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Factors Influencing the Level of Regional Innovation — Qualitative Comparative Analysis

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Abstract

Innovation is a highly complicated and ambiguous phenomenon. It is also a key element of the competitiveness of companies, regions and nations. The aim of this study is to identify the conditions that most affect regional innovation. This research combines a group of indicators that define some tangible factors of regional development with level of innovation performance. The pathways to facilitate a region's higher innovativeness are presented. For this purpose, fuzzy set qualitative comparative analysis is adopted. The analysis was performed for two different groups of regions: Innovative Leaders and Modest Innovators (according to the Regional Innovation Scoreboard). The main findings indicate that there is no single condition that improves innovative performance. It is always a combination of several variables. Having higher GDP, increasing employment in science and technology sectors, improving internet access and taking care of higher education of the population, regional innovativeness will grow. Social conditions such as inhabitants' age do not show significant impact on regional innovation compared with other factors.

Keywords: regional innovation, qualitative comparative analysis (fsQCA), modest innovators, innovation leaders

JEL: O10, O31, P48, R15

Introduction

Innovation is an economic category which can be variously defined and analyzed depending on the level of what is perceived. It does not refer only to the company level, but also to the region and the state. Innovation was conceptualized as a process grounded in proximity relations, in favorable conditions for interaction, and in learning focused on the exploration of new knowledge combinations and opportunities (Asheim and Gertler 2005; Cooke 2004; Doloreux 2002; Shearmur, Carrincazeaux, and Doloreux 2016). Schumpeter (1934) considered innovations a critical dimension of economic change. A phenomenon of innovation is a multifaceted construct that encompasses the generation, development, and implementation of an idea or behavior that is new to the adopting organization (Damanpour 1996). During the innovation process, ideas are transformed into new products or services, new process technologies, new organizational structures, or new managerial approaches (Azar and Ciabuschi 2017; Damanpour and Aravind 2012).

Traditional industrial economies are transformed to knowledge-based economies where innovation is considered to be one of the main drivers for sustained economic growth, if not the single one (Federico, Langus, and Valletti 2017; Grupp and Mogee 2004). Concerning the multidimensionality and complexity of the concept of innovation, its unambiguous assessment is difficult. That is also because the elements at the core of innovation can be both tangible (human and natural resources,

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etc.) and intangible (Camagni and Capello 2013; Mas-Verdu, Ortiz-Miranda, and Garcia-Alvarez-Coque 2016). However, policy makers need efficient and effective tools to measure and monitor innovation related performance so that they can develop new measures, policies, and evaluate current approaches (Carayannis, Goletsis, and Grigoroudis 2017).

The aim of this study is to identify the factors that most affect regional innovation and to indicate patterns which give rise to the higher innovative performance of different European regions. The study's structure is as follows. Section 1 reviews the literature underlining the importance of the regional dimension of innovation, Section 2 describes the research method — fuzzy set qualitative comparative analysis (fsQCA), its key assumptions and the scope of the study. Section 3 presents the results In conclusions are discussed the main results and are provided final considerations and indications for future research.

1 Regional dimension of innovation

From the regional perspective, innovation is a driver of sustainable economic growth that leads finally to higher levels of output and citizens' better well-being. The heterogeneity across regions in their capacity to create knowledge and innovation, and also in their abilities to exploit ideas and technologies available across the European territory, motivates in-depth analyses of the territorial dimension of the knowledge economy (Ciocanel and Pavelescu 2015; Ferreira and Dionisio 2016; Foddi and Usai 2012; Krakowiak-Bal et al. 2016). The undertaken research indicates that territory is important for the innovation process (Antonelli, Patrucco, and Quatraro 2011; Cooke et al. 2011).

Impact of innovations on regional development and its level of competitiveness is widely analyzed and recognize in the literature (Autio et al. 2014; Roig-Tierno, Alcazar, and Ribeiro-Navarrete 2015; Veugelers 2009; Zygmunt 2014).[1] Innovations are treated as the key factor in regional development

