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**Article**

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## INFLUENCE OF CLUSTERS ON THE INTENSITY OF INNOVATION OUTPUTS

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### Abstract

The article evaluates the impact of clusters on innovation outputs in the regions of the Czech Republic. The research was divided into four main phases. An overview of all institutionalised clusters in the Czech Republic, including innate clusters, was compiled in the first phase. Location quotients were used to identify innate clusters. For institutionalised clusters the main declared field specialisation, membership basis and cluster age were established. In the second phase, 5 most important branches were defined per each region by number of employees. Subsequently, the hypotheses that innovation characteristics of the regions depend on the number of clusters, their average age and the number of members were tested. Innovations were characterised by patent applications, utility models, total R&D expenditure and export of technology services. All values were examined as incremental for the period of 2009 to 2012 per one full-time researcher. None of the determined hypotheses were confirmed. There is no systematic dependence between the innovation outputs in the regions and clusters. The possible reasons for this fact are discussed in the article, such as the short time clusters have been operating in the CR, the impact of the economic crisis or underestimating the existence of innate clusters. In the last phase of the research, innovation outputs were evaluated for the branches with operating clusters in respective regions and compared with total innovations per branch in the CR. Two regions were selected to serve as an example. The analysis showed that innate non-institutionalised clusters can also have a major impact on innovation outputs in regions.

**Keywords:** branch structure, cluster, cluster initiative, innovation, innovation outputs, institutionalized cluster, Porterian cluster

**JEL Classification:** D85, L14, L24, O31, O32

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### Introduction

Innovation is the cornerstone of competitiveness of businesses and national economies. Clusters, as entities based on cooperation and competition of independent businesses and associated institutions, play a major role in supporting innovation.

More than € 32M has been spent on cluster support as part of operational programmes in the Czech Republic since 2004. These funds were used to support nearly 80 cluster projects

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(CzechInvest, 2013b). In addition to clusters that were formed by public state intervention, innate clusters also originated in the Czech Republic.

This article aims to evaluate the development of innovation outputs from 2009 to 2012 in individual regions of the Czech Republic and to discover if their intensity was influenced by cluster groups that were formed and financed from public funds in the last couple of years. The research is based on the assumption that cluster groups should generate innovation because supporting innovation is the main reason for setting up cluster initiatives. By creating clusters the innovation outputs in regions should improve. The article seeks to answer three main research questions; whether innovation characteristics in regions depend firstly on the number of clusters in the regions, secondly on their average age, and the third on the extent of their membership. The intensity of innovation outputs was measured by implemented innovations, applications for the protection of industrial property and revenue from the sale of research and development results. Total research and development expenditure and export of technology services were also used to characterise innovative activities.

Furthermore, on the example of two selected regions, the article evaluates whether the declared branch of the institutionalised clusters is based on the dominant sectoral focus in the region and is able to create the core of the cluster in the Porterian concept.

### 1. Theoretical background and literature review

In the last two decades the issue of interorganizational relations, in particular in connection with the analysis of impacts of various forms of partnership (strategic alliance, joint ventures, various types of social networks) on enterprise performance, has been discussed in specialized literature (Kehler, 2004). The concept of interorganizational partnership covers a wide spectrum of forms, starting with arm's length transactions (standard transactions, basic buying and selling), various types of cooperation (e.g. licensing, franchising, strategic alliance, network organizations, joint venture) up to integration (Golicic et al., 2003). Economic independence of partners (concerns) or their legal independence (e.g. mergers and acquisitions) is restricted in pursuance of the integration process. Wöhe (1995) uses the term concentration to describe this condition.

Integration and cooperation performed as part of company management refers to connecting businesses with a similar focus from a horizontal or vertical point of view in order to save costs and acquire a bigger share in the market with respective products or services. Integration and cooperation of businesses is not a new business model. Companies can be integrated and can cooperate either vertically or horizontally. Many authors (e.g. D'Aveni and Ravenscraft, 1994, Frohlich and Westbrook, 2011, Häkkinen et al., 2004, Mahoney, 1992, Zhang, 2013) discuss horizontal and vertical partnerships; however, the question is which form is most beneficial for companies and under what conditions. For example Voorde and Vanelslander (2009) state that the horizontal connection, i.e. a partnership between companies working in the same sector, is implemented rather through alliances than mergers. On the other hand, the vertical connection of companies, i.e. a more close liaison between partners within the whole supply chain, has the tendency to form joint ventures and create specialised management methods. A combined partnership must be considered as part of the current supply chains managed by customer. A term 'lateral alliance' was created to combine vertical and horizontal alliances (Naik et al., 2010).

