Legacy of Socialistic Era in Slovak Networks of Inventors – from Clustering to Fragmentation of Two "Relational" Leaders

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Abstract

The aim of the article is to outline the development of two leading Slovak regional innovation networks from 1988 to 2012. With respect to the networks development, the whole time periods is divided to 5 years periods. Findings for Slovakia regions indicate that the "relaxation of rules" (renewal of cross-branch cooperation) doesn´t necessarily mean increasing of cooperation among innovators on the firm level. In addition, we can observe gradual disintegration of main component and creation of more fragmented networks characterized by closed clusters of inventors. These clusters are usually constituted like stars – with all related members, or like triangles and dyads. Results also show the structural hole in evolution of inventors´ networks in Slovakia.

Key words: innovation systems, networking, social network analysis, transformation process.

JEL Classification: O34

1 Network Analysis as Empirical Tool in Regional Innovation Systems Approach

Networking of innovation actors can be found in evolutionary theory (Nelson and Winter, 1997) and system thinking about innovation systems (Edquist and Hommen, 1999; Lundvall et al., 2002). The basic assumption of this concept roots in division of innovative labour between actors and view of technological change as a "driving force" of economic development (Fischer, 2001). Thus, the process of technological learning is the core of evolutionary approach. And the process of technological learning is result of social relations (actors interaction – actors share their knowledge and in this way, knowledge are developed) (Granovetter, 1973).

Studies of authors like Cantner et al. (2010), Graf and Henning (2009), Cantner and Graf (2006), Fritsch and Graf (2011) or Miguelez and Moreno (2014) use social network analysis to observe innovation relations. Social network analysis becomes the empirical tool to uncover forms of interaction within innovation system and between innovation system and its neighbours (Cantner et al., 2010). The importance of geographic proximity shifts attention on regional level toward regional innovation systems (Cooke et al., 1997; Doloreux and Parto, 2005) – mainly due to difficulty of non-codified knowledge. Diversion from national level is also caused by fact, that relations among innovation actors exceed national boundaries and in this sense, there is no reason

why the analysis of innovation systems should be limited by state borders. In studying of innovation networks, German authors confirm importance of sub-national conditions (histories and resulting macroeconomic conditions) which have impact on innovation effort of innovators on the regional level. But it should be noted, that German authors use political regions which are slightly larger as NUTS 3 level and slightly smaller as NUTS 2 level. According to data availability, Miguelez and Moreno (2014) apply NUTS 2 level for selected European regions and Lengyel et al. (2013) realize their findings for CEE on the city level. Paper focuses on NUTS 3 level with highlighting of interregional linking in the case of Slovak innovation networks.

Based on the same assumptions as can be found in work of Graf and Henning (2009), Cantner and Graf (2006), Cantner et al. (2010), Fritsch and Graf (2011), Lengyel et al. (2013) and Miguelez and Moreno (2014), the paper observe networks of inventors through patent applications. It is no doubt, that the usage of patent applications is related with relatively "narrow" definition of innovations (Cantner et. al, 2010). But it is still challenging to handle knowledge flow among different actors, especially in the case of non-codified knowledge. In this way, patents seem to be a tool how to partially describe relational nature of innovation.

2 Data and Methodology

The common feature of studies in the field of innovation networks (some of them use interview for identifying of innovation partners (Sternberg, 2000; Russo and Rossi, 2008) is to explain specific role and strategy of actors participated in networks and analyze firms and sectors which themselves are responsible for networks creating. Paper follows assumption that innovation networks stimulate innovation on the firm level but in addition, networks became the key tool of regional development strategies. Innovations are driven by interactions among heterogeneous actors who share the same aims but they differ in knowledge, skills, experiences and relations with other actors (Russo and Rossi, 2008). These interactions lead to structural patterns generation expressed as networks. Kogut (2000) defines economic networks as relations patterns between firms and institutions. If relations among actors are not randomly distributed, then these patterns have a tendency to localize in a space. Following each other in successful innovation (Schumpeter, 1939) they can create clusters.

Graf and Henning (2009) model innovation activity as a social network closed in a region. The level of regional innovation output is influenced by quality and intensity of regional innovation networking which is supported by public research in this particular region. As was mentioned above, paper similarly as Graf and Henning (2009) uses patent applications for network creation. While German authors apply six or seven years time periods, the paper uses 25 years in summary. There we can find "advantage" of Slovakia which lies in relatively low amount of innovation actors (approximately 27 thousands for whole Slovakia). In the case of German regions, system dynamics leads to the increasing concentration of actors in network – actors are clustered around the key innovation players (actors with higher betweenness).

