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Dynamics of innovation in European regions

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ABSTRACT

There is interest in both academic literature and regional governments about the innovativeness of regions and the drivers of that competitiveness, especially if considering the impact on economic development and social progress. Innovation is the base for the global competitiveness. Innovative capacity enables regions to increase their productivity and attract investments, thereby sustaining continuous progress in the quality and standard of living. The literature review regarding regions' innovativeness produces some insights regarding to the effect of contextual elements on regions performance and reveals some new perspectives of this issue. This study aims to measure regions' innovativeness in different European regions and to evaluate the nature of the innovation process and the relationship existing between its innovativeness' and its region of origin. It proceeds from the assumption that the competitiveness of a region is reflected in its innovation capacity or innovation dynamic. Thus, it compares the European regions verifying the existence of subjacent clusters and finding out the characteristics that distinguish the different group of regions. The innovative capacity is considered in terms of innovative output and several factors are analysed to identify and differentiate the dynamics of innovations of the regions. The results point to the existence of five groups of regions, and the factors identified are related to innovation process, namely forms of innovation, factors and objectives of innovation and with aspects related to the innovation framework such as tertiary education and life-long learning, business and public R&D expenses, and level of collaboration for innovating.

Introduction

There is an increasing body of literature which emphasis on the different types of national and regional innovation systems as well as innovation activities taking place in various industries and their impact on the economic growth and performance of the region or country.

This has given rise to a series of important studies, both theoretical and empirical and from these seems clear that innovation is the base for the global competitiveness (Porter, 1990). That innovative capacity enables regions to increase their productivity and attract investments, thereby sustaining continuous progress in the quality and standard of living. Even though a large share of the current economic and political discourse is heavily emphasizing the regions innovation pattern, studies in this field remain sparse.

Regional dynamics of innovation require efficient functioning of the regional systems of innovation (Doloreux, 2004; Asheim and Gertler 2005; Trippl 2006; Cooke, 2008), the articulation of networks of agents present in the territory, the interactions between enterprises, higher education and public institutions, in the framework of the model Triple Helix (Etzkowitz, 2003). These dynamics seek to mobilize innovation sources inside and outside the enterprises (Bessant and Tidd, 2007), as well as inside and outside the region in a perspective of open innovation.

To stimulate their innovative capacity, countries need a constant commitment to, and active involvement in, their institutions and organizations, the investment in education and qualification, values of openness and commitment to invest and collaborate. And on the level of the regions, will it be that these conditions/variables are also going to influence dynamics of innovation and have the capability to innovate?

As Edquist (2005:201) referred "given our limited systematic knowledge about determinants of innovation […] studies comparing innovation systems of various kinds as well as the determinants of innovation processes within them […] have great potential".

Based on the literature and theoretical concepts a broad range of determinants or explanatory factors of the regions' innovativeness could be compiled. Having as starting point the assumption that the competitiveness of a region is reflected in its innovation capacity or

innovation dynamic, this study tries to measure regions' innovativeness in different European regions and evaluate the nature of the innovation process and the relationship existing between its innovativeness' and its region of origin.

Thus, the objective is to compare the European regions to verify the existence of subjacent clusters and find out the characteristics that distinguish the different group of regions. The innovative capacity is considered in terms of innovative output and several factors are analysed to identify and differentiate the dynamics of innovations of the regions. The results point to the existence of five groups of regions, and the factors identified are related to innovation process, namely forms of innovation, factors and objectives of innovation and with aspects related to the innovation framework such as tertiary education and life-long learning, business and public R&D expenses, and level of collaboration for innovating.

The remainder of the article is organized as follows: On the second point a brief literature review is perform regarding the innovative capacity of regions. The third point describes the hypotheses. The last two points contains the methodology and the main findings and conclusions, reporting their implications, stressing the limitations of the work and suggesting avenues for future research.

2. Literature Review

For more than three decades, the 'innovation systems approach' has been a favored framework for research in different countries. The concept allows a better understanding of the complex driving forces and mechanisms that mediate the conditions, the extent and the outcomes of innovative behavior of nations, regions and firms.

The competitiveness of countries and enterprises is inherent in the competitiveness of the regions. "In a context of open economy, each region faces the European and global markets on a plane similar to that in which the country was on prior to the process of European integration, meaning with logic of inter-regional and international division of work, although it now lacks protection mechanisms in relation to foreign competition." (DGDR, 2000:20). In the context of increasing globalization, the regions/territories are effectively competing more directly between themselves, not just the enterprises.

On the territorial level, competitiveness is related to the capacity of generating wealth, with productive efficiency as well as quality of life for its population (OCDE, 1996; Mateus *et al*. 2000; Lopes, 2001). It is also related to its ability to attract and establish technical frameworks, young inhabitants and investments, creating work; in other words, to provide quality of life for its people with respect to the environmental and landscape quality, for historical heritage and culture. Therefore, competitiveness in the nations/regions involves a reduction of social and economic cultural differences by providing work and increased quality of life with respect to the environmental, cultural and landscaping issues along with a system of values (Natário, 2004).