Alliances represent an alternative to market relationships and integration. Nowadays, they represent the fundamental element of network economy. Networks are defined as a selected set of autonomous organisations that are directly or indirectly interacting and that are based on alliance agreements among these organisations. The objective of the network is to acquire a competitive advantage, both for its members and for the network as a whole (Fiala, 2008). In particular, small and medium enterprises strive to form strategic alliances that enable them to form power groups. These groups can better protect their joint interests against large businesses. Alliances of such type are represented particularly by clusters (Vodáček and Vodáčková, 2009). Pavelková et al. (2009) consider clusters to be new, more complex forms of cooperative business within networks. Leeder et al. (2004) add that compared to other types of networks, clusters differ due to their openness to public institutions and their link to a specific region.

The standard definition of clusters by Porter (1998, p. 78) reads: „*Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and other institutions – such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations – that provide specialized training, education, information, research, and technical support.*“

Clusters can either be formed as innate formations of interconnected businesses in a specific region, or they can be a result of organised efforts, known as cluster initiatives. As mentioned by Pavelková et al. (2009), according to Porter, clusters are not considered a type of organisation or a result of a certain project. A cluster exists regardless of whether the businesses are aware of it or not. Pavelková et al. (2009) calls such clusters Porterian or innate. By comparison, cluster initiatives express industrial, regional and innovation state policies.

Clusters in the Czech Republic have a relatively short tradition. Their development can be divided into two phases. In the first phase, defined by the years of 2002-2006, cluster concepts described in the Czech professional literature were introduced to the state administration and business managers working in the fields with a cluster potential. Concurrently, European structural funds supported mapping and foundation of clusters using cluster initiatives. 53 cluster projects were supported from public funds in 2004-2007. In particular, the mapping of possibilities to form cluster groups was supported; the beneficiaries were, for example, universities preparing projects. In the second phase, which started in 2007, cluster activities focusing on the development of innovations and international competitiveness (Skokan et al., 2012) were supported. So far, 25 cluster projects were supported in the second phase (CzechInvest, 2013b), see table no. 1. In this case the grant from public funds was drawn for a specific cluster group, and it is registered in the CEDR information system (a centralised system for recording grants from the state budget).

Kettels (2003) can see clusters benefitting three areas: a higher level of efficiency, a higher level of innovation and a tendency to enlarge clusters. Clusters support innovative levels, in particular by sharing knowledge, and narrow integration with customers and other

enterprises; this enables generating new ideas, whereas the cluster environment decreases the cost of experimenting. Out of all advantages arising out of the concentration of companies in a cluster, Rosenfeld (2002) considers the access to innovation, knowledge and know-how to be the most important ones. The conditions are geographical vicinity of partners, a close liaison with suppliers, a highly educated workforce, the existence of research and development equipment and presence of leaders in the branch. Lan and Zhangliu (2012) analyzed the mechanism of interactive learning and processes of knowledge sharing in the clusters of small and medium sized enterprises. They found out that knowledge spillover increases the dynamics of clustering. Companies within clusters exchange and share knowledge using face to face interactions which significantly strengthens innovation.

Supporting innovation belongs to the key aspects of cluster operation. Pavelková et al. (2009) state that clusters enable the businesses involved to improve their competitiveness, in particular by increasing their productivity, through higher innovation potential of cooperating enterprises, and growing clusters and spin-offs of new businesses. Innovation potential is positively influenced by knowledge spillover within clusters, generating new ideas and putting more pressure on innovation. The objective of supporting innovations in clusters should be to develop products with higher added values.

The innovation potential of clusters is fundamental for the development of clusters. Pavelková et al. (2013) carried out a survey of 1,110 member companies in Czech clusters on the basis of which a conclusion was made that innovative activities of enterprises in cluster organisations were at a low level. Only the processing industry showed higher values. During the evaluation of cluster excellence in the Czech Republic the role of clusters in the innovative environment was examined on the basis of data showing the representation of universities and research centres in the membership base, data on company participation in innovation projects, economic data (R&D investment) and research, development and innovation results. The obtained results confirmed the rule that excellence in clusters is achieved after several years of development (3 years minimum). Evaluation of the innovative role of clusters positively depended on the representation of universities and research centres in the membership base and on their participation in innovation projects. The finding that the innovation advantage of clusters is closely linked to the cooperation among companies, universities and research institutions is also mentioned by Lan and Zhangliu (2012). A similar conclusion was reached on an empirical basis by Vicedo and Vicedo (2011) who, using the Spanish textile cluster as a case study, document the positive impact of cooperation with universities on the innovation of member companies, in particular with regard to R&D.

Rydvalová and Pittnerová (2013) analysed innovative activities of companies in the glass and bijouterie industry in the Czech Republic (using the CZ-NACE classification, branches 231 and 321) which has a character of an innate cluster. The analysis showed that most often companies implemented marketing innovation. Companies used mostly private resources to finance innovation. The overall innovative potential of companies was very low. It was established that the priority of companies is to manage current problems and that thinking about their future development, including innovation, is postponed.