The structure of networks, clustering of its actors and resulted structural patterns are related with a lot of regional or national conditions like the size of particular area, level of its agglomeration,

industrial specialization or historical and cultural factors. In this light, it is still challenging to compare different innovation networks with including of all mentioned factors.

Patent applications include data about two groups of actors – innovators (applicants) and inventors. Innovators and inventors, both of them can be nodes in social network analysis. In this sense, networks of innovation actors can be created on two levels – networks of innovators and networks of inventors. Authors Fritsch and Graf (2011) create networks of innovation actors with both groups based on principle of cooperation and mobility.

Principle of cooperation means that two inventors are connected if they are on the same patent application. On the other hand principle of mobility means that we can connect two innovators, if they employed the same inventors. Taking into account both principles, this leads to inventors – innovators networks (Fritsch and Graf, 2011). Regardless of studied level, linkages are based on concept of knowledge transfer through personal relations (Almeida and Kogut, 1999). Due to poor mobility among Slovak inventors, paper deals only with inventors networks (inventors as knowledge bearers).

Similarly like Fritsch and Graf (2011), paper uses patent applications obtained on the national level. In the case of Slovakia, patent applications are available through Office of Industrial Property. On the other hand in international comparison, Migualez and Moreno (2014) or Lacasa and Giebler (2014) apply data from PATSTAT (European Patent Office's (EPO) Worldwide Statistical Patent Database) database and Lengyel et. al (2013) use database of USPTO (United States Patent and Trademark Office). Lengyel et al. (2013) suggest that USPTO database is more stable, especially in the case of CEE countries. Authors indicate that analysis of innovation performance of CEE countries plays a crucial role, because inventors in post-socialist countries limit the protection of their intellectual property on domestic markets. To observe patent activity mainly on domestic market, paper focus on patent applications from National Office of Industrial Property. Finally, paper deals with inventors networks from 1988 to 2012. Networks are created for 5 years period like “moving windows”.

3 Historical Backgrounds – Legacy of Socialistic Era in Slovak Networks of Inventors

In socialistic era, CEE countries could be characterized by linear innovation approach with limited horizontal cooperation (Koschatsky, 2002), without improvements of productivity through localized collective technological activity (Žížalová, 2010). On the other hand, soviet regime considered science and technology for integral part of each economy (Graham, 1990). Universities were gatekeepers of knowledge between basic and applied research. Nevertheless, it was prevalent basic and lack of applied research which caused problems in establishing of partnerships among firms (Žížalová, 2010). With focusing on relations among innovation actors (Lengyel et al., 2013; Fritsch and Graf, 2011; Bathelt and Gluckler, 2011) and network evolution (Zaheer and Soda, 2009), factors like deformation of linkages with initial markets, weak structural and institutional reforms (Koyame-Marsh, 2011) and deformations in human perception inherited from socialistic era seem to be factors which have had impact on development of innovation effort. As Donnorummo (2006) highlights, the process of economic

transformation is determined, among other things, by existing macroeconomic conditions in 1989 (or in 1991). Due to Historical Statistical Yearbook of ČSFR from 1990, official reported national income and consumption was increasing during the whole socialistic period. But these values do not include hidden inflation or other dysfunctions in economy.

It was probably hybrid economy in CEE countries, which influenced their path-dependence (Smith, 1998). Fritsch and Graf (2011) analyze how different historical and resulting macroeconomic conditions shape regional innovation activity. Their findings for East and West Germany indicate important structural differences between innovation networks of East and West RIS. This is probably result of various innovation implemented in RIS in the past. It should be note, that East Germany is a benchmark among other CEE countries. During the transformation process, East Germany had enough administration and financial capacities with specific position in patenting – companies still apply for patent protection on domestic market (Lengyel et al., 2013). Despite unfavourable situation on labour market, opening markets in 1990 led to "start-ups" boom and unemployment was partially solved by self-employment of east Germans (Fritsch et al., 2014). While CEE countries can be characterized by international cooperation assigned to foreign countries, there are domestic inventors in East Germany (Lengyel et al., 2013).

3.1 Development of regional innovation networks in Slovakia 1988 – 2012

Paper deals with evolution of inventors networks applying for initial patent protection on domestic market for time period 1988 - 2012. In 1953, Slovakia started its industrialization process which unfortunately led to widespread of sectors with low added value (Koyame-Marsh, 2011). Although industrialization was connected with market integration of the outermost region into the economy, the later socialism and path-dependence caused uneven regional industrial structure occurred after the Second World War (Smith, 1998). The Czechoslovak economy was characterized by mechanical engineering and chemical sector and it is not surprising that we can find the most patent applications exactly in these two sectors, especially in years 1988 – 1992.

