



INNOVATION NETWORKING

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Abstract:

Innovation networking can boost new knowledge production, innovation, knowledge transfer and also commercialisation of new knowledge. These are important factors influencing economic performance of any country. Governments have a central role in encouraging the cooperation among business sectors, higher education sector and research organisations. However, there exist various other important factors that influence success of such mechanism of innovation. We analysed some of the networking mechanism in Slovenia trying to pinpoint the important incentives for promotion of innovation synergies. We also tried to make clearer picture about R&D activities and possible cooperation between the key actors in this area in Slovenia.

Keywords: networking, innovation clusters, social network analysis, innovation.

1. INTRODUCTION

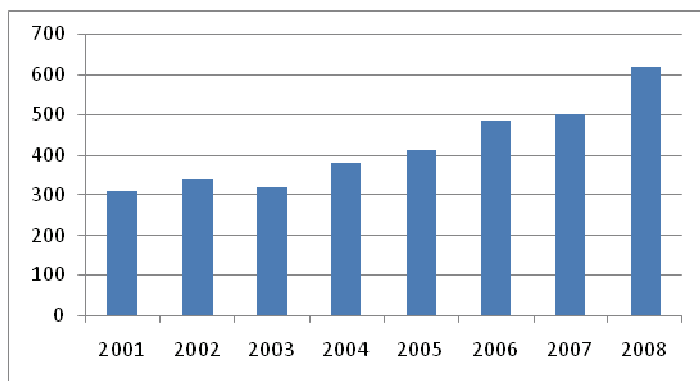
Currently, Slovenian business sector is largely unable to place Slovenia among the economically most successful countries in the world. As shown by the data (Eurostat, 2011), Slovenia has achieved 72 % of average Gross Value Added per Capita (GVA) of the twenty-seven European Union members (EU27). The difference has been slightly reduced in recent years, but the lag behind the most successful European countries (e.g. Austria, Finland) persists. Gorenak and Pagon (2006) consider that GVA is a key measure of country's economic performance because by achieving an appropriate level of GVA its business sector does not satisfy only the interests of shareholders, but also provides jobs, pays taxes, and enables the reward for investment risks for capital investors and lenders etc. Gorenak and Pagon (2006) claim that high GVA could be generated only by highly motivated and well trained employees that promote innovation, thus increasing the possibility to take the advantage of potential business opportunities, increasing productivity and lowering the costs.

In 2009, Slovenia was ranked as European innovation follower (MVZT, 2010a). This means that the volume of innovation activity of Slovenian companies grows, but in spite of this, the level of innovation activities is still relatively low. In addition to some relative advantages in the quality of human resources and entrepreneurship support services, the key weaknesses of the Slovenian business environment relate particularly to weak technological achievements in terms of patenting, commercialisation of new knowledge, exporting of high-tech products and the transfer of high technology as well. The main concern is that Slovenia lags behind the rest of Europe especially in technological innovation (e.g., new business processes, work organization, dealing with customers, etc.).

The figures showing the inventiveness and commercialization of new knowledge and the Slovenian high-tech export, are alarming. In Slovenia the number of European patent applications per million inhabitants, for example, reaches only 44 % of the EU27 average. Situation regarding Slovenian patent applications in the North American market is even worse, because they reach only 13 % of the EU27 average. Slightly better is the situation regarding the European high-tech patents applications - Slovenia has achieved 61 % of the EU27 average. Slovenia is also very weak in high-tech exports. The export share of high-tech products in total exports reaches only a 28 % share of exports of EU27 average.

