THE POSSIBILITIES OF REGIONAL SYMBOLIC KNOWLEDGE BASE FOR RESILIENCE OF THE REGIONS

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ABSTRACT

Knowledge bases became an issue of cardinal importance in recent literature concerning with knowledge creation, innovation process and construction of regional advantage. Knowledge bases impact the adaptability of the region to develop new grow paths. From this "evolutionary" point of view, they are crucial for the regional resilience. The paper is focused on the analysis of symbolic knowledge base. We distinguish three dimensions (technology, organization, geography) which operate in innovation systems based on symbolic knowledge base and measure their interactions by using entropy statistics. The prevailed synergy is measured by analysing distributions of firms in terms of geographical locations (postal code), organizational sizes (number of employees) and technology (NACE codes for knowledge base). The results show that in the case of symbolic knowledge base the synergy is generated within the district level. Results have implication to the regional innovation policy. First of all our research confirm the importance of differentiated regional knowledge bases in connection with the establishment of regional advantages which could be linked to regional resilience. Regional innovation policy must be adjusted to reflect particularities of requirements of industries based on different knowledge base.

JEL: *D80, R58, R19*

KEYWORDS: *knowledge bases, regional innovation system, synergy, resilience*

INTRODUCTION

Nowadays, more and more literatures about knowledge bases have been developed and knowledge bases have started to be one of the key elements for formulating dedicated and specific support customised to different industries and thus, to different regions (Cooke et al., 2006). Knowledge bases contain different mixes of tacit and codified knowledge, qualifications and skills required by organisations and institutions involved in the process of knowledge creation and innovation. Each knowledge base is different in terms of its specific innovation challenges and pressures, which justify its different sensitivity to geographical distance and, accordingly, the importance of spatial proximity for localised learning. Asheim et al. (2011) distinguish three types of knowledge bases: synthetic, analytical and symbolic.

An analytical knowledge base is dominant in economic activities where knowledge creation is mainly based on formal modes, codified science and rational processes (Asheim and Gertler, 2005). Examples include genetics, biotechnology and information technology. In these sectors the geographical distance does not play important role as knowledge are based on a commonly accepted language that can be more easily codified and transferred. Therefore, knowledge sourcing in this knowledge base is assumed to take place on a wide geographical scale, often within globally configured networks (Martin, 2012).

A synthetic knowledge base prevails in industries where incremental innovation dominated by the modification of existing products and processes is crucial. A good example for a sector with a synthetic knowledge base is manufacturing and automotive industry. Compared to the analytical knowledge base synthetic knowledge base required know-how, craft and practical skills for their knowledge production and circulation process (Asheim et al., 2011). Those skills are often provided by professional and polytechnics schools or by on-the-job training (Asheim and Coenen, 2006; Broekel and Boschma, 2011).

Symbolic knowledge base is related to the creative industries that has become increasingly important components of modern post-industrial knowledge-based economies. Creative industries have starting to play an important role in fostering economic development as well as for determining successful integration into a rapidly changing global economy. They are characterised by knowledge incorporated and transmitted in aesthetic symbols, images, sounds and other. Symbolic knowledge is highly context-specific, as the interpretation of symbols, images, designs, stories and cultural artefacts is narrowly tied to a deep understanding of the habits and norms and “everyday culture” of specific social groupings (Asheim et al., 2011). This shows that in symbolic knowledge bases geographical proximity is absolutely decisive (Mattes, 2014), thus knowledge flows and networks are expected to be locally configured (Martin, 2012).

We understand the connection between regional resilience and regional knowledge base from the evolutionary perspective (e.g. Boschma, 2014). A comprehensive view on regional resilience is proposed in which history is key to understand how regions develop new growth paths, and in which industrial, network and institutional dimensions of resilience come together (Boschma, 2014). In this point of view knowledge bases predetermine the adaptability of the region and its ability to overcome the crisis and to take advantage of opportunities. The synergy of the regional innovation systems policies can contribute to the adaptation of regional economies and therefore their economic resilience (Simmie, 2014).

The aim of the article is to confirm theory-led expectations about configuration of systems based on symbolic knowledge base. There are some studies about resilience of the creative industries (e.g. Pratt, 2015), which show their specifics in terms of regional resilience. The objective of our paper is to contribute to the recent academic discussion in this area. The basic research question is whether one can measure configuration of regional innovation system based on symbolic knowledge and specify its role in regional resilience.