Tab. 1 Specialization of institution applying for patents in time period 1988-2012

	1988-1992	*1993-1997*	*1998-2002*	*2003-2007*	*2008-2012*	*Overall*
Section A – Human Necessities	35	31	23	12	22	123
Section B – Performing Operations, Transporting	47	36	31	28	21	163
Section C – Chemistry, Metallurgy	63	55	54	47	39	258
Section D – Textiles, Paper	3	2	1	1	4	11
Section E – Fixed Constructions	14	7	11	4	15	51
Section F – Mechanical Engineering, Lighting, Heating, Weapons, Blasting	21	21	18	23	18	101
Section G – Physics	29	17	10	18	19	93
Section H – Electricity	17	11	7	8	21	64

Source: Self-processing

As Lacasa and Giebler (2014) suggest, chemical sector and mechanical engineering are industries of CEE specialization and sectors of their technological advantage. On the other hand these

sectors have been losing their technological opportunities (decreasing of technological dynamics). Industrial specialization is mirrored in network structure with one or two bigger components and higher amount of smaller groups. Radosevic (1999) indicates that horizontally integrated institutes created stronger linkages between R&D and enterprises, but in comparison, connections among different sectors were weak. Innovation were process rather than product oriented and organization of networks were "in hands" of headquarters. It is natural to assume, that the later openness of tight linkages existing in concerts will lead to increasing of cooperation among various institutions (amount of innovators on the same patent application). But while we can find maximum of five partners (appliers) on the same patent application in time period 1988-1992, later there are maximal two or three innovators. These findings for Slovakia show that the "realizing of rules" (recovery of sectoral cooperation) does not necessary mean the increasing of cooperation among innovators on institutional level.

We register 113 existing external R&D organization at the end of 1989 (Historical Statistical Yearbook of CSFR from 1990). At the same time, there are 136 enterprises with innovation effort (applying for patents) in 1988-1992. Decreasing share of research institutions and Slovak Academy of Science on overall innovation activity suggests decreasing state involvement in activities of basic research in comparison with socialistic era. Enterprises with less than three patent applications create majority part of all innovation actors on firm level during 25 years. These institutions apply for patents only once and subsequently they disappear from Slovak patent market. Presence of individual appliers with closed research team leads to relatively highly fragmented networks of inventors. Increasing share of closed research teams is mirrored in gradual disintegration of main component over the time.

3.2 Inter-connectivity of Slovak regional innovation networks

As Smith (1998) suggests, after November 1989 Slovak economic area passed by dramatic fragmentation based on low amount of regional winners but much larger amount of regional "fallen". Deindustrialization influenced sectors and regions with weak ability to react on fast liberalization. Old regional dependencies on companies prevailing in local economies were devastated. In this sense, we can talk about localities with unilaterally industrial structures, which are related with classic model of forced industrialization and concentration of arms industry, heavy engineering, mining, steel and chemical industry. Region is still the level on which innovation is generated through regional innovation networks, local clusters and activities of research institutions (Bathelt et al., 2004).

Slovak enterprises are usually small or medium-size firms with low knowledge intensity, limited access to external financial sources without needed support from state side. Microeconomics basis is in hands of small amount of large companies. Overall, we can find only few large enterprises which were applying for patents during whole period. These companies employ inventors with higher centrality and these inventors are nodes of main component in inventors' networks. Existence of small amount of firms responsible for majority of patent activities with access to central actors in network mirrors comparable networks development in the case of eight Slovak regions. Figure 1 offers view on networks development in time period 1988 – 2012. The size of circle represents value of network characteristic in each region due to values reached by others regions.

