Innovation Synergies through Networking in Slovenian regions

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Abstract

Purpose – This paper aims to expose the necessity of networking among organisations to increase innovation performance. Specifically, it highlights the correlation between various indicators of innovation and the level of intra-regional and inter-regional cooperation between enterprises, higher education institutions and research organisations.

Design/methodology/approach – Data for the study was collected from internet open sources exclusively. Besides standard descriptive and inferential statistical approaches, several network analytic methods and techniques were applied to provide a deeper insight into the problem.

Findings – In compliance with previous studies the impact of geographical proximity and innovation clustering was confirmed. The results expose inter-regional networking, publishing achievements and the number of citations as the key factors related to the economic performance of the region. However, the impact of registered patents is more dubious and requires further investigation. Furthermore, the problem of uneven participation of Slovenian regions in the process of innovation and economic performance was recognised – the Central Slovenia region clearly outperformed other regions in Slovenia.

Research limitations/implications – The study is focused on Slovenian organisations and centres only. However, it could serve as the basis for conducting similar future studies in other countries and/or regions.

Originality/value – The study represents one of the first attempts to analyse cooperation and clustering issues related to innovation in Slovenia.

Keywords – *networking, synergy, innovation clusters, social network analysis*
Paper classification – *research paper*

1. Introduction

Innovation can be defined as "a process of commercialisation of a newly developed or adopted product or practice" (Freeman, 1982). The number of patent registrations might be an important indicator of innovation since they provide the sole right to make, use and sell that invention for a set period of time. Besides, researchers relate innovation to scientific publishing and publishing in most cited (i.e. visible) scientific publications worldwide (UNU-MERIT, 2011).

There is a correlation between innovation and organisational performance (Akgun et al., 2007) but practice shows that even "the largest firms [...] cannot always undertake major innovations alone" (Dickson and Hadjimanolis, 1998). Innovation is a learning process which requires the exchange of knowledge and a high level of interaction and cooperation between different partners – entities within the innovation network (Roelandt and Hertog, 1999). Liao et al. (2003) note that the most important knowledge probably comes from customers and competitors, but a larger number of knowledge sources creates better options for identifying changes in the environment, thus leading to improved performance. Therefore, successful innovation seems to be closely related to combining specialised yet complementary knowledge (Roelandt and Hertog, 1999). Entities in innovation networks are usually companies, higher education institutions (HEIs) and research organisations (ROs) (Whittington et al., 2009). Especially HEIs and ROs might be vital sources of innovation since "they are the producers of both technical personnel and cutting-edge scientific knowledge". Nevertheless, Robinson et al. (2011) note that companies' size may be related to their propensity to cooperate. Their study shows that very few small and medium enterprises (SMEs) cooperate with the government and HEIs as highly important sources of knowledge.

In studies of networking some authors focus primarily on the horizontal links and cooperation between SME. Marshall (1961) names this type of networks industrial districts. Others highlight the links between big firms and their suppliers, usually smaller firms (Marceau, 1999). In such cases hierarchical relationships or clusters in the vertical supply chain appear. Links may be developed between firms which need or base their business on the same resources. Furthermore, relationships emerge among firms involved in joint innovation or joint production (Marceau, 1999). Whittington et al. (2009) list other possible reasons for networking, e.g. the reduced costs of moving goods, increased availability of people and ideas, external economies of scale, benefiting from spill-over of knowledge, and making research and development (R&D) programmes more fertile.

Networking seems to be an important factor of fostering innovation (Dickson and Hadjimanolis, 1998). Mukkala (2010) confirms that the high-technology firms' success depends on their innovation capacity but also on their network relationships. Whittington et al. (2009) even notes that "there is a strong correlation between an organization's network of partnerships and its innovative output, particularly in research-intensive industries". They believe that "positions in networks shape access to the information and resources that support innovation [...] thus enhancing [firm's] performance".

In most cases researchers emphasise the importance of geographical proximity between entities and/or the regional nature of networks. For example, Whittington et al. (2009) note that "physical propinquity [might be] the wellspring of scale and information benefits that enhance the productivity of co-located firms". Proximity encourages interaction and is an important part of the dynamics of the network. Furthermore, Marceau (1999) notes that performance of co-located firms may be even better when there are various HEIs or ROs in the vicinity. Most authors agree that geographical proximity is the key but not the only criterion for successful innovation networking. In this context, literature pays particular attention to innovation in technology-intensive regions such as the Silicon Valley.

Pekkarinen and Hermaakorpi (2006) further develop the idea of geographical proximity and networking opportunities. They highlight the importance of introducing

regional strategies "based on a thorough assessment of regional resources, capabilities and competencies, and future opportunities leading to business potentials, which can give a region a competitive advantage". Mukkala (2010) adds that regional governments should focus on developing networks especially in the fields of R&D, export and internationalisation and sales and marketing, and on encouraging innovation processes by supporting the business knowledge of firms, including the analysis of business ideas, commercialisation and distribution of new products in the market. Antončič et al. (2007) underline the importance of prior cooperation between network entities and the reputation of key entities as important factors of trust. Spielkamp and Vopel (1999) further note that companies often join a network on the basis of belonging to the same industry.