In 2007-2011 Jirčíková et al. (2013) carried out a survey of 169 clusters in 23 countries in the world. The survey examined the preferences of 8 basic types of cluster activities, inter alia, research and innovation. Research and innovation is the second most frequent activity

in clusters, immediately following the networking. Research and innovation activities were implemented in more than 60% of investigated clusters, and other approximately 20% of clusters planned to implement these activities in the upcoming years.

There are many more empirical surveys investigating the influence of clusters on innovation in specific clusters discussed in literature. Shu-en and Nie (2007) surveyed an optoelectronic cluster in China to find out that sharing knowledge with customers and suppliers increases company product and process innovations. Specifically, companies with a higher level of shared knowledge create more innovations. Another study carried out on a sample of 166 automobile companies in China (Wu et al., 2013) examined the impact of the cluster age, R&D investment and other variables on innovation. The number of patents in the following three categories was used to measure innovation: invention, utility model and exterior design. The analysis shows that the most important factor is the age of the company as it has a positive and significant impact on corporate innovations. On the basis of an analysis of 1,772 companies from an electronic cluster in Korea it was established that clusters, open innovation and fast learning are factors that have enabled Korean electrotechnical companies to successfully fend off Japanese and US competition (Park et al., 2012). Foley et al. (2011) show clusters as a suitable form of public private partnerships that has proven itself when supporting innovation for energy saving constructions. A research carried out by Hsieh-Sheng (2011) proved a positive correlation between high-tech industry clustering and innovation in Taiwan. Occurrence of clusters was measured using localisation coefficients in this study (see also Skokan, 2004); innovations were quantified using the number of patents. Huang and Rice (2013) carried out an extensive survey of 3,468 European companies in 14 different branches, focusing on the impact of different factors on innovation. Innovation was seen as introducing a new or significantly improved product or service to the market in the last two years. The research results show that clustered companies have closer links with universities, more efficient flows of knowledge, exchange of tacit knowledge and they are less dependent on internal research. Islam (2010) compared the efficiency of textile companies in clusters and outside clusters in Pakistan. A conclusion was reached that companies in clusters reached higher productivity, innovation, they introduced new products to the market and made greater investments into modernisation of their machinery. On the other side, financial efficiency of both groups of the compared businesses did not significantly differ. To a certain extent the financial efficiency corresponds to other studies dealing with the influence of different forms of cooperation between companies on their profitability. Institutionalised clusters, in particular, can induce effects known from vertical integration (see e.g. D'Aveni and Ravenscraft, 1994, Zhang, 2013). These include, for example, increasing overhead costs as a result of increased internal coordination, inefficient purchases of inputs for production, problems with coordination of independent activities, unused and unbalanced capacity or bureaucratic costs (see for example Huang and Rice, 2013).

Lang (2009) sees creation of homogenous macroculture, discrepancy of social identity, power imbalance, rationalisation of markets, lack of untraded interdependencies and occurrence of negative externalities as cluster negatives. Frohlich and Westbrook (2001) in their study covering 322 enterprises from 23 countries in the world reached the conclusion that partial integration only leads to a small improvement in performance. It is necessary to take into consideration the fact that in order for innovations to succeed in clusters, several basic success factors must be observed. In particular, there must be educated staff with technology qualification, corporate R&D, financial resources, enquiring customers and

complementary commercial services (Mohannak, 2007). It can be added that the efficiency of clusters is closely associated with the method of governance and the scope of formal and informal institutions influencing the governance. Industrial policy and its orientation towards supporting clusters also play an important role (Parto, 2008). Nishimura and Okamuro (2011) examined the impact of the Industrial Cluster Project in Japan on innovation and R&D productivity of its participants (the sample contained 229 SMEs). The number of patent applications and application forms and quotations in other patents were used to measure innovation. The conclusions of the research showed that the actual participation in the project does not guarantee increased R&D efficiency. It was not confirmed that companies participating in the cluster project submitted more patent applications than independent companies. On the other hand, the research proved the hypothesis that cluster members cooperating with national universities in the same region were more active with regard to submitting patents which is probably connected with deeper involvement (not only a formal one) in cluster activities.

As shown by the implemented research, the success of a cluster is influenced by the quality of the business environment. Viturka et al. (2013) identified 7 important factors of the business environment quality which includes 16 sub-factors. These sub-factors include support services, i.e. the occurrence of businesses providing production services (businesses offering professional, scientific and technical activities, administrative and support activities), the entrepreneur factor and a knowledge base covering regional information on industrial zones, scientific-technological parks, business incubators, universities, colleges, high schools and research centres. These factors, according to Porter (1998), comprise supporting cluster elements.