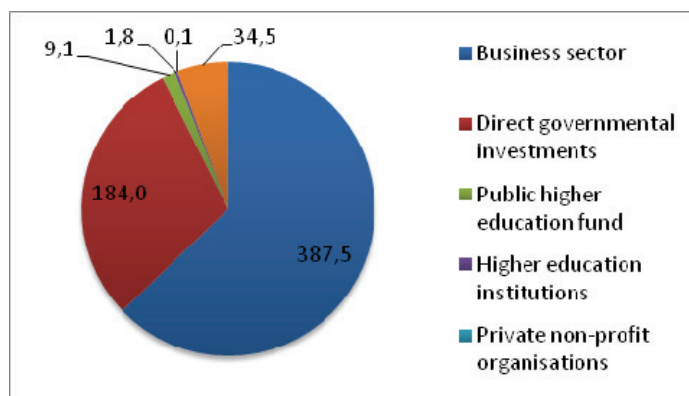
Slovenia's spending for research and development (R&D) reaches 1.9 % of Gross Domestic Product (GDP). This is 0.1 percentage points less than the EU27 average (Eurostat 2011). Total R&D expenditure per capita in Slovenia is rather modest since it reaches only 68 % of the EU27 average. In higher education (HEF) sector it is even only 48 %. Slightly better situation is in the business sector, but its R&D expenditure is still only at 71 % of the EU27 average. Nevertheless, in the recent years Slovenian R&D expenditure is rising. For example, in Figure 1 we illustrate the annual volume of R&D expenditure in Slovenia between 2001 and 2008. As can be seen in the figure, the volume of total expenditure in this period rose from about 300 million EUR to about 600 million EUR. As shown in Figure 2, most of these funds were allocated to research by Slovenian business sector (387.5 million); slightly smaller proportion was invested in R&D activities by Slovenian government (187.0 million).

Figure 1: Gross domestic expenditure for R&D activities in Slovenia from 2001 to 2008 (in millions of EUR)



To raise GVA it seems particularly important to encourage the volume and quality of innovation - the creation of new knowledge, its protection and commercial use of this knowledge. To realise such ambitions, in addition to accessibility and quality of tertiary education, significant positive influences could be expected by: (1) the scope of research and development (R&D) activities and (2) networking of key actors of R&D - higher education institutions (HEI), public research organizations (RO) and companies (Vidulin and Gams, 2006).

Figure 2: Sources of finances for R&D activities in Slovenia in 2008 (in millions of EUR)



2. NETWORKING FOR INNOVATION

As already mentioned, networking seems to be a key factor for fostering the innovation. In the studies of entrepreneurial networking, for example, some authors have focused primarily on horizontal links and cooperation between small to medium-sized enterprises (SMEs). Marshall (1961) named this kind of networking the industrial districts. Other authors highlight the links between big companies and their suppliers, which are usually smaller firms (Marceau, 1999). In such cases we talk about the hierarchical relationships, or clusters in vertical supply chain. Links can also be developed between companies which need the same resources, or base their business on the same kind of resources. In addition, connections emerge among companies which are involved in joint innovation or in joint production (Marceau, 1999). In such cases we often talk about innovation clusters.

Businesses rarely innovate in isolation. An innovation can actually be defined as a learning process, which requires the exchange of knowledge and a high level of interaction and cooperation between different actors within the network or value chain (Roelandt & Hertog, 1999). Innovation activities obviously require involvement of several parties, which combine their specialized yet complementary knowledge (Roelandt & Hertog, 1999). Active participants in innovation clusters are often companies (large and small), academic research institutions, as well as HEI and public or private providers of education and training (Roelandt & Hertog, 1999).

In most cases of innovative networking researchers emphasises the importance of geographical proximity between the members of the network. Proximity encourages interaction and is an important part of the dynamics of the network (Marceau, 1999). As noted by Marceau (1999), operating in the geographic vicinity is even easier, if there are various HEI or RO in the vicinity. Most authors are of the opinion that geographical proximity is the key, but not also the only criterion for successful networking.

Knowledge sharing and cooperation between organizations in networks are based on trust and shared experience and often exercised informally and through direct contacts between individuals. Research shows that the bulk of the knowledge transfer is self-organized, and implemented directly among employees, professionals and managers (Spielkamp & Vopel, 1999). Antončič, Ruzzier & Bratkovič (2007) in addition to geographic concentration, emphasise the importance of supporting institutions in terms of infrastructure (e.g. information centres, computer networks), the involvement of HEI and research organisations, but also underline the importance of prior cooperation between network members and the reputation of key members of the network. Spielkamp & Vopel (1999) further note that companies often join the network on the basis of belonging to the same industry (e.g. information technology, food industry, the financial industry, etc.). Despite this the innovative clusters tend to include bigger companies as well.

3. R&D INTEGRATION MECHANISMS IN SLOVENIA

According to the data on innovation activities in Slovenia in 2006 about one half of the innovation active companies were involved in R&D cooperation with some other organisation. Less than 25 % of such companies cooperate with HEI and about 15 % of them cooperate with public RO (MVZT 2010). The percentages we have just mentioned positioned Slovenia among the best in the area of R&D cooperation in EU27, but on the other hand, only a relatively small part of Slovenian companies are innovation active.

