Technological Forecasting & Social Change 84 (2014) 197–214

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Visualising components of regional innovation systems using self-organizing maps—Evidence from European regions

Petr Hajek [a,*], Roberto Henriques [b], Veronika Hajkova [c]

[a] Institute of System Engineering and Informatics, Faculty of Economics and Administration, University of Pardubice, Studentská 84, Pardubice, Czech Republic
[b] ISEGI, Universidade Nova de Lisboa, 1070-312 Lisboa, Portugal
[c] Institute of Administrative and Social Sciences, Faculty of Economics and Administration, University of Pardubice, Studentská 84, Pardubice, Czech Republic

ARTICLE INFO

Article history:
Received 11 October 2012
Received in revised form 16 July 2013
Accepted 22 July 2013
Available online 16 August 2013

Keywords:
regional innovation system
self-organizing map
economic growth
research and development

ABSTRACT

Regional innovation systems are regarded as complex systems in which components are strongly dependent on each other. Such relationships can have both linear and nonlinear character. One of the ways to investigate the structure of regional innovation systems is to use a self-organizing map resulting from an unsupervised learning process. In this paper we employed this procedure to visualize and study the patterns present in the individual components of European regional innovation systems. Our findings suggest that there is a similar level of diversity in individual regional innovation systems' components due to their strong intercorrelations. Additionally, the visualisation of the components in geographical maps shows on a positive effect of the Knowledge intensive regions on the spatially close Catching up regions. Finally, the economic growth of the European regions appears to be associated to European economic integration (for lagging behind regions) and the level of innovative and entrepreneurial activity (for knowledge intensive regions).

1. Introduction

People and their knowledge play a key role in the transition from industrial economy towards knowledge economy. Given that the developed regions cannot compete with low-cost regions, it is the knowledge-based industries, which determine their competitiveness. In the process of European integration, the importance of individual states decreases and the role of regions increases, respectively. This is due to the fact that the benefits of spatial proximity are realized at regional level, and the benefits are reflected in the effective formal and informal cooperation among regional actors (investors, entrepreneurs, researchers, enterprises, public institutions, and consumers). It is this long-term cooperation which is crucial in creating innovation. In this context we refer to the so-called regional innovation systems (RISs) [22].

Since the early 1990s, the concept of the RISs has gained considerable attention from both policy makers and academic researchers as a promising analytical framework for advancing our understanding of the innovation process in regional economies [24]. According to [33,34], RIS can be defined as a set of interacting private and public interests, formal institutions, and other organisations that function according to organisational and institutional arrangements and relationships conducive to the generation, use, and dissemination of knowledge. According to [81], the systems of innovation approach argues that innovation should be seen as an evolutionary, non-linear and interactive process, requiring intensive communication and collaboration between different actors, both within companies as well as between firms and other organisations such as universities, innovation centres, educational institutions, etc.

The attention of the researchers has been attracted to several branches related to RISs, namely to elucidating the

* Corresponding author. Tel.: +420 466 036 074; fax: +420 466 036 010.
E-mail addresses: petr.hajek@upce.cz (P. Hajek), roberto@isegi.unl.pt (R. Henriques), veronika.hajkova@upce.cz (V. Hajkova).

0040-1625/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.techfore.2013.07.013

complex mechanisms within RISs, finding similar patterns in the development of RISs, and to understanding the process of transformation of R&D inputs into innovation and economic growth within RISs. The first two approaches resulted in the design of several typologies of RISs. While the first approach is based on the assessment of qualitative connections among regional actors using case studies, the second approach is represented by the quantitative evaluation of RISs' performance.

The latter approach have evolved from the use of multivariate statistical models [59] to recent use of neural networks' models [32,41,42,66]. Especially, employing self-organizing maps (SOMs) have shown promising results since they allow modelling and visualizing highly dimensional data in a low dimensional space. Thus, it is possible to find and easily interpret similar patterns of RISs. Additionally, due to SOM dimensional reduction and visualisation capabilities, we are provided with a new set of visual products that can be used to map the economic growth and this way, gain a new insight on the relation between RIS components and the economic growth.