Theory and practice indicate that firms are situated in geographic as well as social structural and industry spaces. Whittington et al. (2009) found out that both proximity and centrality (a measure of relative importance of an actor within a social network e.g. social structural space) were important factors of innovation. Their research suggests that being located near other firms positively affects innovation, but being located close to HEIs and ROs is more important to the firms which are also well connected within the industry. Furthermore, being a member of either a local (physically co-located partners) or global (physically distant partners) network is positively related to innovation. There is also a positive relationship between both kinds of networking. Globally and locally well connected firms operating in the vicinity of HEIs and ROs seem to be much more innovation active (for definition see OECD, 2005). Local networks could also be understood as intra-regional networks; on the other hand inter-regional networking is an important part of global networking.

In our paper we focus on innovation-oriented integration mechanisms in Slovenia, introduced by Slovenian government primarily to enhance innovation and links between research and business sectors. Slovenia is a typical Central European country, categorised as a European innovation follower (European Commission, 2010), with 12 very differently developed regions, some of them with HEIs and ROs and some without. In our opinion, Slovenia is a good choice for the study. An earlier version of this paper was presented at the international conference *Management, Knowledge and Learning (MakeLearn) 2011* **which took place in Celje, Slovenia on 22–24 June 2011.**

2. Integration mechanisms in Slovenia

According to the data on innovation activities in Slovenia in 2006 about one half of the innovation active firms were involved in innovation cooperation with some other organisation. Less than 25% of such firms cooperated with HEIs and about 15% of them cooperated with (public) ROs (MVZT, 2010). These percentages position Slovenia among the best in the area of innovation cooperation in EU27 (European Union with 27 member states). However, only a relatively small part of Slovenian companies seem to be innovation active.

Slovenian government puts quite a lot of effort into encouraging innovation links and cooperation between firms, ROs and HEIs by introducing financial incentives. From 2009 to 2015 the government plans to encourage innovation activities through three key mechanisms of integration (Competence Centres – CCs, Centres of Excellence – CEs and Development Centres of Slovenian Economy – DCs) amounting to about 314

millions EUR. This amount of money shows a relatively high importance of these three mechanisms since it exceeds the volume of almost two years of regular government investment in innovation activities in Slovenia.

In our paper we analyse innovation links in Slovenia recognising (1) few tightly integrated, industry-based innovation clusters, (2) the level of intra-regional innovation related integration between different, mainly co-located organisations, i.e. firms, HEIs and ROs, within a region, and (3) the level of inter-regional innovation related integration between organisations belonging to 12 Slovenian regions. We reveal relationships between different levels of networking and innovation performance in terms of publishing achievements, the number of citations and patent registrations, all of which we consider as important indicators of innovation, and try to relate innovation performance with regional and national economic performance. The main research questions which we try to answer in our paper are therefore:

1. Is the level of intra-regional and inter-regional cooperation between enterprises, HEIs and ROs related to innovation performance?
2. Is there a relationship between intra-regional and inter-regional networking and economic performance of the region (and country)?
3. Is there a relationship between the indicators of innovation (publishing, being cited in most visible publications, patenting) and economic performance of the region?
4. Which scientific disciplines and industries are to be supported by national and regional authorities due to their potential to efficiently encourage Slovenian innovation and economic performance?

3. Research methodology

3.1. Data

Our research includes 336 organisations (firms, HEIs, ROs and others) cooperating in 34 CCs, CEs and DCs. Variables related to organisational innovation performance are the number of registered researchers in the organisations, their SICRIS points as a measure of their research performance, the number of citations (only in journals indexed by SCI-Expanded, SSCI and A&HCI) and the number of registered patents at Slovenian and foreign intellectual property offices. The additional data was collected from the website of the Institute of Information Science (http://sicris.izum.si/) and the website of the Slovenian Intellectual Property Office (http://www2.uil-sipo.si/dse.htm).

In order to establish the relationship between geographical proximity and innovation clustering we clustered organisations into 12 Slovenian regions. However, it was not possible to determine the region of origin for four organisations which were eventually excluded from the regional part of the study.

3.2. Procedures

Network analytic techniques are statistical methods focused on the characteristics of relations rather than on the characteristics of individual entities. As the special emphasis of our analysis was on the cooperation among the analysed organisations, we used these

methods in the major part of the empirical study. As reported by Jackson (2008), 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. In the following part of this section we are going to provide a basic description of obtained networks.

Membership of an organisation in a centre (CC, CE or DC) is called an affiliation. Affiliations are often institutional or "structural" – forced by circumstances (De Nooy et al., 2005). As mentioned above, the described integration mechanisms were introduced by Slovenian government through public calls. Organisations which already had some kind of common history jointly signed up for the call. In our case affiliation connects organisations to centres and not organisations to organisations or centres to centres, at least not directly. This type of network is called two-mode network – organisations are "actors" and centres are "events". We will call it *the two-mode innovation network in Slovenia*.