Relative modesty of networking activities is acknowledged by the research on networking for lifelong learning as well (Natek, Dermol, Kosir, Breznik & Musek-Lesnik, 2010). The study identifies only a few networks of learning, consisting mainly small part of Slovenian business and technical HEI (such as the Faculties of Economics in Ljubljana and Maribor, Faculty of Electrical Engineering and Computer Science in Maribor, Faculty of Mechanical Engineering in Maribor, Turistica, Faculty of Tourism Studies Portorož, Biotechnical Faculty in Maribor), a small proportion of Slovenian high-tech companies (e.g. Iskratel, Mobitel, Telekom) and few tourism oriented companies (e.g. Terme 3000, Terme Maribor, Hit Alpine and Thermana Laško).

An innovation is most often generated in cooperation of companies, RO and HEI. Therefore, we should highlight the importance of innovation networks (Roelandt & Hertog, 1999). Slovenian government encourages this kind of integration with some financial incentives.

From 2009 to 2015 the government plans to encourage R&D activities through three key mechanisms of R&D integration (Competence Centres - CC, Centres of Excellence - CE and Development Centres - DC) in amount of about 314 millions of EUR. This amount of money shows relatively high importance of these three mechanisms, since we can see in the figure 2, this amount exceeds the volume of almost two years of governmental investment in R&D in Slovenia. Ministry of Higher Education, Science and Technology (MVZT) together with the European Regional Development Fund supports research and networking through CC in amount of 45 million EUR in the years 2010–2013 and through CE in amount of 84 million EUR in the years from 2009 to 2013. Ministry of Economy in cooperation with the European Regional Development Fund encourages research and networking in the range 185 million in the period of 2010–2015 investing in the construction and operation of DC.

With our study we identified the centres of the Slovenian R&D and innovation, beside, we tried to identify research areas within which Slovenian companies, public RO and HEI most often cooperate.

4. RESEARCH METHODOLOGY

The data about companies, HEI, RO and other organisations cooperating in CC, CO and RC were obtained from the internet. The additional information related to research activities and performance of organisations' researchers and research groups was collected from the web pages of IZUM (Institute of Information Science). We were especially interested in the number of registered researchers in the organisation, their SICRIS points, measuring their research performance, number of citations (in journals indexed by SCI-Expanded, SSCI and A&HCI) and number of registered patents in the organisation. Eventually, organisations were clustered into twelve Slovenian statistical regions.

Special emphasis of our analysis was on cooperation among analysed organisations. Therefore, we use the network analytic techniques. These statistical methods are focused on characteristics of relations, rather on characteristics of individual entities. Nevertheless, examining the structure of any given network is a formidable task that includes significant hurdles associated with how to define and measure links or relationships (Jackson, 2008). The relation in our network was defined in the following way: two organisations are in the relationship if they are in the same CC, CE or RC. Thus, the defined relation is symmetrical and the network is undirected. Furthermore, the pair of organisations could be involved in various CCs, CEs or DC's thus the network is considered as weighted. The weight on each edge (undirected tie between entities in the network) is determined by the number of CCs, CEs or DCs in which organisations are included.

For descriptive analysis and for writing algorithms in the preparation of network the R package (CRAN) software was used. Network analysis was carried out by Pajek (Slovenian word for Spider) (Batagelj & Mrvar, 2002, 2004). Pajek is a program for analysing and visualising large networks (Wasserman & Faust, 1994). Both programs are an open source programs and freely available, for non commercial use.