The developed typologies of RISs are based on the assumption that there is no general model of RIS that can be implemented in any regional context. On the contrary, the particular socio-economic and cultural context plays an important role in the definition of regional innovation strategy. In addition, European policy is characterized by a strong emphasis on social inclusion and cohesion issues where lagging regions represent an important target group of European technology and innovation policy [14]. Therefore, the research on the RISs' typologies has become a central issue in regional innovation policy.

In the present study, SOMs were used to assess the potential relationships among RISs' components and, further, to investigate the relationships between RISs' components and economic growth. In previous research, the components of RISs have been defined from the process point of view [6,81]. As such, RISs include socio-economic setting, knowledge generation and diffusion component, knowledge application and exploitation component; and knowledge transfer component. The components are interconnected and they are regarded as the most important source of economic growth in developed economies ([39,58,70]; and others). However, far too little attention has been paid to individual RISs' components, their interrelations, and their impact on economic growth.

Our objective is to fill this gap and examine: (1) the impact of the diversity of individual RISs' components on the typology of RISs; (2) the effect of RISs' components on economic growth depending on both the level of European economic integration and global economic development. The results should give an insight on the functioning of various European RISs during the monitored period 2003–2009. This is mainly due to the capabilities of SOMs in effective processing of high-dimensional data. Therefore, we also aim to present both the benefits and limitations of SOMs in this study.

The remainder of this paper is structured as follows. In the next section related literature on RISs' analysis is briefly reviewed. Section 3 describes the SOM method used to analyse and visualise RISs. Further, the design of attributes for RISs' components is realized which serve as input data for the analysis. Section 5 presents our experimental results. In the following sections, discussion is provided, and conclusions and future work are described.

2. Previous studies on analyzing regional innovation systems

In the literature, there have been two approaches in analyzing RISs, namely case studies and statistical analyses.

In the case studies, complex relations between actors in RISs have been studied both to understand the mechanisms within RISs and to assess political implications in specific conditions of selected countries [11,48]. Various conceptual categories of RISs were verified in case studies. [23] defined the categories of RISs based on RIS governance (grassroots, network and interventionist RISs) and entrepreneurial innovation (localist, interactive and globalised RISs). [5] introduced territorially embedded RISs (stimulated with geographical, social and cultural proximity), regionally networked RISs (still an endogenous model) and regionalised national innovation systems (exogenous model of development). [13] classified RISs into industrial core regions (with a low or medium technology level), industrial or service-oriented business regions (with emphasis on SME), destroyed industrial regions, and metropolitan RISs (research, communication and culture-based service regions).

In the studies employing multivariate statistical analyses, proxies for RISs are used to represent the components of RISs, namely socio-economic development, R&D performance, and education level. [45] applied hierarchical cluster analysis to detect 12 categories of RISs. [59] employed factorial analysis on a set of 25 attributes (concerning knowledge creation, knowledge absorption, diffusion of knowledge, demand of knowledge and governance) to distinguish between the following new member states regions: capitals, regions with tertiary growth potential, qualified manufacturing platforms, regions with industrial challenges, and agricultural laggers. In a similar manner, [2] identified regions with a weak economic and technological performance, restructuring industrial regions with strong weaknesses, and capital-regions specialized in high value-added services.

[61] analysed Spanish RISs using principal component analysis and hierarchical cluster analysis and derived four types of RISs: capital regions specialized in advanced services; medium-high tech industrial regions; medium-low tech regions; and agricultural or touristic less developed regions. [42] employed SOMs to analyse the structure of European RISs. However, in this study there was used only a limited number of inputs representing the proxies of education, economy and R&D. Moreover, the potential of analyzing and visualizing of individual components of RISs was not exploited at all.

[56] applied cluster analysis to find the typology of OECD regions. In this study three macro categories were detected, namely knowledge hubs, industrial production zones, and non-science & technology (S&T) driven regions. Knowledge hubs comprise knowledge-intensive cities and knowledge and technology hubs which show very high GDP per capita. Industrial production zones include four clusters with different production characteristics that face specific challenges for restructuring and transformation to keep up with the moving