From each two-mode network two one-mode networks can be created – a network of interlocking events (in our case centres) and a network of actors (organisations) members of the same event (centre). The latter, which we call *the innovation network of Slovenian organisations,* was obtained in the following way: two organisations are in a relationship (and consequently connected with a link) if they are in the same centre. Therefore, the relation defined is symmetrical and the network is thus undirected. Furthermore, a pair of organisations could be involved in various centres, as a result of which the network is considered as weighted. The weight on each edge (an edge is an undirected link between entities in the network) is determined by the number of centres in which linked organisations are included. Loops in this one-mode network represent the number of centres in which an individual organisation is incorporated. A one-mode network of centres, *the network of Slovenian innovation centres*, was obtained in a similar way. Whenever two centres share an organisation in the two-mode innovation network in Slovenia there is a line between them. Moreover, a weight on a line between two centres represents the number of common organisations and a loop represents the number of organisations in the centre.

A more detailed insight into networks was obtained by using the generalized core principle. Through the use of valued cores or S-cores (Batagelj and Zaveršnik, 2011) weights on the links are also taken into account. A subset of vertices C determines an S-core at level *t* if and only if for each vertex in the set C the sum of the weights of the links of the vertex to other members of C is at least *t*. C also has to be the maximal set with this property.

For the descriptive analysis and writing algorithms in the preparation of the networks the R package (CRAN, 2011) software was used. The programme R was also used for the statistical analysis. The network analysis was carried out with the Pajek programme (Batagelj and Mrvar, 2011). Pajek (Eng. Spider) is a programme for analysing and visualising large networks (Wasserman and Faust, 1994).

4. Results of the study

4.1. The two-mode innovation network in Slovenia

The two-mode innovation network in Slovenia consists of 336 organisations and 34 centres. Among organisations and centres 479 edges (affiliations) have been detected. The network is divided into two components (groups of connected entities), the big

one consisting of 361 entities and the small component with only 9 entities. The latter contains organisations joined in the research centre for obtaining energy from municipal waste. Organisations in this centre participate in no other centre. The reason for the occurrence of such isolated centre might be either the uniqueness of the industry to which organisations belong, or the beliefs about their self-sufficiency and low necessity for cooperation.

In order to analyse the obtained two-mode network with standard techniques we have modified it into two previously mentioned one-mode networks described in more details in the following sections.

4.2. The innovation network of Slovenian organisations

Multiple lines in the one-mode network of organisations were replaced by a single line indicating the original number of lines between two organisations (representing common centres). In this way 3,697 valued edges have been obtained. The vast majority of edges (3,527 or 95.4%) have the value 1, while the remaining 170 edges have a higher value. The edges of the Jožef Stefan Institute (IJS) have the highest values since it participates, together with the Faculty of Electrical Engineering at University of Ljubljana (UL FE), in seven different centres, and together with the Faculty of Electrical Engineering and computer science at University of Maribor (UM FERI) and Lek (Slovenian pharmaceutical company) in five different centres. Furthermore, the UL FE and UM FERI are together in six aggregations. All other values of edges in the network are lower than 5. We decided to remove all edges with values lower than 2. Indeed, organisations that participate in only one centre are not difficult to trace, but we are interested in (a) more integrated innovation network(s). In the obtained subnetwork, only one weak component emerges. It includes 58 vertices. By the definition of the derived subnetwork, each organisation is a member of at least two common centres together with at least one organisation from this subnetwork. The subnetwork is graphically displayed in Figure 1. The vertices representing organisations are grey scaled according to the region to which they belong. It appears that among the participating organisations those from the Central Slovenia region dominate. Furthermore, a surprisingly large number of organisations involved in the obtained network come from the small Gorizia region. On the other hand, only a few entities in this network originate from the Podravska region, which is a region with the second largest university in Slovenia (UM).

4.2.1. Cooperation between regions in Slovenia

In the next step of our study we grouped the organisations by their regions of origin (see Figure 2). This way we obtained a network with 12 vertices to examine the extent to which different regions in Slovenia cooperate in the area of innovation. After all the loops (edges within the same region) were removed, we normalised the rest of the edges by dividing the individual edge value with the square root of multiplied numbers of organisations in both connected regions. The size of the vertices representing regions in Figure 2 is proportional to the number of their inhabitants.

As shown in Figure 2, Slovenian innovation activities are rather centralised and located mainly in the Central Slovenia region. This was expected since it is in this region that the largest Slovenian university (UL) and most of the major high-tech companies and public ROs are located. The Gorizia region surprisingly has the strongest links (relative to the number of organisations) with the Central Slovenia region. Links between the Podravska and particularly the Coastal-Karst region and the Central Slovenia region are quite weak although the first two regions have the second and third largest university in Slovenia, i.e. UM and University of Primorska (UP), respectively.