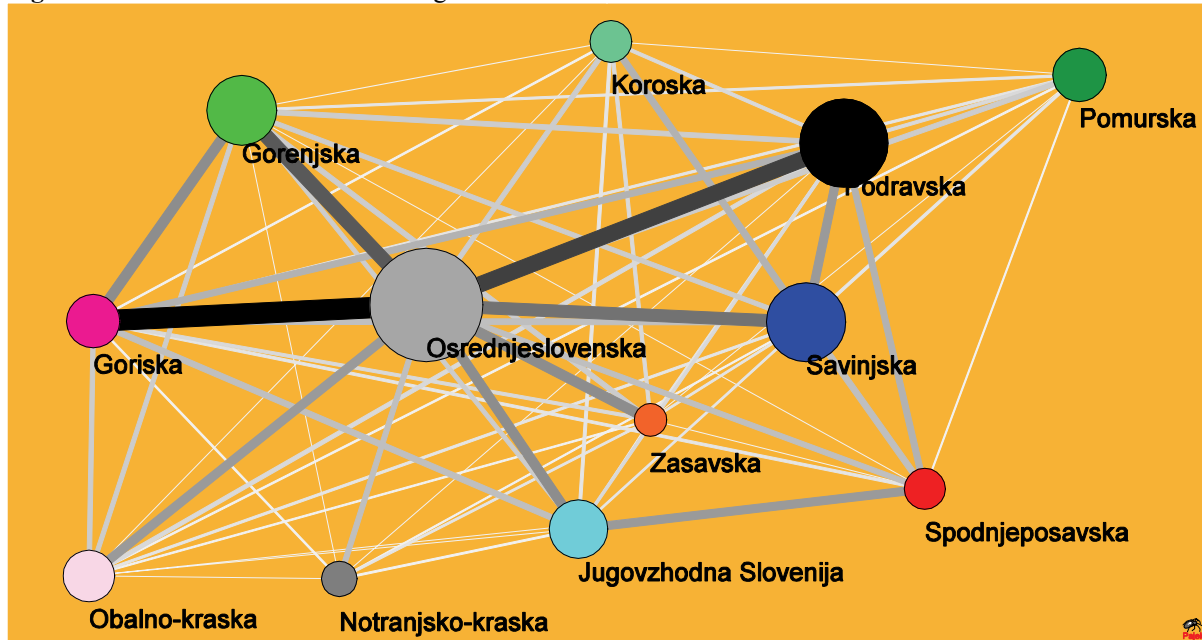
5. RESULTS OF THE STUDY

5.1. The basic network of the Slovenian R&D

The basic network consists of 336 organisations, grouped in 34 CC, CE and DC, and 3697 edges among them. The vast majority of edges (3527 or 95.4 %) has the value of 1, the

and public RO are located. Gorizia Region has surprisingly the strongest links (relative to the number of organizations) with the Central Slovenian Region. Links between Podravska Region and in particular the Coastal-Karst Region on one side and Central Slovenian Region on the other are quite weak although there are the second and third largest university in these two regions.

Figure 4: R&D network of statistical regions in Slovenia



5.3. Evaluation of R&D performance

In table 1 we present the data related to indicators of average R&D performance of companies, RO and HEI in 12 Slovenian statistical regions. Only organisations in our basic network are included. In addition, there is a data regarding number of residents in the regions and number of organisations in the basic network. R&D performance could be measured by three indicators – SICRIS points measuring publishing achievements, number of citations measuring the quality and relevance of research work and publishing, and number of patents measuring commercialisation of new knowledge. The best ranking region in the sense of publishing performance is very surprisingly Gorizia Region, outperforming even the Central Slovenian Region consisting of the majority of high-tech companies, RO and HEI. Situation concerning the number of citations is somehow different. The differences between Slovenian Regions are quite big in this area, and the numbers of citation are consistent with the size of public universities in these regions (University in Ljubljana, University in Maribor, and Primorska University in Coastal-Karst Region). The number of patents pinpoints the major problem of Slovenian innovation performance. In general, the numbers are very low showing either weak commercialisation of new knowledge or low quality if it. The highest numbers of patents are achieved in Central Slovenian Region with plenty of technical and natural-science HEI and surprisingly in South-East Slovenian Region with practically no HEI and RO, but with important foreign car producing company and major Slovenian pharmaceutical company.

Table 1: Data about R&D performance in Slovenian statistical regions

Region	Number of Residents	Organisations in Basic Network.	SICRIS points per organisation	Citations per organisation	Patents per organisation
Gorenjska Region	203,427	30	16.10	23.17	0.03
Gorizia Region	119,146	16	28.25	13.62	0.00
Koroška Region	72,494	15	8.53	53.53	0.00
Inner-Karst Region	52,287	8	2.00	0.00	0.00
Coastal-Karst Region	110,760	7	21.00	493.71	0.00
Central Slovenian Region	533,213	135	27.50	1877.01	0.76
Podravska Region	323,119	26	17.69	922.35	0.23
Pomurska Region	119,145	8	7.12	36.25	0.00
Savinjska Region	259,726	43	18.16	11.70	0.05
South-East Slovenia Region	142,483	21	16.57	131.14	0.48
Spodnje-posavska Region	70,167	9	2.00	0.78	0.00
Zasavska Region	44,222	13	13.00	0.29	0.07

5.4. Evaluation of R&D performance

Analyzing the basic network presented in figure 1, we identified the organisations that cooperate with each other most frequently. For this purpose, we used the generalized core method. Based on the data, we found that 14 is the highest possible order in the basic network. We decided to analyze the core with order of 10. In this generalized core all of 31 organizations participate in at least 10 common CC, CE and DC, together with other organizations from this (sub)network. This is also the only (sub)group of organizations in our primary network with such feature.