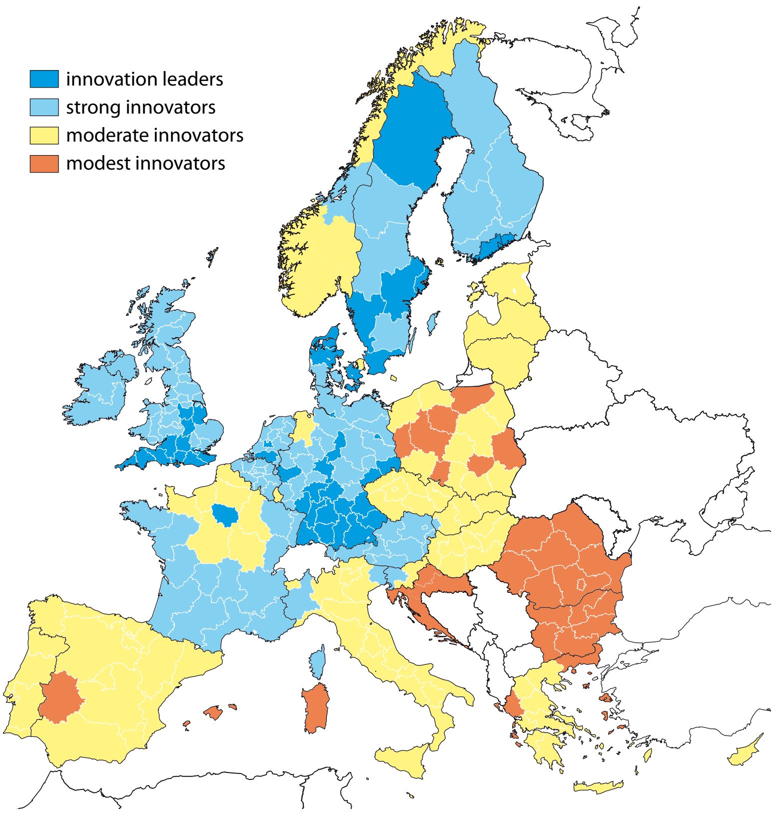

Fig. 1. Regional Innovation Scoreboard in the year 2016

Source: Own elaboration based on Regional Innovation Scorecard 2016, op. cit. (see footnote 2), page 4

1. See also: A Study on the Factors of Regional Competitiveness. A draft final report for the European Commission Directorate-General Regional Policy. Prepared by Ronald L. Martin, [@:] http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/3cr/competitiveness.pdf.

dependent on a region's specificity and ability to create a friendly environment for knowledge transfer. The significance of innovations is shown not only in increasing a region's competitiveness but also upon firms which conduct their business in the region. As regions are important engines of economic development, innovation performance deserves particular attention at the regional level.

There is a need to adopt a new approach to innovation policy. It must acknowledge the importance of territorial specificity and needs to be adapted accordingly to the specific conditions of each territory. Economic literature has identified three stylized facts: (1) innovation is not uniformly distributed across regions, (2) innovation tends to be spatially concentrated over time, and (3) even regions with similar innovation capacity have different economic growth patterns.[2] To emphasize the importance of the regional scale and of specific local resources in enhancing the innovation performance of regions, the concept of Regional Innovation Systems (RIS) has been proposed. The RIS is a regional extension of the European Innovation Scoreboard (EIS), assessing the innovation performance of European regions on a limited number of indicators. It uses data for 12 indicators for 214 regions across Europe. Compared to the EIS, the RIS has a stronger focus on the performance of small and medium-sized enterprises.[3]

The 2016 Regional Innovation Scoreboard classifies the European regions into four innovation performance groups.The RIS 2016 Report indicated that there is a partial process of convergence with the Strong and Moderate Innovators decreasing their performance gap towards the Innovation Leaders. However, declining average performance of regional Modest Innovators is also observed. That is whether the determinants of innovation in different groups of regions are also different should be explored. Are there other factors (which?) more important for Innovation Leaders than for Moderate Innovators? Under what conditions is the regional innovation higher?

2 Research material and methodology

The aim of the study is to evaluate which variable factors contribute to high innovation performance in European regions. The research attempts to identify scenarios for achieving high levels of innovation based on fuzzy qualitative comparative analysis (fsQCA). Because of innovation specifics, it is a suitable method to analyze complex and nonlinear relationships among variables (Ragin 2008; Woodside 2013).

In the first step the input and output variables that describe the analyzed regions were selected. Inputs are those factors, influences or conditions that promote innovation and create knowledge. Outputs are the direct outcomes and economic improvements that result from innovation inputs. The adopted input variables are presented in table 1. They characterize some demographic, economic and infrastructural resources. The Eurostat database was used. The variable selection criterion was also availability and timeliness (variables for 2016). The adopted variables are directly and indirectly connected with the output (innovation). The following assumptions were made, that more innovative regions are those with:

Tab. 1. Adopted causal conditions

Notation	Meaning
medage	median age of population
dependratio	age dependency ratio (population aged 0–19 and 60 and more to population aged 20–59)
internet	percentage of households with broadband access
gdp	gross domestic product at current market prices in euro per inhabitant
employm	employment rate between 15–64 years
scitechemp	persons employed in science and technology (percentage of total population)
tertiedu	percentage of persons (25–64 years) with tertiary education (levels 5–8)

2. See: Regional Innovation Scorecard 2016. Report prepared by: Hugo Hollanders, Nordine Es-Sadki and Minna Kanerva, [@:] http://ec.europa.eu/DocsRoom/documents/17824.