Quantification of knowledge transfer is a fairly complex matter. Patents are usually used as a simple measure which is based on the idea that transfer and application of tacit knowledge create innovation leading to patents (Almeida et al., 2002). Szabo et al. (2013) evaluated innovative capacity and performance of businesses in Romania using a summary innovation index (SII). This index is comprised of individual indicators based on the innovation efforts of businesses and effects of corporate innovative activities. The analysis showed a positive correlation between the SII index value and the share of population with tertiary education and the share of innovative SMEs collaborating with one another. The analysis also showed that cooperation between innovative SMEs has a positive impact on innovative activities of businesses.

## 2. Research Methodology

The research was divided into several consecutive phases. In the **first phase** it was essential to compile an overview of all clusters operating in the Czech Republic. A CzechInvest database (2013c) was used as starting point. The database includes an overview of existing clusters in the Czech Republic, showing their branch specialisation, year of origin, seat and a link to their website. The database shows 79 clusters and cluster organisations. The number of active clusters is smaller, only 62 (CzechInvest, 2013a). In addition, there are innate clusters that are not institutionalised (e.g. the bijouterie cluster in the Liberec Region). Their identification was made in 2004 when potential clusters were mapped out in the Czech Republic and there were branch analyses carried out in individual regions, including round table discussions with local experts. Evaluation of innate clusters is very difficult as they do not comprise one legal entity with a clearly defined number of

members. Only institutionalised clusters were covered by the analysis in the first phase of the research.

The existence of public support was registered only when a grant was utilized for creation of a cluster group. In this case, the drawing of the grant was listed in the CEDR information system (Ministry of Finance, 2013).

In addition, it was essential to determine the main branch specialisation of the clusters and their membership base. CzechInvest (2013b) states the main declared branch specialisations of clusters based on the CZ-NACE classification and the total number of members per cluster. Websites of individual clusters were analysed for detailed identification of the membership base. The number of employees of the main “umbrella organisation” for the cluster group (cluster operators), their branch specialisation and year of foundation were established. CzechInvest data from the ongoing mapping of the development of cluster initiatives from 2004 was used, in addition to the data from the ARES register (Ministry of Finance, 2013). The analysis resulted in a database including the following data:

- main business activities of the cluster operator,
- year of cluster foundation,
- regional delimitation based on the seat of the group,
- contact and link to the website,
- a list of and contact for members involved in the cluster, both registered in the Business Register and stated on publicly available websites of the clusters,
- main business activities of individual cluster members.

The most significant branches in the regions of the Czech Republic were analysed in the **second phase** using CZ-NACE classification and its three digit codes (groups). Since the publicly available database of the Czech Statistical Office (CZSO) does not include data in so much detail, the company database of MERIT-CDF (Meritum, 2012) was used as a data source. The database includes the number of employees in individual companies in 2011. In order to establish the rate of employment in the branches, it was essential to aggregate the corporate data by the main business activities using CZ-NACE classification. In each region, five branches with the largest number of employees were specified and location quotients were determined for these branches as follows (1).

$$LQ_i = \frac{e_i / e}{E_i / E} \quad (1)$$

where:  $LQ_i$  is the location quotient for the branch  $i$ ,  $e_i$  is the number of employees in the branch  $i$  in the region,  $e$  is the total number of employees in the region,  $E_i$  is the number of employees in the branch  $i$  in the country and  $E$  is the total number of employees in the country.

If LQ is higher than 1, the respective branch employs more workforce regionally than nationally (Skokan, 2004). Location quotients show the branch specialisation of the region. An overview of the most important branches in the region was published in the work of Žižka et al. (2013) and was used for the purpose of further research in this article.

The declared specialisations of clusters with dominant branches in individual regions were compared in the **third phase** of the research with the aim to establish the level of



compliance with the branch profile. The declared specialisation of clusters was first converted into the three digit code of the CZ-NACE classification. This process consisted of the following steps:

- analysis of the specialisation of individual cluster members, focusing on the main business activity (stated first in the register of business entities).
- if it was one specific branch, e.g. bijouterie (CZ-NACE 321), no further data had to be searched for,
- if the cluster declared a wider specialisation, it was essential to aggregate data for all related branches (e.g. in the Hradec Kralove Region food processing industry – aggregated branches CZ-NACE 101 to 108).

The successive and fundamental part of the research focused on the quantification of the impact of clusters on innovation in all regions of the Czech Republic. First, the following **hypotheses** were tested: innovation characteristics in the regions depend on:

- the number of clusters in the regions,
- the average age of clusters in the region,
- the number of members in the cluster per 1000 business entities in the region.

Input data were taken from CZSO (2013b, 2013c) for the time period of 2009-2012:

- patent applications filed by domestic applicants at the Industrial Property Office of the CR (IPO) by application year and region,
- utility models registered by domestic applicants at the IPO CR by year and region,
- total R&D expenditure by year and region,
- exports of technology related services by year and region,
- researchers by year and region (full-time equivalent – FTE),
- registered businesses total by region.

Technology related services include IT services, research and development, technical services, procurement and sale of ownership rights and charges for licences and trademarks.