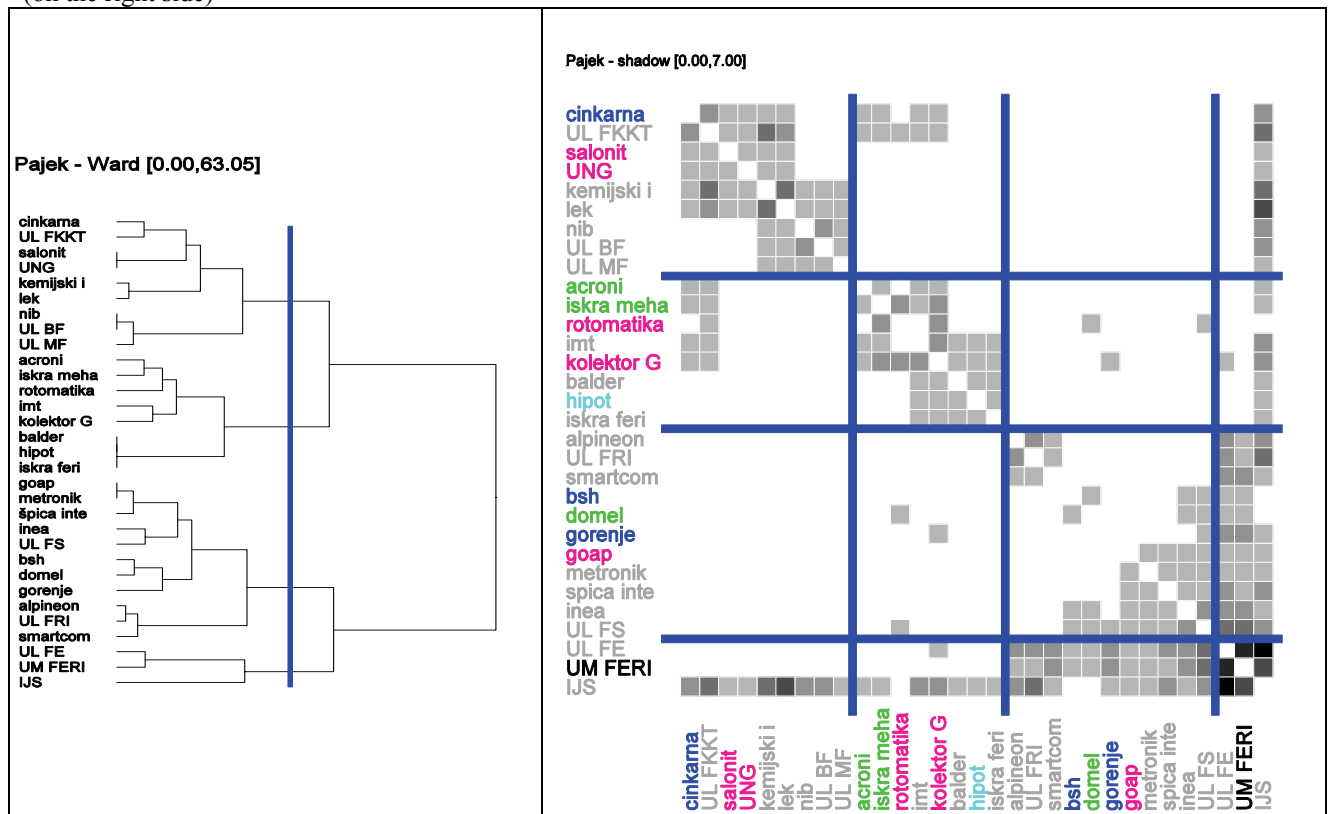
Companies in the generalized 10-core were divided into four groups using Ward's method of agglomerative hierarchical clustering and generalized Euclidean distance (Ferligoj, 1984; Doreian, Batagelj & Ferligoj, 2005). Dendrogram of this method is shown on the left side of figure 5. Moreover, the 10-core is presented with a matrix on the right side of figure 5. Organisations in the matrix are coloured by regions and divided according to the outlined classification method into four groups. The matrix is symmetrical since we are dealing with undirected network. The inference is that these groups might actually represent cases or rudiments of innovative networks.

