientific publications per 1 mil. inhabitants	R&D expenditures (% GDP)	% labor force	% of total employment	Number of inventors of high-technology EPO patents per 1 mil. inhabitants	Number of inventors of ICT EPO patents per 1 mil. inhabitants	Number of inventors of biotechnology EPO patents per 1 mil. inhabitants
Source of data	CSO, calculation	Industrial property office, calculation	CSO, Yearbook of education, calculation	CSO	Czech national bibliography, calculation	CSO, calculation	Eurostat, CSO, calculation	Eurostat	Eurostat	Eurostat	Eurostat
Mean	25,27	58,66	1,26	2057,64	191,93	1,22	38,00	24,16	1,33	1,90	0,53
Std. Deviation	20,59	44,20	1,24	3329,38	179,04	0,75	8,31	5,85	1,03	1,63	0,45
Skewness	2,33	2,92	2,79	3,05	1,27	0,58	2,76	3,52	0,21	0,76	0,33
Region (min value)	ÚST	KV	KV	KV	KV	KV	KV	KV, ÚST	JHČ, PLZ	JHČ, PLZ	KV, ÚST
Region (max value)	PHA	PHA	PHA	PHA	PHA	PHA	PHA	PHA	PHA	PHA	VYS, JHM

Source: own calculation based on Eurostat, Czech statistical office, Industrial property office, Yearbook of education and Czech national bibliography (2004 - 2006)

Attachment 3: Innovation score and innovation min-max normalized score in the Czech Republic 2004-2006, 2007-2009

		Innovation 2004-2006		Innovation 2007-2009	
Region	Region code	Innovation score	Min-max normalized score	Innovation score	Min-max normalized score
Hl. m. Praha	PHA	0,78	100	1,39	100
Středočeský	STČ	0,36	71	0,28	60
Jihočeský	JHČ	-0,15	37	-0,26	40
Plzeňský	PLZ	0	47	-0,1	46
Karlovarský	KV	-0,69	0	-1,36	0
Ústecký	ÚST	-0,4	19	-0,42	34
Liberecký	LIB	0,21	61	0,23	58
Královéhradecký	KH	-0,2	33	-0,05	48
Pardubický	PAR	0,01	48	0,32	61
Vysočina	VYS	-0,55	10	-0,77	21
Jihomoravský	JHM	0,41	75	0,68	74
Olomoucký	OL	0,29	67	-0,03	48
Zlínský	ZL	-0,23	31	-0,04	48
Moravskoslezský	MS	0,16	58	0,11	53

Source: own calculation based on Eurostat, Czech statistical office, Industrial property office, Yearbook of education and Czech national bibliography (2004 - 2006)