Ratio indicators were created on the basis of these absolute indicators, representing the increase in innovation outputs per one researcher (full-time equivalent, FTE) in the region. The increase in innovation outputs for 2012 was examined and compared to the base year 2009, i.e. for a four year period which roughly corresponds to the average age of clusters in the CR (see table no. 1). Positive effects of clusters on innovation performance should already show during this period (see Pavelková et al., 2013).

The intensity of innovation outputs was measured using the following indicators:

- PATENT – increase in patent applications and utility models per researcher in the region during 2009-2012,
- R&D – increase in R&D expenditure in CZK million per researcher in the region during 2009-2012,
- TECH\_SERV – increase in the export value of technology services in CZK million per researcher in the region during 2009-2012.

Independent variables were the number of clusters in regions (CLUSTER), their average age (AGE) and the number of member organisations per 1,000 business entities in the region (MEMBERS).

Pearson product moment correlation coefficients and Spearman rank correlation coefficients were used to measure dependencies. Pearson correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Spearman correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients (StatPoint, 2010).

In the **last phase** of the research the intensity of innovation outputs of clusters per branch specialisation was evaluated. As mentioned above, clusters have been mapped in the Czech Republic since 2004. Since no significant impact of institutionalised clusters on innovation outputs was established in the previous phase of the research, innate (Porterian) clusters were included in the last phase too. The specialisation of Porterian clusters was defined using location quotient (formula 1) by the number of employees in the respective region using a three digit numeric CZ-NACE code. For clusters registered in the CzechInvest database, branch specialisation declared by respective subjects was used. Subsequently, the declared branches were converted using the CZ-NACE numeric code. Due to the restricted scope of the article, an example of the analytical approach is presented using two regions (NUTS 3 level), i.e. the Liberec Region (LBK) and Hradec Kralove Region (HKK).

Evaluation of the intensity of innovation outputs was implemented using data from the CZSO survey (2013a) marked as VTR5-01 for 2009-12. CZSO monitors the characteristics of research and development (R&D) outputs using a direct statistic survey; all legal entities and sole traders involved in R&D in the Czech Republic as their main or auxiliary business activity have been participating in this survey. The research is comprehensive for the government, university and private non-profit sector. For the business sector, a rotary selection of a third of the enterprises complying with the determined conditions is used. The following indicators of innovation outputs were selected:

- introduction of technical and non-technical innovations – use of R&D results for new or innovated technology, machinery, equipment, productions, materials etc.;
- submitted applications for the protection of industrial property – using R&D results for patent applications and other subject matters of the protection of industrial property;
- sold R&D results – R&D results are sold to another entity.

The stated results were compared by the respective year (2009-2012), branch and region. The ratio of the innovation output indicator of the respective branch in the region was compared against the indicator of the respective branch in the Czech Republic.

Further, with the use of keywords, there was examined information about industrial property rights registered in the Czech Republic (IPO) and industrial property rights registered in foreign countries which are valid in the Czech Republic (i.e.: EPO – European Patent Office, WIPO – World Intellectual Property Organization, OHIM – Office for Harmonization in the Internal Market).

### 3. Results of analysis

Basic characteristics of institutionalised clusters in the Czech Republic were determined in the first phase, regardless of whether they originated with or without public support of the CzechInvest agency (table no. 1). The average age of clusters in the Czech Republic

exceeds four years which, based on the findings (Pavelková et al., 2013), should mean that the first positive impacts of clusters on innovation should already be evident.

Table 1 only contains institutionalized clusters; however, in some cases institutionalized clusters have grown on the basis of innate clusters that operated in the region for several years. A cluster of technical textiles in the regions of Liberec and Hradec Kralove may serve as an example. In both regions this branch shows a geographic concentration (according to LQ) with the existence of educational and research institutions. This innate cluster focused on the textile industry existed in these regions for decades. After the establishment of a specialized program to support clusters, companies, research institutions and the university opted to institutionalise their cooperation in order to overcome branch crisis with the use of subsidies from public sources. Based on the above mentioned findings, just these two regions were subjected to further in-depth analysis that also included innate clusters.

The basic descriptive characteristics of the values typical for innovation are stated in table no. 2. High variability of data is clearly evident at first sight.