3. Ibid.

- high level of GDP (wealthy areas),
- highly educated and young workforce,
- high employment rate (low unemployment),
- high share of persons employed in science and technology, and
- widespread internet access (broadband access).

As the output (innovation performance), the value of the Regional Innovation Index (RII) is adopted. It should be considered as the outcome of pro-innovation activities and conditions at the regional level. FsQCA identifies possibly multiple sets of conditions (tab. 1) that may causally relate to an outcome RII (Rihoux et al. 2013). Consequently, the model used in analysis identifies possible causal configurations, which explain a high innovation performance as follows:

$$\text{RII} = f(\text{medage, dependratio, internet, gdp, employm, scitechemp, tertiedu}).$$

The analysis was performed for two different groups of regions. To the first group belong Innovative Leaders, to the other Modest Innovators. The quantitative data were collected for EU regions at NUTS 2 level from Eurostat and RIS databases. The finally data set includes 36 innovation leaders and 30 Modest Innovators. The fsQCA procedure runs in following stages:

- identifying relevant cases and causal conditions
- data calibration
- testing for necessary conditions
- construction the truth table and resolving contradictions
- analyzing the truth table
- evaluating the results

The fsQCA technique requires that the original data for both the causal conditions and the outcome need to be transformed into fuzzy membership scores — calibration. Therefore, in order to define the set membership values, three anchors need to be fixed for the presence or absence of the conditions in continuous variables. Ragin (2008) defines these thresholds as: entirely within the set 0,95, entirely outside the set 0,05, and a crossover point 0,5.[4] In this study, the 90th percentile and 10th percentile are the cutoffs to determine the presence or absence of the conditions, and the 50th percentile is the point of maximum ambiguity (Mas-Verdu, Ortiz-Miranda, and Garcia-Alvarez-Coque 2016; Misangyi and Acharya 2014; Woodside 2013). Anchor points help a researcher clarify how to distinguish a case that is more in the set from a case that is less in the set.

The fsQCA produces an output with a complex solution (makes no simplifying assumptions), a parsimonious solution (includes all simplifying assumptions) and an intermediate solution (uses some remainders to simplify the solution). In this study, the intermediate solution is presented. The fsQCA's original purpose is to analyze small and medium databases (e.g., less than 50 cases) (Collier 1993) but no mathematical limitation impedes working with larger databases (Ragin and Fiss 2008; Woodside 2013).[5] This method has a wide range of applications in the social sciences, with some contributions on the comparative performance of firms and countries related to hi-tech activities (Fiss 2011; Mas-Verdu, Ortiz-Miranda, and Garcia-Alvarez-Coque 2016; Schneider, Schulze-Bentrop, and Paunescu 2010). The analysis has been performed with the fs/QCA 2.5 software.[6]

3 Results

The overall characteristic of the adopted variable is presented in table 2. The biggest disparities between groups are indicated in values of GDP, employment rates and tertiary education. The analysis results show interdependencies of many conditions that coexist in a region. A condition is necessary if the consistency threshold exceeds the value of 0,90 (Ragin 2008; Schneider, Schulze-Bentrop, and Paunescu 2010). In table 3, results of necessary conditions analysis are given. There

4. [In the journal European practice of number notation is followed — for example, 36 333,33 (European style) = 36 333.33 (Canadian style) = 36,333.33 (US and British style). — Ed.]

5. See also: User's Guide to Fuzzy-Set/Qualitative Comparative Analysis by Charles C. Ragin assisted by Sarah Ilene Strand and Claude Rubinson, September 2008, based on: fsQCA 2.0, [@:] http://www.u.arizona.edu/~cragin/fsQCA/download/fsQCAManual.pdf.

6. Ibid.

Tab. 2. Basic descriptive statistics for variables

	Innovation leaders				Modest innovators			
Condition	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
dependratio	86,45	8,81	67,10	105,30	81,10	8,66	65,80	101,70
medage	43,15	3,21	34,60	50,90	41,66	2,99	33,70	46,80
tertiedu	35,14	8,57	21,90	57,10	22,64	5,62	12,90	35,10
scitechemp	27,78	3,81	21,99	39,10	13,02	3,11	8,70	21,70
employm	75,66	2,67	66,60	79,60	58,53	6,00	45,20	67,80
gdp	42 197,22	9 781,72	25 900,00	67 500,00	12 383,33	6 329,19	4 700,00	32 300,00
internet	86,71	5,78	80,81	96,00	76,83	7,24	59,00	88,00
RII	0,53	0,05	0,43	0,63	0,20	0,04	0,12	0,33

Tab. 3. Analysis of necessary conditions for high innovation performance (high RII)