1 SYSTEM CONFIGURATION AND SYNERGY

In general, configuration can be measured using the mathematical theory of communication (Shannon, 1948; McGill, 1954; Abramson, 1963; Theil, 1972). Configurational information is thus understood as a reduction of the uncertainty in the system. If more uncertainty is reduced in the system, then more mutual information is generated and this mean, that there is configurational synergy at the system level. The synergy can be considered crucial for the strength of an innovation system (Leydesdorff and Fritsch, 2004).

The first authors dealt with calculation of knowledge system configuration were Leydesdorff and Dolfsma and van der Panne (2006). According to them, configuration of system depends on the geographical distribution of partners involved and on relations between them. The network of relations can resonate into a configuration which is productive, innovative, and flourishing. The geographical dimension authors investigated by the postal codes in the firms ‘addresses. However, geographical distribution is not only one of the relevant dimensions for a configuration (Leydesdorff and Fritsch, 2004).

Second dimension is technological dimension. Due to the different character of innovation processes, one can expect that geographical conditions have different effects on the various economic sectors, such as manufacturing or knowledge-intensive services. Authors indicated technology by the NACE code of industrial sectors.

Assuming that a division of labor can yield efficiency gains, one would expect that regions with a profiled configuration could be more productive than other regions. The division of labor among firms of various sizes can be considered as a third determining factor of the quality of innovation systems (Cooke et al., 2004; Fritsch, 2000). Average firm size in terms of numbers of employees can be used as a proxy for thi industrial organization dimension (Pugh and Hickson, 1969; Pugh et al., 1969; Blau and Schoenherr, 1971).

Further, authors use these three dimensions (geography, technology, and organization) and measure mutual information (reduction of uncertainty) flowing between this three dimensions by means of an indicator based on entropy statistics (Fig. 1). The gap in the overlap between the three circles in Fig. 1 can be understood as negative entropy, that is, a reduction of the uncertainty in the system. This reduction of the uncertainty is in this case a consequence of the networked configuration. With this indicator, one can measure synergy at the systems level and thus, assessed the quality of regional innovation systems (Leydesdorff, 2003; Jakulin and Bratko, 2004). It should be emphasized that the indicator measures a synergy at the system level of an economy but, it is not a measure of knowledge creation or economic output (Carter, 1996). In other words, this indicator measures only the conditions in the system for innovative activities, and thus specifies an expectation (Dolfsma, 2005). Regions with a high potential for innovative activity can be expected to organize more innovative resources than regions with lower values of the indicator.

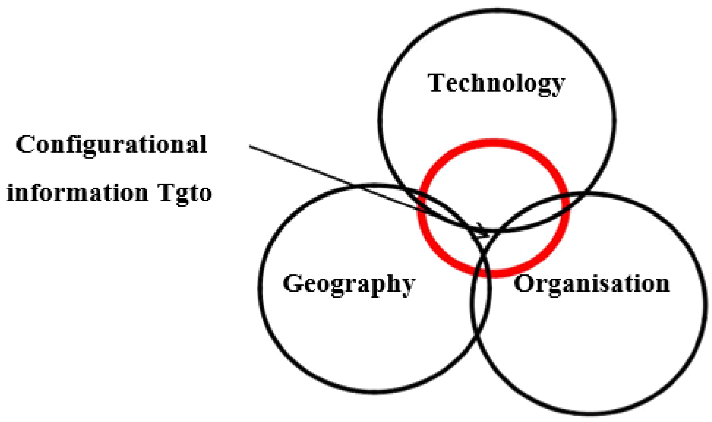

Figure 1 Three dimensions in the innovation system

2 DATA

Authors had access to unique database about each firm in Slovakia from Statistical Register of Organization provided by Statistical Office of Slovak Republic. All data were gathered between the years 1998-2014. Additionally to information at the company level, the data contain three variables which will use as proxies for three dimensions (technology, organization, and geography).Technology will be indicated by the knowledge based sector classification, organization by the company size in terms of numbers of employees (Pugh et al., 1969a, 1969b; Blau & Schoenherr, 1971), and the geographical distribution by the postal codes in the addresses. Sector classification is based on the European NACE system. To run the analysis we apply classification brought forward by Aslesen and Freel (2012), who assign different NACE code of industries symbolic knowledge base (Table 1).