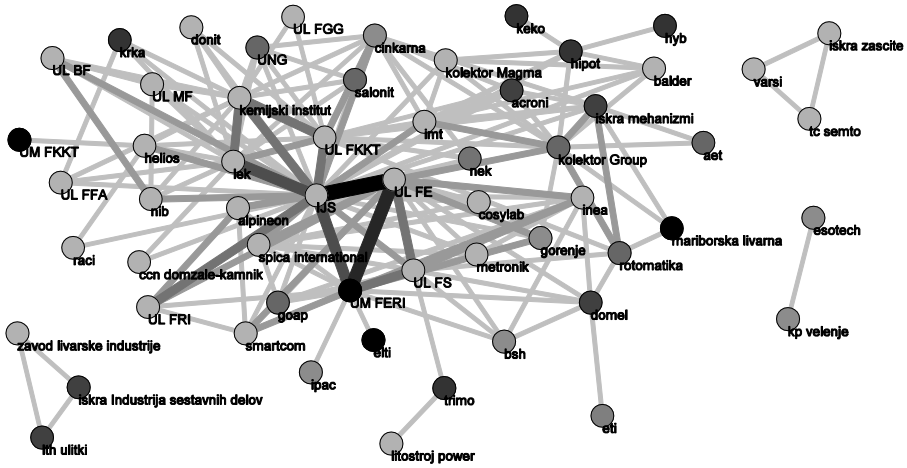

Figure 1: One-mode innovation network presentation of Slovenian organisations

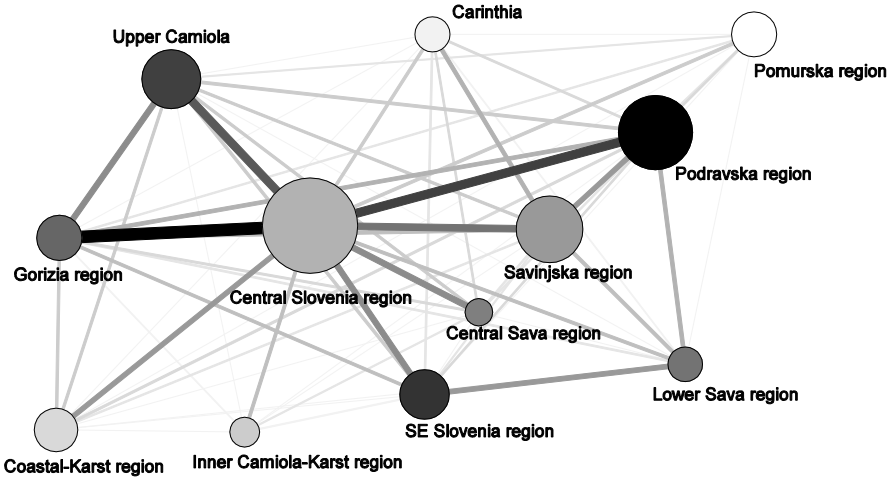

Figure 2: Innovation network of organisations grouped in Slovenian regions

4.2.2. Evaluation of innovation performance

In Table 1 we present the data related to the indicators of average innovation performance of firms, ROs and HEIs in 12 Slovenian regions. Furthermore, data regarding the number of regions' residents and the number of organisations in the basic network is also included. Innovation performance could be measured using three indicators – SICRIS points measuring publishing achievements, the number of citations measuring the international visibility of research findings, and the number of patent registrations measuring the intentions to commercialise new knowledge.

Table 1:
Data on innovation performance in Slovenian regions

Region	No. of residents	No. of org.	SICRIS points per org.	Citations per org.	Patents per org.	Norm. links inside the region	Sum of norm. links outside the region
Upper Carniola	203,427	29	334.05	5.38	3.72	3.10	1.30
Gorizia	119,146	17	1,959.66	330.76	3.24	4.00	1.55
Carinthia	72,494	15	163.14	15.00	0.07	8.80	0.63
Inner Carniola-Karst	52,287	8	0.00	0.00	3.00	2.75	0.36
Coastal-Karst	110,760	7	6,601.93	158.29	2.71	0.00	0.72
Central Slovenia	533,213	139	8,439.63	563.10	5.02	14.09	2.80
Podravska	323,119	25	5,830.45	310.24	1.72	2.08	1.53
Pomurska	119,145	10	45.75	3.10	0.80	1.00	0.52
Savinjska	259,726	40	140.52	6.67	2.05	6.65	1.41
Southeast Slovenia	142,483	20	306.48	23.15	7.20	5.10	1.00
Lower Sava	70,167	9	33.43	0.00	0.22	2.67	0.87
Central Sava	44,222	14	79.96	0.64	2.50	4.00	0.80

As expected, the best ranking region in terms of innovation performance is the Central Slovenia region where the majority of high-tech firms, ROs and HEIs are located. The Central Slovenia region is followed by the Coastal-Karst region, Podravska region and Gorizia region. All Slovenian universities, UL in the Central Slovenia, UM in the Podravska, and UP in the Coastal-Karst region, are located in the leading regions in terms of innovation performance. As can be seen from Table 1, the number of SICRIS points is proportional to the size of universities in these regions. Surprisingly, the Gorizia region outperforms the Coastal-Karst and Podravska regions in terms of citations and registered patents per organisation. This might be due to a better visibility of research or innovation achievements. Otherwise, the differences in innovation performance between different regions in Slovenia are quite large.