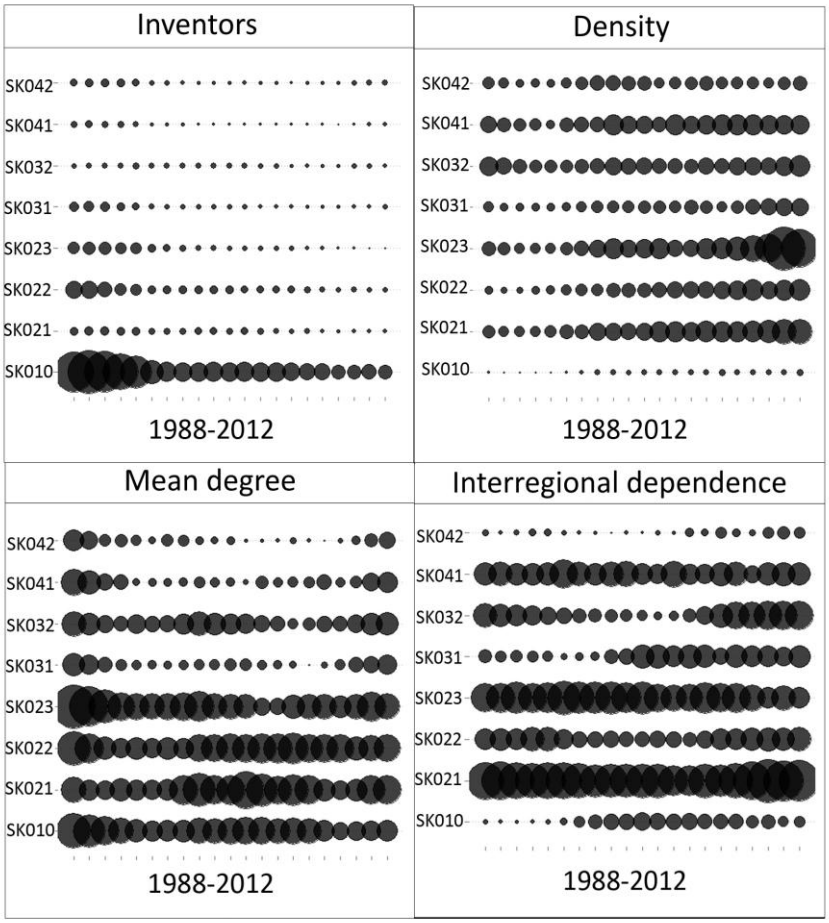

Fig. 1 Selected networks characteristics of 8 Slovak regions (NUTS3) in 1988-2012
Source: Self-processed

As we can see on Fig.1, the amount of inventors is decreasing during whole period. Later increasing of patent applications without appropriated increasing of inventors amount is mirrored in increasing density and mean degree of selected networks. These findings indicate increasing cooperation among inventors. From the networks view, we can say that this is a positive networks development. But it is creation of pairs and triplets which lead to higher density without extensive cooperation resulted in the growth of main component and in the generation of larger components. Inter-regional dependence shows dominant position of west and east Slovakia centers. Dependence of Bratislava and Kosice regions is obviously lower in comparison with other regions. In other words, networks created for these two regions include lowest amount of inventors with addresses localized elsewhere. This is probably related with inventors´ traveling to work.

3.3 Fragmentation of main component

Decreasing size of research teams is shown on Fig.2. Fig.2 displays fragmentation of main component in the case of Bratislava region. Situation is very similar in Kosice region, although with the main amount of inventors and relations. At the beginning, there are 1232 inventors creating 2739 edges in Bratislava region, while at the end only 469 inventors with 747 linkages.