Table 1 NACE codes assigned to symbolic knowledge base

Knowledge base	NACE codes
Symbolic (SYMB)	59110,5910,59200,60100,60200,63910,71100,73120,74100,74200

Source: author´s own elaboration based on Aslesen & Freel (2012)

3 METHODS

For quantification of configurational information (synergy) data had to be organized into structure that is shown in the following table (Table 2). For each firms we have basic information between the years 1998-2014. Twenty-year period was divided into four periods as follows: 1998-2002; 2002-2006; 2006-2010; 2010-2014.

Table 2 Sample of data structure for calculating synergy indicator

ID code of firm	Postal code (3-digit) (G)	NACE code (3-digit) (T)	Category of firm size (O)	District	Region	Year
1	PC 126	24	a	601	6	1998
2	PC 236	31	b	707	7	2002
3	PC 126	24	c	801	8	2010
4	PC 352	71	b	209	2	2014

Source: author´s own elaboration

Configurational information is (synergy) is calculated for each knowledge base and for each administration level (nation, region, and district) by using STATA according to the description provided on the website: http://www.leydesdorff.net/software/th4/th4.prg. Configurational information is closely connected to entropy measures. Entropy is widely used in geography as a measure of inequalities across or diversity within territorial units (Boschma and Iammarino, 2009). Entropy is used as a measure of uncertainty represented in a probabilistic distribution or system of distributions (Johnston et al., 2000). According to Shanonn's (1948) formula, HT, HO) uncertainty in the distribution of the variable x (in our case H_G, H_T, H_o) can be measured according to the equation:

$$H_x = -\sum_{x=G,T,O} p_x . \log_2 (p_x) \qquad 1)$$

According to our sample data (Tab. 2) the value of H_G is as follow:

$$H_G = -\log_2 \left(2/4\right)\left(2/4\right) - \log_2 \left(1/4\right)\left(1/4\right) - \log_2 \left(1/4\right)\left(1/4\right) = 1.5 bit \qquad 2)$$

If the basis two is used for the logarithm all values are expressed in bits of information. The sigma in the formula allows all the information terms to be fully decomposed. Analogously, *Hxy* is the uncertainty in the two-dimensional probability distribution (matrix) of x and y (in our case H_{GT}, H_{TO}, H_{GO}) and can be measured according to equation (3):

$$H_{xy} = -\sum_{x,y'=1}^{N}\sum \left(p_{xy}\right) \log_2 (p_{xy}) \qquad 1)$$

According to our sample data (Tab. 2) the value of H_{GT} is as follow:

$$H_{GT} = -\log_2 \left(\frac{2}{4}\right)\left(\frac{2}{4}\right) - \log_2 \left(\frac{1}{4}\right)\left(\frac{1}{4}\right) - \log_2 \left(\frac{1}{4}\right)\left(\frac{1}{4}\right) = 1.5 bit \quad 4)$$

In the case of two dimensions, the uncertainty in the two interacting dimensions (x and y) is reduced with the mutual information (Txy). Using Shannon's formulas, this mutual information is defined as the difference between the sum of the uncertainty in two systems without the interaction (*Hx +Hy*) minus the uncertainty contained in the two systems when they are combined (*Hxy*). This can be formalized as follows:

$$H_{xy} = H_x + H_y - T_{xy} \Rightarrow T_{xy} = H_x + H_y - H_{xy} \quad 5)$$

Abramson (1963) derived from the Shannon formulas that the mutual information in three dimensions is:

$$\mathrm{T_{xyz} = H_x + H_y + H_z - H_{xy} - H_{xz} - H_{zy} + H_{xyz}} \quad 6)$$

The value of T_{xyz} (T_{GTO}) measures the interrelatedness of the three dimensions and the fit of the relations and correlations between and among them. T_{xyz} has been used as an indicator of potential reduction of uncertainty in complex systems in many disciplines (Ulanowicz 1986; Jakulin 2005). As was stated above, synergy reduces the uncertainty in the innovation systems. Thus, a more negative value of T_{xyz} (T_{GTO}) will indicate a stronger reduction of uncertainty and thus more synergy among the three dimension at the innovation system. This overall reduction of the uncertainty can be considered as a result of the networked configuration. Unlike the mutual information in two dimensions (Shannon, 1948; Theil, 1972), information among three dimensions thus can become negative (McGill, 1954; Abramson, 1963). In order to make a comparison between districts (region), the values of T_{GTO} were weighted with the number of firms in the districts (region) as follow:

$$nT_{GTO} = \frac{n_i}{N} T_{GTO} \quad 7)$$

n_i is the number of firms in district (region) *I* and *N* is the number of firms in the whole country.