The number of registered patents highlights the major problem of Slovenian innovation performance. Numbers are generally low showing either weak intentions to commercialise new knowledge or the commercialisation of new knowledge itself or even low quality of innovation. Surprisingly, the highest number of patents is registered

in the Southeast Slovenia region with practically no HEIs and ROs but with an important foreign car producing company and a major Slovenian pharmaceutical company.

The last two columns of Table 1 display normalised numbers of links inside (intra-networking) and outside (inter-networking) the region respectively. Normalisations applied in both areas are consistent with the normalisation used in Figure 2. Weighted links are divided by the product of the number of organisations in linked regions. Consequently, inside the region the division by the number of organisations was carried out, and outside the region the remaining (normalised) links were summed up and divided by 11 to obtain the average of all weighted links of each individual region.

Again, the Central Slovenia region clearly outperforms other regions in both segments. The number of links between the organisations in the Central Slovenia region is on average more than five times higher than the average number of links between the organisations inside this region and the organisations in other parts of Slovenia. This is more or less also true for all the other regions with two exceptions. Organisations in the Coastal-Karst region are extremely disconnected among themselves and therefore the sum of normalised links outside the region is significantly higher than that of the normalised links inside the region. The situation in the Podravska region is even more interesting, with the organisations inside the region being almost equally linked to the organisations outside the region. Nevertheless, in Slovenia inter-regional networking seems to be rather undervalued in comparison with intra-regional networking.

4.2.3. Innovation clusters in Slovenia

Analysing the basic network presented in Figure 1, we identified organisations that cooperate with each other most frequently. For this purpose we used the generalized core method. We found that the generalized core at level 14 is the highest possible order core in the basic network. Due to some intriguing implications we chose to analyse the generalized core at level 10 containing 31 organisations which participate in at least 10 common centres, together with other organisations from this subnetwork. This is also the only subgroup of organisations in our primary network with such feature.

Organisations in the generalized core are classified using Ward's method of agglomerative hierarchical clustering and generalized Euclidean distance (Ferligoj, 1984; Doreian et al., 2005). The resulting dendrogram is shown in Figure 3. A relatively obvious decision for cutting the dendrogram is at the level 4. Therefore, we divided organisations in the generalized core into four groups presented in a matrix in Figure 4. The inference is that these groups might actually represent cases or rudiments of innovative clusters.

As seen in Figure 4, the IJS occupies central position regarding innovation networking in Slovenia, cooperating with almost all organisations in the generalized core. As we consider only the edges with weight 2 or more, 27 organisations in the generalized core cooperating with the IJS participate in at least two common centres.

The first, most strongly associated group in the generalized core consists of the IJS and two higher education institutions – UL FE and UM FERI, operating in the fields related to computer science, informatics and electrical engineering. The second group