As seen in figure 5, IJS occupies central position of the Slovenian R&D cooperating with almost all organizations in the 10-core. As we consider only the edges with weight 2 or more, 27 organizations in the generalised core, cooperating with IJS, participate in at least two common CC, CE or DC. There are only three exceptions: Rotomatika, BSH and Domel.

The first, from bottom up, most strongly associated group in the generalised core consists of IJS and two higher education institutions - UL FE and UM FERI, operating in the fields related to computer science, informatics, electrical engineering and related fields. The second group consists of organizations, almost all involved in the cooperation with the first group, and some of them also among themselves. This group consists of companies whose primary activity is associated with process automation, computer engineering and computerization, as well as the development and use of electronic communications and speech technology. There are also two HEI involved in this group - Faculty of Mechanical Engineering (UL FS) and Faculty of Computer Science and Information Science (OJ FRI), both members of University in Ljubljana. The third group of cooperating organizations is closely related to the development and use of electronic circuits and components, technologies and materials for

electronics with optoelectronics components and measuring instruments. The fourth group is focused into different discipline – chemistry and pharmacy. It involves some chemical companies (Cinkarna, Salonit, Lek), two public RO (National Chemical Institute and National Institute of Biology) and relevant HEI - University of Nova Gorica and also Faculty of Chemistry and Chemical Technology (UL FKKT), Biotechnical Faculty (UL BF) and Medical Faculty (UL MF). All institutions are members of University in Ljubljana. Some of these groups poorly cooperate with each other - a typical example are groups, of which one focuses on the research and production in chemistry and pharmacy, and the other on the research and production in the field of automation and computerization.

Figure 5: Dendrogram of hierarchical clustering with Ward's method (on the left side) and the matrix of 10-core (on the right side)



We've done analysis of R&D performance for 4 recognised groups as well. The results are presented in table 2. The most successful group, regarding publishing performance, is the one consisting of 2 HEI (UM FERI and UL FF) and IJS. This finding is quite logical, since IJS, when analysing its performance, is really the leading R&D organisation in Slovenia. On the other hand, the group with the best result in the area of citations is the last one – chemistry based group of companies, RO and HEI. This group is also the best when considering number of patents. Their achievement in this area is almost the same as the achievement of IJS. On the other hand, R&D performance of group 3 and also group 2 is rather poor (despite the fact that IJS is also involved in these two groups). In group 3, for example, there has been no evidence of registered patents, which is quite worrying since there are some leading Slovenian companies (e.g. Gorenje) in the group.

Table 2: Data about R&D performance in 4 recognised groups and IJS

Groups	SICRIS per individual per group	Citations per individual per group	Patents per individual per group
Group 1	205.86	47.95	0.0274
Group 2	36.82	3.80	0.0015
Group 3	59.79	8.67	0.0000
Group 4	138.28	55.44	0.0330
IJS	342.86	113.55	0.0344

6. DISCUSSION

In the present paper we tried to identify innovative clusters in Slovenia. As a base for the research we analysed 3 governmental mechanisms for encouraging R&D activities through cooperation between business sector (companies), public RO and HEI which represent quite a big share of public spending for R&D in Slovenia. These 3 mechanisms are: competence centres, centres for excellence and development centres.

Through the analysis we somehow confirmed basic assumptions stemming from the theory of networking. We found out that innovative clusters (or groups as we defined them) usually consist of members coming from similar disciplines or industries (in our case process automation, computer engineering, computerization, development and use of electronic components, chemistry, etc.), that there should be some history of cooperation present in the group (there are very obvious relationships between HEI which educate engineers and RO or companies where these engineers mostly operate), and that groups are usually geographically concentrated (we even recognised relatively weak cooperation between different Slovenian statistical regions). Besides, we confirmed and revealed some real problems related to Slovenian technological development and consequently economic performance. We somehow recognised weak links between research performance (SICRIS points), relevance of research (number of citations) and transfer of knowledge (number of registered patents). The main weakness of Slovenian R&D space seems to be relatively poor cooperation between business, HE, and research and dominance of one public research organisation. It seems that synergies which are probably expected due to introduction of 3 networking mechanisms are really not implemented.

This study represents one of the first attempts to analyse cooperation and clustering issues in R&D in Slovenia. Our findings and approaches to the study could be a starting point for further research. We are sure that such research could bring benefits both - to theory and practice as well.

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