One advantage of entropy statistics is that the values can be fully decomposed (Theil, 1972).The decomposition algorithm enables us to study the next-order level of Slovakia as a composed system (NUTS 1) in terms of its lower level units like the LAU 1 districts and the NUTS 3 regions:

$$T = T_0 + nT_{GTO} \quad 8)$$

where T_0 is the in-between region (district) entropy, nT_{GTO} is entropy measured in region (district).

The in-between group uncertainty T_0 is then defined as the difference between uncertainty of the contributions and the uncertainty prevailing at the level of the composed set (Leydesdorff et al., 2006). In this case, T_0 is an indicator of the in-between group contribution to configurational information in three dimensions. A negative value would indicate that the national agglomeration adds to the synergy in the system, while a positive value indicates that the synergy occurs at regional (district) rather than at national levels.

4 RESULTS

For confirmation of our theory-led expectations we calculated configurational information (synergy indicator) T_{GTO} for each district, region and for Slovakia as a whole. After normalization of configurational information we calculated in-between group uncertainty T_0 to find out, whether national, regional or local agglomeration adds to the synergy in the system. Comparison of different levels will serve for defining their importance for the further research related to knowledge bases, but especially for accurately targeted regional policy. Next table provides the results of synergy indicator at each administrative level for industry based on symbolic knowledge base (Table 3).

Tab. 3 Configurational information at national, local and regional level-SYMBOLIC (mbit)

	98-02	02-06	06-10	10-14
(1) T_{GTO} districts (LAU1)	-97.47	-84.19	-76.78	-71.57
(2) T_{GTO} Slovakia	-100.24	-92.44	-70.92	-53.51
To= (2) - (1)	**-2.77**	**-8.25**	**5.68**	**18.06**
(3) T_{GTO} regions	-108.96	-85.78	-74.16	-57.44
(2) T_{GTO} Slovakia	-100.24	-92.44	-70.92	-53.51
To= (2) - (3)	**-7.28**	**-7.66**	**-16.76**	**-12.07**

Source: author´s own elaboration

The results show that an important part of the reduction of the uncertainty is provided at a level lower than the NUTS-3 regions. In other word, higher synergy is generated at local (district) level, which means that the network of relations at local level can resonate into a configuration which is productive, innovative, and flourishing. The economic benefits of symbolic knowledge base are thus, not located at the level of the regional innovation system but at the local level of innovation system. Our findings are in line with our theoretical expectations. The nature of symbolic knowledge is highly context-specific and the meaning and value associated with them can be different between social groupings and places (Martin and Moodysson, 2011a). Therefore, knowledge flows are more likely to occur in the network between partners, who share similar socio-cultural background and are part of the same local innovation system. Industries based on symbolic knowledge will certainly require local access to potential partners, emphasize thus the role of local level government. Despite of general opinion, that the cultural industries has been carried out in the context of state funding (Pratt, 2015), we discovered, that they are influenced significantly by the local level, too.

CONCLUSION

The mutual information in three dimensions was calculated for symbolic knowledge base to demonstrate the specific pattern of knowledge flow and to determine whether local, regional or national level is the center of knowledge exchange between firms and related actors. The quality of knowledge flows has been retained as the synergy generated between three dimensions of the innovation system: geography, technology and organizational dimension.

The results are in line with the theoretical assumptions. In the case of symbolic knowledge base we confirmed that knowledge flows and synergy is generated at the districts level. Economic activities in symbolic knowledge based industry are very much locally configured and draw on knowledge that is generated through cooperation and interaction between actors in the same district. Thus, one could expect that polices aiming at networking activities on the local level will have a positive impetus on the development of these industries.

The role of government should be to create and implement programmes to promote networking between related firms through various forms of informal meetings, as for symbolic knowledge base know-who knowledge is considered far more important than in other knowledge base. Perhaps the most important contribution of this paper is the acknowledging that different knowledge bases ask for different political actions and this differentiating between industrial knowledge bases must be taking into account if regional advantages are constructed. In addition, sector based on symbolic knowledge base need a different set of tools than the industry primarily based on analytical or synthetic knowledge base. A policy aiming to support the activities of local networking can fail in the case of analytical industries. Regional innovation policy must therefore be adapted to the industry-specific demands instead of implementing universal 'one-size fits-all' formulas. Tailor made innovation policy could strengthen the regional resilience.

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