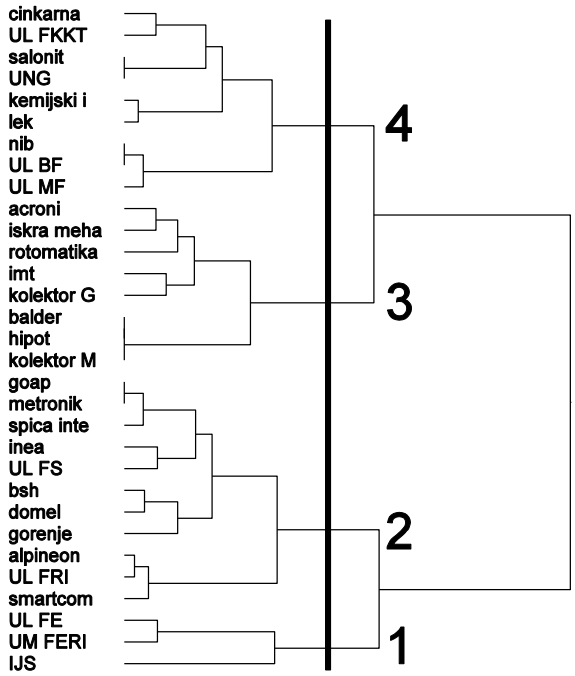

Figure 3:
Dendrogram of hierarchical clustering and demonstrated cut level

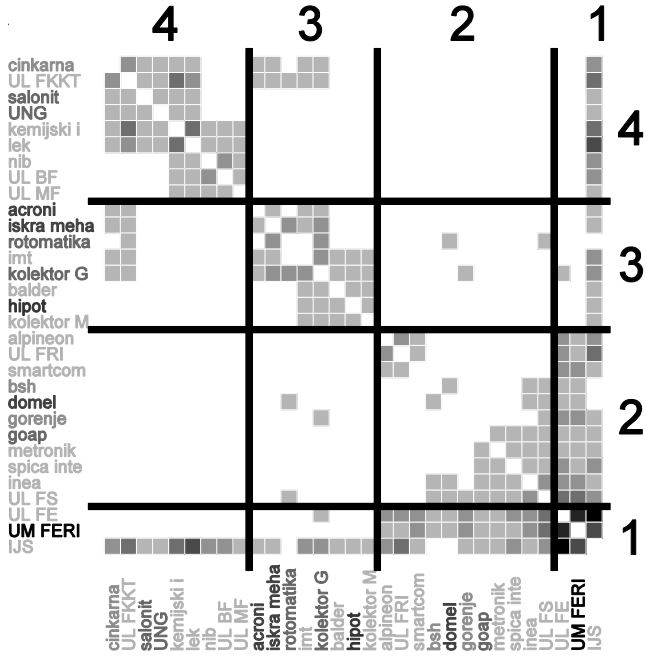

Figure 4:
The matrix presentation of the generalized core

consists of organisations almost all of which are in cooperation with the first group and some of them also among themselves. This group consists of firms whose primary business is related to process automation, computer engineering and computerization, as well as the development and use of electronic communications and speech technology. It includes also two HEIs of the UL, i.e. the Faculty of Mechanical Engineering (UL FS) and the Faculty of Computer and Information Science (UL FRI). The third group is closely related to the development and use of electronic circuits and components, technologies and materials for electronics with optoelectronics components and measurement instruments. The fourth group is focused on a different discipline, i.e. chemistry and pharmacy. It involves some chemical and pharmaceutical companies (Cinkarna, Salonit, Lek), two public ROs (National Institute of Chemistry and National Institute of Biology) and relevant HEIs – University of Nova Gorica and also some HEIs from the UL, i.e. the Faculty of Chemistry and Chemical Technology (UL FKKT), the Biotechnical Faculty (UL BF) and the Faculty of Medicine (UL MF).

Innovation performance of four innovation clusters was analysed in Table 2. The most successful group in terms of innovation performance is group 1 consisting of two HEIs and the IJS. This is quite logical since the IJS is the leading RO in Slovenia. However, the group with the highest number of citations is group 4 – a chemistry related group. This group is the leader in terms of the number of patents. On the other hand, innovation performance of groups 2 and 3 is rather poor (despite the fact that the IJS cooperates with these two groups). Furthermore, group 3 has very poor achievements in terms of registered patents which is quite worrying since this group includes some of the leading Slovenian firms (e.g. Gorenje).

A degree as a measure of centrality inside each group has also been determined. In fact, a calculated degree inside a group is the average of all weighted links inside the group (Wasserman and Faust, 1994). All four groups have degrees much higher compared to the degree outside these four groups. Nevertheless, group 1 stands out as the group with the highest average degree compared to other organisations, meaning that the organisations within this group are on average better linked with organisations outside the group than other organisations. When considering bivariate correlation in Table 3 we can see that publishing achievements (SICRIS points) are related to both intra-regional and inter-regional networking, patenting seems to be related to the number of citations, and both kinds of networking are correlated too. The correlations are marginally significant.

4.3. The network of Slovenian innovation centres

The second one-mode network, the innovation network of Slovenian centres, consists of 34 entities representing 34 centres. As in the innovation network of Slovenian organisations, multiple lines were replaced by a single line indicating the original number of lines between two centres (representing common organisations). Thus, centres are linked by 173 edges most of which (99) are weighted by only one common organisation. Eight common organisations are shared between the CC of Modern Control Technologies (CC STV) and the CE of Modern Control Technologies (CE STV). The CE of Nanoscience and Nanotechnology (CE NIN) shares seven common organisations

Table 2:
Data on innovation performance of the four recognised groups, other organisations and IJS

Innovation cluster	SICRIS per individual researcher per group	Citations per individual researcher per group	Patents per individual researcher per group	Degree inside the group	Average degree btw. group - others
Cluster 1	283.73	15.26	0.1376	6.0000	0.40140
Cluster 2	55.03	1.46	0.0828	1.0181	0.13118
Cluster 3	79.54	4.24	0.0026	1.3928	0.15434
Cluster 4	174.82	20.40	0.2305	1.5000	0.17703
All other	63.55	3.55	0.0000	0.0454	0.15103
IJS	374.78	33.56	0.1928	–	–

Table 3:
Correlations between the innovation performance indicators in recognised clusters

z	SICRIS	Citations	Patents	Links inside	Links outside
SICRIS	1				
Citations	0.800	1			
Patents	0.646	0.882*	1		
Links inside	0.914*	0.522	0.396	1	
Links outside	0.927*	0.535	0.350	0.982*	1

*** p<0.001; ** p<0.01; * p<0.05

with the CE of Modern Metal Materials (CE MKM) and with the CE of Environmental Technologies (CE OT).