**Table no. 1: Main characteristics of institutionalised clusters in the Czech Republic**

Region	Number of clusters	out of which clusters formed with public support	Number of members	Average age in years	Standard deviation
HKK Hradec Kralove	6	3	125	6.00	1.29
JHC South Bohemia	11	3	181	4.27	2.30
JHM South Moravian	12	3	215	4.17	2.11
KVK Karlovy Vary	2	0	9	4.50	0.50
LBK Liberec	4	1	31	4.00	3.00
MSK Moravian-Silesian	14	6	458	5.86	2.29
OLK Olomouc	6	1	56	3.67	2.56
PAK Pardubice	3	1	58	4.75	1.48
PHA Prague	2	0	8	2.50	0.50
PLK Pilsen	1	0	14	2.00	0.00
STC Central Bohemian	7	4	159	3.57	2.06
ULK Usti nad Labem	2	0	6	2.50	1.50
VYS Vysocina	4	2	59	3.75	1.48
ZLK Zlin	5	1	87	4.40	1.85
<b>Total</b>	<b>79</b>	<b>25</b>	<b>1,466</b>	<b>4.44</b>	<b>2.28</b>

*Sources: CzechInvest, 2013c, Ministry of Finance of the CR, 2013, own calculations*

In 5 regions the absolute and recalculated numbers of patent applications and utility models decreased in the monitored four year period. These were South Bohemia, Usti nad Labem, Hradec Kralove, Vysocina and Olomouc Regions. The highest increase was recorded in the region of Moravia-Silesia where there is also the highest number of clusters. The highest drop was recorded for the region of Vysocina where there are 4 clusters. The highest

increase in R&D expenditure was recorded in the region of Liberec; on the other hand in the region of Hradec Kralove the R&D expenditure decreased despite the fact that there are 6 clusters operating in the region. The export of technology services in the monitored period decreased in 2 regions (South Bohemia, Pilsen); the highest increase was recorded in the region of Zlin.

**Table no. 2: Basic statistic characteristics of innovation outputs**

	<b>PATENT</b>	<b>R&amp;D</b>	<b>TECH SERV</b>
Average	0.0064	0.9896	0.6159
Standard deviation	0.0330	0.6596	1.1414
Coeff. of variation	515.8010%	66.6569%	185.3140%
Minimum	-0.05481	-0.0659	-1.1744
Maximum	0.0516	1.9876	3.9385
Range	0.1064	2.0536	5.1129

*Source: own calculations*

At the significance level  $\alpha = 5\%$ , the correlation analysis did not prove any statistically significant correlation between the number of clusters in the regions, i.e. their age and number of members (per 1,000 business entities in the regions), and the recalculated innovation characteristics (table no. 3). No significant correlation between the order of regions by innovation characteristics and their order by the number of clusters, or their age and number of members, was proved (table no. 4). Correlation coefficients are very low and P-values (stated in brackets below the correlation coefficients) are very high. *Therefore, we reject all hypotheses about dependency of innovation characteristics in the regions on the number of clusters, their average age and the number of cluster members in the regions.* For the sake of completeness it must be stated that the dependency of absolute indicators (number of patent applications and utility models, total R&D expenditure, value of the import of technology services) on the number of clusters and number of members in the region was also tested; however, no significant dependency was proven in these cases either.

On the one hand, there are regions with a high number of clusters and above-average intensity of innovation outputs (Moravian-Silesian and South Moravian Regions), however there are also regions with a high number of clusters and below average intensity of innovation outputs (South Bohemia and Central Bohemia Regions). There are only two clusters in the Karlovy Vary Region and still the region shows above average innovation outputs. It can be stated that there is no systematic dependency between the number of clusters, the age of clusters and the number of membership organisations and the innovation outputs.

**Table no. 3: Pearson product moment correlation coefficients**

<b>Variable</b>	<b>PATENT</b>	<b>R&amp;D</b>	<b>TECH SERV</b>
CLUSTER	0.1368 (0.6410)	-0.2911 (0.3126)	-0.1053 (0.7201)
AGE	0.2042 (0.4838)	-0.2996 (0.2980)	0.1491 (0.6108)
MEMBERS	0.1360 (0.6428)	-0.4229 (0.1319)	-0.0595 (0.8400)

*Note: P-value stated in brackets*

*Source: own calculation*

**Table no. 4: Spearman rank correlation coefficients**

Variable	PATENT	R&D	TECH SERV
CLUSTER	0.0243 (0.9302)	-0.3400 (0.2203)	0.0044 (0.9873)
AGE	0.2178 (0.4322)	-0.2134 (0.4416)	0.2904 (0.2950)
MEMBERS	-0.0286 (0.9179)	-0.4198 (0.1301)	0.1253 (0.6515)

Note: P-value stated in brackets

Source: own calculation

The previous analysis has been performed for all institutionalised clusters in the Czech Republic. In the next phase, a detailed analysis of cluster organizations, including all variants in two selected regions – Liberec (table no. 5) and Hradec Kralove (table no. 6) was carried out.

The following specialisations are discussed in connection with clusters in the Liberec Region:

- glass production, including technical glass (an innate cluster spanning over to the region of Usti nad Labem, secondary schools and universities present);
- technical textile manufactures (the cluster is linked to traditional industrial activities in the region, where secondary schools and universities are present);
- bijouterie manufacturing (an innate cluster within the region boundaries, where secondary schools and universities are present);
- waste processing (an institutionalised new cluster).