Condition tested	**Innovation leaders**		**Modest innovators**	
	Consistency	**Coverage**	**Consistency**	**Coverage**
employm	0,864	0,824	0,852	0,842
scitechemp	0,850	0,866	0,835	0,856
gdp	0,845	0,838	0,823	0,843
internet	0,777	0,770	0,817	0,845
tertiedu	0,764	0,788	0,809	0,812
dependratio	0,350	0,962	0,348	0,917
medage	0,302	0,875	0,312	0,916

Tab. 4. Truth table analysis for Innovation Leaders, intermediate solution (frequency cutoff: 1,000; consistency cutoff: 0,894; Algorithm Quine-McCluskey)

	Raw coverage	**Unique coverage**	**Consistency**
internet AND **gdp** AND **citechemp**	0,680	0,680	0,864
Solution coverage	0,680		
Solution consistency	0,864		

Note: AND is a logical operator "AND"

is no single condition that explains the presence of high innovation performance of the regions, both in leaders and the modest group. Nevertheless, several indicate values above the 0,80 cu-toff point. They can be classified as "almost always necessary" conditions (Ragin 2000). For modest regions, only age (dependratio and medage) of inhabitants does not exceed 0,80. Table 4 presents the causal configurations that lead to high innovation performance (RII) in the Leader regions.

The analysis identified only one configuration that can be sufficient for the innovation performance in Innovation Leader regions. It assumes the presence of three conditions: internet, gdp and scietechemp. It means, that in leader regions, high innovation performance is a combination of widespread internet access, high GDP and high share of employees in science and technology. This configuration is not necessarily the only solution that may lead to innovativeness. The fsQCA does not ignore the presence of other conditions. The consistency of the whole model is 0,864 and is suitable for interpretation (Fiss 2011; Woodside 2013). The solution total coverage (0,680) indicates that most of the outcome is covered by the presented configuration, it accounts for 68 percent of membership. The results for Modest Innovators are presented in table 5.

The presented results for Modest regions report the causal paths which are the combinations of causal conditions. Four different configurations emerge from the analysis. That means that more than one pattern causes the high innovation performance in these regions. Furthermore, these pathways do not refer to only one condition but rather include a combination of factors, which lead to the high RII. The first casual path shows that for high innovativeness are needed high GDP,

Tab. 5. Truth table analysis for Modest Innovators, intermediate solution (frequency cutoff: 1,000; consistency cutoff: 0,852; Algorithm Quine-McCluskey)

	Raw coverage	Unique coverage	Consistency
gdp AND ~**employm** AND **scitechemp** AND **tertiedu**	0,250	0,015	0,924
internet AND **gdp** AND **scitechemp**	0,673	0,035	0,897
gdp AND **employm** AND ~**tertiedu**	0,274	0,032	0,882
internet AND **gdp** AND **tertiedu**	0,666	0,083	0,881
Solution coverage	0,817		
Solution consistency	0,878		

Note: AND is a logical operator "AND"; ~ is a logical operator "NOT" (i.e., absence of the condition)

employment in science and technology and well-educated inhabitants. The second configuration combines widespread internet access, high GDP and high share of employees in science and technology. This path is equal to the solution observed for Leaders group. The third recipe identifies combination of high GDP and overall employment rate. The final fourth configuration leading to high regional innovativeness illustrates the presence of internet access, GDP and well-educated inhabitants.

Conclusions and discussion

Using fsQCA, this study examines the effect of a combination of different factors on the level of innovation performance in EU regions. The overall results confirm that innovation is a complex phenomenon and in order to achieve high innovation performance in regions, attention must be paid to various factors. The findings reveal that no single necessary condition exists to achieve a high level of innovativeness.

Primarily the presence of high GDP, employment in science and technology, and a well-educated society determine the level of innovation performance. However, a population's age does not show significant impact on the regional innovation compared with other factors. For modest innovators there are a few paths leading to innovation performance in region. Having a higher GDP, many people working in the science and technology sector and a highly educated population, regions will be more innovative. Therefore, one way to increase the regional innovative output are investments in science parks, incubators, cluster initiatives and education. For Innovation Leaders the way to reach higher innovativeness might be to develop communication infrastructure (internet) and to increase the employment in science and technology; both of these conditions must be accompanied by a sufficient budget (high GDP). An interesting finding is that in Leader regions, the social factors such as education and population age are not present in the identified configuration. Younger societies do not mean more innovative. Finally, for both innovation leaders and modest innovators the same path leading to innovation performance has been indicated.

The results of this research also suggest areas for further studies. They should include other regional characteristics, specificities of regions, their location and other factors not specified in presented study. In addition, other innovation outputs can be analyzed, and various types of innovation may be assessed. It has been indicated that infrastructural support is important to build innovative advantage in a region. Future research should evaluate the importance of other infrastructural elements for regional innovativeness. The limitation of the study is mainly connected with data availability for regions at NUTS 2 level. The approach presented in this study could help to verify existing regional innovation strategies and presents a tool to assess such a broad and ambiguous phenomenon as innovation.

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