However, some centres include more organisations than others. For this reason weights on edges were normalised. Each weight was divided by the square root of the product of the number of organisations in the connected centres. The resulting network is displayed in Figure 5. The shapes of vertices are defined by centres partition; diamonds are used for Competence Centres (CCs), and circles and squares are used for Centres of Excellence (CEs) and Development Centres of Slovenian Economy (DCs), respectively. The size of vertices is proportional to the number of organisations in an individual centre. Some intriguing strong cliques are revealed in Figure 5:

1. CC of Biomedical Engineering (*CC BME*), CC of Modern Systems for Efficient Use of Electricity (*CC SURE*), CE STV and CC STV;
2. CE of Biotechnology with Pharmacy (*CE BF*), CE of Studies of Structures and Interactions in the Biotechnology and Pharmacy (*CE NMR*) and CE OT;
3. CC of Open Communication Platform for Service Integration (*CC OPCOMM*), CC of Services Supported by Cloud Computing (*CC CLASS*) and CE of Information and Communication Technologies (*CE IKT*).

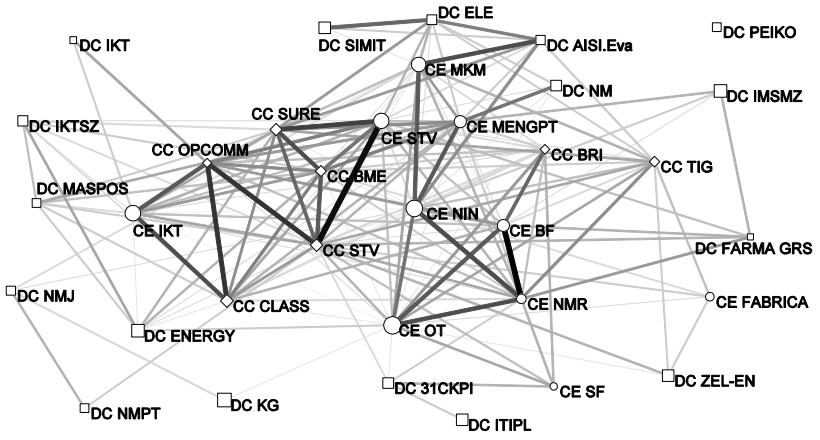

Figure 5: One-mode innovation network presentation of Slovenian centres

5. Discusion

Slovenia has achieved 73% of the average Gross Domestic Product (GDP) per Capita of the EU27 (Eurostat, 2011). In recent years, the difference between the GDP of Slovenia and the average GDP of the EU27 has been slightly reduced, but Slovenia still lags behind the most successful European countries. The key question is what measures should be introduced to further improve the relative economic performance of Slovenia. Gorenak and Pagon (2006), for example, note that there is a connection between national economic performance and highly motivated and well trained employees that promote innovation. Vidulin and Gams (2006) stress the importance of tertiary education and especially innovation performance – in their extensive research they link national economic performance with the volume of new knowledge commercialisation and patenting.

In our study we have applied the same logic at the level of the regions in Slovenia, because the better the innovation performance of the regions, the better the innovation performance of the country. We've analysed the data in Table 1 using bivariate correlation analysis. The results (see Table 4) show that there are statistically significant relationships between regional GDP on one hand and publishing achievements (SICRIS points), the number of citations and the number of inter-regional links with organisations outside the region on the other. The number of intra-regional links seems to be marginally significant and, surprisingly, the number of registered patents doesn't seem to be related to the economic performance of the region at all. This might be an important message for regional and national authorities. Our study shows that they should increase their effort to encourage regional organisations into quality scientific publishing and establishing links with other organisations inside and outside their own regions.

Table 4:
Correlation between the innovation performance indicators in the regions of Slovenia

	SICRIS	Citations	Patents	Links inside	Links outside	Regional GDP
SICRISs	1					
Citations	0.859**	1				
Patents	0.237	0.304	1			
Links inside	0.276	0.485	0.276	1		
Links outside	0.649*	0.839**	0.412	0.667*	1	
Regional GDP	0.797**	0.810**	0.513	0.599*	0.817**	1

*** p<0.001; ** p<0.01; * p<0.05

When considering relationships between intra-regional networking, inter-regional networking and innovation performance, the results of our study (see Table 4) stress the importance of links between organisations from different regions of Slovenia. This kind of relationships seems to be strongly related to the number of citations and publishing achievements. Nevertheless, as it can be seen in Table 4, we have also identified a marginally significant positive relationship between intra-regional and inter-regional networking. Therefore, organisations which have links with Slovenian organisations outside their own region seem to be better linked with the organisations within their own region as well (and vice-versa). Figure 6 shows the actual situation of networking and possible innovation performance on the level of Slovenian regions. We have identified the regions which show a relatively high innovation potential (lower quadrants in Figure 6) and the regions with a relatively low innovation potential (upper quadrants in Figure 6).

On the other hand, our study does not support the existence of a relationship between (any type of) networking and patenting, which is quite interesting and might be a Slovenian peculiarity. Patenting seems to be related to the number of citations (see Table 3), but only in the case of highly connected organisations. This finding suggests that most organisations in Slovenia are probably not aware of the fact that patenting is an important issue. On the other hand, there are also some doubts about the quality and usefulness of already registered patents whereas we have detected a weak relationship between patenting achievements and regional GDP (see Table 4).