Other clusters either do not have their seats in the region (NANOPROGRES, production of other parts for motor vehicles), or they do not carry out any business activities. A significant share of innovative output within the region and the whole country was found in companies of an innate cluster of “Bijouterie production” and “Production of other parts and accessories for motor vehicles”. Furthermore, the analysis showed that even the companies of "Glass Production, including technical glass" pursued registering their intellectual property in the period of 2009-12. Out of the institutionalised clusters, the CLUTEX organization was the only one that showed registration of industrial property rights. In this light, it can be stated that in the Liberec region, there is an occurrence of innovation outputs mostly in the innate clusters and clusters which grew on the basis of a traditional industry in the region.

**Table no. 5: Development of clusters and cluster initiatives in the Liberec Region**

Mapping of the fields 2004 to 2013	Records in the CzechInvest database	Commentary
Bijouterie	None	Major employer in the region, an <i>innate cluster can be expected</i>
Technical textiles	CLUTEX	A functioning cluster supported by public funds. It can be viewed as transregional at NUTS 2 level.
Glass production, including technical glass	CGC – Czech Glass Cluster	CGC – inactive. It was founded as an association with no major glass manufacturers participating. It can be expected that the <i>cluster exists naturally</i> and it was not necessary to institutionalise it.

Mapping of the fields 2004 to 2013	Records in the CzechInvest database	Commentary
ICT	None	Identified in 2004 but not considered.
-	Craft	New
-	Waste processing cluster	New
Nanotechnology	NanoProgres	Involving TUL in a national cluster. The seat of the cluster is in the Pardubice Region.
Production of other parts and accessories for motor vehicles	None	A significant field in terms of employment, an <i>innate cluster can be expected. Link to the region of Central Bohemia.</i>

Source: custom mapping

The following cluster specialisation was discussed for the Hradec Králové Region:

- processing of non-ore materials;
- information technologies;
- food processing;
- production of plastic and rubber products;
- packaging technology;
- wood processing.

The intensity of innovation outputs can only be considered in general, due to a small number of evaluated data. More significant results can be stated for IT Cluster, both in terms of innovative companies in the region compared to the Czech Republic, and in terms of a stable sale of licences. It is a supported cluster and the effect of invested public funds can be expected. Based on a survey of registered industrial property rights valid in the Czech Republic, there can be traced only data on the organization of "Cluster of packaging producers" in case of institutionalised clusters.

Other specialisations, where high significance for the region was established in terms of the number of employees and which can be considered to be innate clusters, are as follows:

- production of other parts and accessories for motor vehicles with links to other regions and
- pharmaceutical-medical technology linked to the Charles University in Prague.

**Table no. 6: Development of clusters and cluster initiatives in the Hradec Kralove Region**

Mapping of the fields 2004 to 2013	Records in the CzechInvest database	Commentary
Printing	None	Identified in 2004 but not considered.
Packaging technology (Omnipack)	Cluster of packaging manufacturers	A functioning cluster supported by public funds.
Pharmaceutical-medical technology	None	Institutional care is one of the most important employers in the region, an <i>innate cluster can be expected.</i> There is a spin-off effect in the region.
Technical textiles	CLUTEX	Part of the CLUTEX cluster with its seat in LBK.

Mapping of the fields 2004 to 2013	Records in the CzechInvest database	Commentary
IT cluster	Hradec Kralove IT cluster	A functioning cluster supported by public funds.
Czech Stone Cluster	Czech Stone Cluster	A functioning cluster supported by public funds.
Production of other motor vehicle parts and accessories	None	A significant field in terms of employment, an <i>innate cluster can be expected</i> .
-	NUTRIPOL cluster	New
-	Technical plastics cluster	New
-	Hradec Kralove wood processing cluster	New

*Source: custom mapping*

#### 4. Discussion

The analysis has resulted in several issues to be discussed. No correlation between the intensity of innovation outputs and the number of clusters, their age and scope of membership base was proven. There can be many causes for this fact. One of the factors can be the short existence of the clusters, although the oldest clusters have been in operation in the Czech Republic for more than 7 years (three clusters in the South Moravian Region and one cluster in the Zlin Region). Most of the clusters are younger. This corresponds with the findings of Pavelková et al. (2013) that the youngest clusters among champions in the Czech Republic were founded in 2010; however more than half of the champions were founded earlier.

The recent global economic crisis could have had a negative impact on the operation of clusters as many companies had to limit investment and development activities including innovation. For these reasons, it would be advisable to repeat the research using new data from 2013.

Furthermore, it must be stated that only cluster groups that are institutionalised were included in the main survey. This means that a business entity was founded for the operation of the cluster and the entity comprises members involved in the "artificially" created group. For Porterian clusters, which operate innately, it is more difficult to specify and identify specific members involved in a specific field and region. The Karlovy Vary Region can serve as an example of a region with only two institutionalised cluster groups. In addition to these, innately functioning clusters of ceramic industry and brown coal mining and processing (see the fields analysis of regions in the article by Žižka, 2012) can be assumed in the region. Related economic activities, from technical to chemical ones, develop in connection with these branches. The fact mentioned above that innate clusters are not included in the evaluation of the impact of clusters on the development of regions is fairly significant and offers possibilities for further research analyses to compare the results of institutionalised and non-institutionalised clusters.