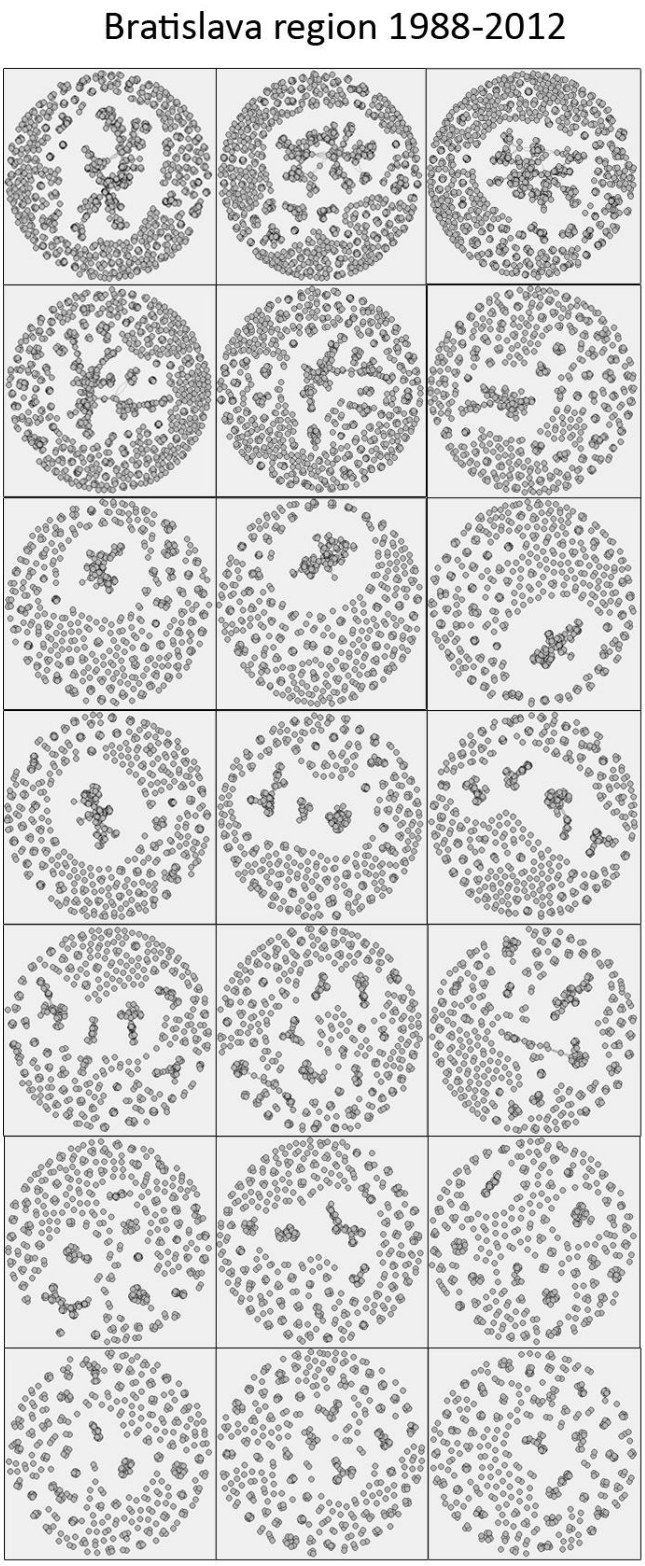

Fig. 2 Decomposition of main component in Bratislava region
Source: Self-processed

Decomposition of main component (networks core) seems like cells segmentation, but these cells disappear gradually. More important is fact that it is still the same component which is disintegrating. Actors, who lost linkages with the main component, subsequently do not create new, more extensive connections. In comparison with the past, entrance of new research teams is connected with creation of relatively small amount of linkages (maximal 10 edges on inventor). Fading of innovation linkages with Czech Republic is reflected in networks in period 1992 – 1996. In this time, there are approximately 15 % of initial inventors with more than 5 edges who were completely disconnected from main component. This trend continues and it is the most obvious in 1995-1999 with the loss of more than 27 % actors. In the case of Slovak leading regions, increasing networks density means decreasing amount of inventors. Regional networks of inventors generate clusters in the shape of stars (all actors are connected), triangles or dyads.

4 Conclusions

During the whole period (1988 – 2012), almost all organizations (universities, research institutions, Slovak Academy of Science and enterprises) were reducing their patent activity. The largest decline is found after year 1993. Research institutions and institutes of Slovak Academy of Science were dominated patents actors at the beginning, but they froze innovation activities in later periods. State support in time of socialistic era, regardless of markets needs, is probably major cause of higher innovation activity (higher amount of patents applications) in comparison with post-socialist existence of Slovakia. In the sense of amount of patent applications, innovation effort was higher in socialistic era. But the later commercialization of granting patent cannot be confirmed.

Linkages among inventors from 1988 to 1992 indicate networks with relatively high mean degree, higher average distance in main component, which is related with higher amount of nodes in main component and relatively lower share of isolates. Lower networks density is probably a result of closed cooperation within industrial associations without need of external cooperation with other innovation actors. We can find these structures especially in economies with two or three dominated sectors. Situation is typical also for Slovakia with patent application prevailing in a few areas: industrial technology and transportation, chemical industry and metallurgy. Patent specialization is consequently reflected in network structure with one or two larger components and higher amount of smaller groups. Unfortunately, as Lacasa and Giebler (2014) suggest, chemical industry and metallurgy are sectors of CEE countries specialization which are losing technological opportunities.

Fragmentation of relations among inventors after 1996 suggests structural hole in evolution of Slovak innovation networks. This structural hole is mirrored in disintegration of research teams which have not been replacement by new research groups (Zaheer and Soda, 2009). Actors, who initially participated in main component, are losing connections and entrance of new researchers is related with creation small amount of linkages (low relational capacity). Regional networks of inventors generate clusters in the shape of stars (all actors are connected), triangles or dyads. Decreasing amount of linkages and innovators highlights increasing dependence of Slovak regional innovation activities on foreign research. As Lengyel et al. (2013) indicate for CEE countries, inflow of FDI is reflected in faltering force of local innovation ties.

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