The logic of links between the organisations of the same innovation cluster and links among organisations within and organisations outside the cluster may also be applied when analysing the innovation performance of innovation clusters. As it can be seen in Table 2, cluster 1 is relatively very successful in terms of its publishing achievements (SICRIS points) and the number of citations. It also shows the highest degree of intra-group and inter-group networking. The second place in terms of the intensity of (especially) inter-group networking goes to cluster 4 whose innovation performance is in accordance with its networking intensity. On the basis of our data we might conclude that inter-group and intra-group networking are

significantly related to the innovation performance of clusters in terms of publishing achievements and the number of citations, but again, the role of patent registrations is somewhat unclear.

The analysis of the cliques of Slovenian centres (CCs, CEs or DCs) in Figure 5 identifies scientific disciplines and/or industries where organisations are probably the most integrated in terms of innovation. The first clique includes organisations focusing on sustainable development through the efficient use of electrical energy, automation, cybernetics and biomedical engineering. The second clique is focused on environmental issues based on biotechnology, functional genomics and environmental technologies. The third clique focuses on informatics, communication technologies and the development of users' platforms and interfaces. In our opinion, the authorities might consider channelling financial resources into these industries because in this way the best innovation performance on the level of regions or the country might be expected.

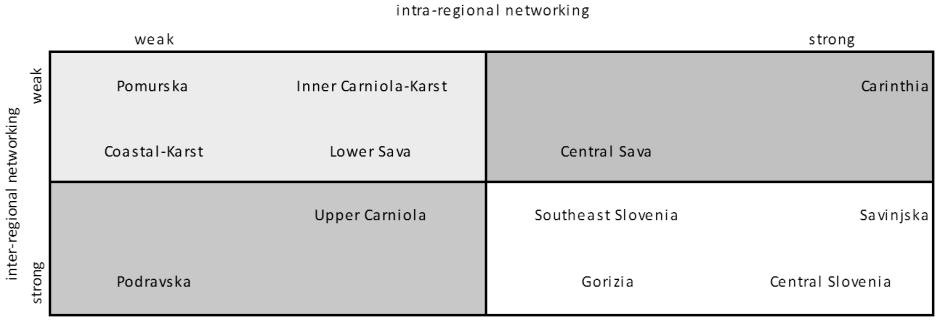

Figure 6: The matrix presentation of levels of networking in the regions of Slovenia

6. Conclusion and implications

The paper identifies some of the leading innovation clusters in Slovenia, as well as the level of innovation performance of the regions in Slovenia. In the following section we answer the 4 research questions from the section 2.

1. When considering innovation clusters in terms of most strongly connected organisations, and more broadly in terms of intra-regional and inter-regional networking, we've found strong and positive relationships between innovation performance in terms of publishing achievements and the number of citations on one hand and the degree of networking on the other. But it seems that in this context inter-regional networking might be more important than the intra-regional one. Therefore, organisations belonging to certain innovation clusters and the clusters themselves, as well as Slovenian organisations in general should be encouraged to cooperate with organisations outside the cluster or/and outside their region.
2. On the basis of our study and despite the assumed importance of intra-regional networking, we can conclude that Slovenian organisations are on average better connected with

organisations within their own regions than with organisations from other Slovenian regions. Because there seems to be a relatively strong correlation between intra-regional networking and regional GDP, additional mechanisms should be introduced at the level of regions or wider to encourage this kind of innovation networking.

3. In our study we've determined some important factors that are positively related to regional GDP. Publishing achievements, the number of citations and especially inter-regional networking seem to be important factors related to the economic performance of the region. This might be an important message for regional and national authorities. Surprisingly, the number of registered patents does not seem to be related to any of the analysed innovation factors or dependent variables (e.g. GDP). This is an area which requires additional research.
4. We've confirmed the basic assumptions stemming from the theory of networks. We recognise that innovation clusters usually consist of entities from similar industries, based on common scientific disciplines, and with some common history of cooperation present in the group (e.g. there are obvious relationships between HEIs which educate engineers and ROs and firms which employ them). Slovenia has a tradition especially in two technological disciplines, i.e. chemistry and electrical engineering (Sitar, 1987), which is obviously reflected in the results of our study. Within these two orientations we can recognise few key scientific disciplines which might be supported in Slovenia – e. g. biotechnology, the efficient use of electrical energy, automation, cybernetics, biomedical engineering, informatics, communication technologies, etc.

Our study represents one of the first attempts to analyse cooperation and clustering issues related to innovation in Slovenia. Findings and approaches in the study could serve as a starting point for further research. Our work may proceed in two main directions, firstly, we could focus on the investigation of additional links among organisations in the network (e.g. joint meetings, trainings, research papers, patents, etc.), and secondly, the innovation network border might be extended into international context (involving organisations outside Slovenia).

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