When examining the impact of clusters on innovation outputs of regions, it is important to consider their overall capacity. Even in the Moravian-Silesian Region, where the biggest

number of institutions (nearly 500) are engaged in clusters, these institutions still represent only 2 per thousand of business entities in the region. Clusters can be successful as such; however, their impact on the whole region can be negligible.

There are only two clusters in the capital city of Prague, which is interesting. The reason might be that the programmes supporting foundation of clusters were designated for regions that were economically below average (in reality, for all regions apart from Prague). Furthermore, many companies have their seats in Prague but their actual activities take place in neighbouring regions. Prague also shows an atypical branch structure where services are dominant (Žižka, 2012), whereas most clusters focus on industry.

Still, the ascertained results show the specific position of two regions – Moravian-Silesian and South Moravian. The Moravian-Silesian Region shows the highest increase in patents and utility models for the monitored period. The South Moravian Region is above average in all monitored indicators. The question is whether the stated results were accidental or if they resulted from the activities of the local clusters (e.g. compared to the Liberec Region that reached similar results without clusters). The Moravian-Silesian Region has the most extensive experience and also the most diverse experience with clusters in the CR, and its local clusters are leaders in internationalisation activities (Pavelková et al., 2013). A pilot study of clusters was prepared in this region in 2002 and the main driving forces for the development of clusters were VSB – Technical University in Ostrava and the Regional Development Agency (Skokan et al., 2012). The South Moravian Region takes advantage of the fact that it is one of the most innovative regions in the Czech Republic (Skokan et al., 2012). The established Centre of Excellence for natural sciences, advanced materials and technologies plays an important role in this case; six Brno universities and research institutions under the auspices of the South Bohemia Region and the city of Brno joined together to establish the centre. The centre became an important part of the infrastructure of the environment for innovative business in South Moravia.

Last but not least, it is important to pose the question why nearly 80 groups that claim to be cluster operators were founded in the Czech Republic. And yet, only 25 out of them were founded from the support received from public funds. They are not even innate clusters in the Porterian sense of the word. It can be assumed that roughly 50 companies that are often involved in project management or accounting expect some advantages from institutionalising their cooperation, i.e. possible public funding in the future.

### **Conclusions**

The results of the research analysis did not prove a clear positive influence of clusters on innovation in the regions of the Czech Republic. Czech regions can be divided into five categories in terms of innovation and clusters. First, regions with an above average intensity of innovation outputs and above average density of clusters (Moravian-Silesian and South Moravian Regions). Second, a group of regions with an above average intensity of innovation outputs but a small number of clusters (Liberec and Karlovy Vary Regions, the capitol of Prague). Third, there is a category of regions with an above-average number of clusters and below-average innovation characteristics (South Bohemia, Central Bohemia, Hradec Kralove and Olomouc Regions). The next category is represented by regions with a small number of clusters and average innovation characteristics (Pilsen and Pardubice Regions). Finally, Ustí nad Labem and Vysocina Regions represent a category with a low number of clusters and below average innovation outputs.



It is evident that the intensity of innovation outputs in the regions is influenced by more variables than just institutionalised clusters and the scope of their membership base. We cannot omit to mention the potential influence of innate clusters as documented by the example of the bijouterie cluster in the Liberec Region. The fairly short period of operation of institutionalised clusters in the CR must also be taken into consideration as the speed of innovation outputs is influenced by technology and market (e.g. different situations in biotechnology and in software development).

In a more detailed analysis focused on innovation outputs in the two regions selected by the CZSO survey, there were no significant changes in the growth of implemented innovations in branches of existing cluster organizations. When searching for registration of industrial property rights the following situation was found:

In the region of Hradec Králové, there was identified the existence of registered industrial property rights in the Cluster of packaging producers, cooperative, Jaroměř. In the Liberec Region there was only one registration of the industrial law of the CLUTEX organization – technical textiles cluster.

Other institutionalised clusters observed in the two regions had no record of the registered industrial property rights. In case companies of dominating branches with the assumption of existence of Porterian cluster in both regions were searched, there were identified registrations of industrial property rights. Given that innovation is one of the major expected outputs of the cluster groups support, it is recommended to further investigate the following problem areas: To what extent is the public support to institutionalised clusters effective, especially in those cases where the declared branch of institutionalised clusters is not a dominant industry in the given region with the ability to follow up with another industry in the region? Is it not rather a kind of a purpose-based partner alliance than a cluster grouping based on both a competition and a cooperation of businesses involved? It will be very difficult to prove these facts, mainly because of the complex data survey.

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