Thus, a region is considered competitive when, in face of national and international competition, it is capable of generating income in a sustainable manner with productive, social and economic efficiency, to attract and fix technical frameworks, investments and young population, to create jobs and provide a higher quality of life to its people, with respect to the environment as well as the historical heritage, cultural and native.

Therefore, regional competitiveness does not depend solely on its endowment of traditional resources (capital, labor and currency); it depends on productivity (Porter, 1990), intellectual and intangible resources, namely knowledge and fundamentally, innovation. It is the capacity for innovation of the region that is ultimately the source of the competitive advantage.

The capacity for innovation of the regions improves their productivity, attracting investments and sustaining the progress of the region, simultaneously providing quality of life to their citizens. The innovation capacity plays a prominent and decisive role in determining who prospers in the global arena, where a vast number of partners can contribute to it (Kaufmann and Tödtling, 2001; Natário *et al.*, 2007). The interactions between firms and institutions that make up the regional innovation system (universities, research and transfer centres, innovative firms, etc.) generate external economies of knowledge that benefit firms and enhances inbreeding innovation process.

As mention by Hájková and Hájek (2010) the source of these concepts relies in the observation that innovations do not arise solo inside a firm, but the potential of their conception is related to the process of learning determined by firms' relationship to its environment. The capacity for innovation varies between companies (Hadjimanolis, 1999) but

also between countries and regions. It is determined by a complex and vast number of internal and external factors, both stimulating and restrictive, which promote a significant impact on the process and territorial dynamics of innovation. (Segarra-Blasco, 2010).

A territorial innovative capacity depends on that territorial institutional efficiency, based on the commitment and performance of the institutions, its national culture, human capital, innovation's workers skills and technological intensity, as well as the financial resources for innovation, and the linkages and cooperation networks used to stimulate/promote the innovation capacity (Natário *et al.,* 2010).

The regional dynamics of innovation are particular importance to the efficient functioning of the regional systems of innovation (Cooke, 1992, 2003, 2008; Autio 1998; De la Mothe and Paquet 1998; Howells 1999; Cooke *et al.,* 2000; Doloreux, 2003, 2004; Asheim and Gertler 2005; Doloreux and Parto, 2005; Tödtlinng and Trippl, 2005; Trippl 2006; Asheim and Coenen 2006). The regions also have distinct government characteristics and cultural features making them singular and unique. Therefore, the innovation system of a regional level or regional system of innovation enables a larger format and adaptation of national policies in regional environments since there is greater proximity between the many agents and a greater cultural homogeneity, and also because the intensities and the dynamics of innovation are sometimes more disparate between the regions than the nations. As stated by Frykfors and Håkan (2010), this regional vision of innovation in some countries has a recent character deriving from the global competitive situation itself, namely the allocation of funds based on regional criteria.

Starting in the nineties decade, the dynamics of innovation became associated with networking of actors (or helixes) – higher education institutions-business-government- in the scope of the model Triple Helix (Leydesdorff and Etzkowitz, 1996) as stimulators of the business dynamics and regional development. As opposed to the linear model where the sense of innovation was unique to the state, this model is based on a spiral with interactions between the three helixes.

The Triple Helix model is based on the hypothesis that economy is based on knowledge, that innovation comes from interactions between companies, higher education and public institutions, with the production companies and the source of knowledge and technology from

the higher education and public institutions providing contractual relationships guaranteeing stability in their interactions and exchanges (Etzkowitz, 2003; Jacob, 2006).

The Triple Helix model is therefore based on three basic elements: a prominent role of the higher education on innovation, partnered with companies and the government in a society based on knowledge; a collaboration between the three main institutional spheres where the context of innovation has increasingly become the result of interaction instead of a receptacle of the government; and besides the functions each institutional sphere has in the process of innovation, each agent: government, business and higher education institutions switch roles in some aspects (Dzisah and Etzkowitz, 2009).

In the context of "Triple Helix", the dynamics in the spaces of innovation (Etzkowitz, 2002), viewed on international, national and regional levels have an energizing role in the regional innovation. At the regional level, the overlapping between the education-business-state spheres allows the exchange of knowledge, consensus and spaces of innovation. Etzkowitz (2002) stated that such spaces of innovation are created as a consequence of a change in values between the promoters of economic and regional development.

The spaces of innovation, also known as regional environments of innovation (Etzkowitz, 2002), are a combination spaces, the space of knowledge (mechanism that allows production of knowledge in the sense of economic and social development), with the space of agreement (area where strategies, ideas and perspectives can be managed as well as gather the promoters of the process of innovation) and the space of innovation; aside from articulating the capital, the technological and business knowledge as well as stimulating the creation of enterprises. The benefits of interconnecting the promoters of innovation are defended by Segatto and Mendes (2001), as well as their roles to perform (Massey *et al.*, 1992). The spaces of innovation are thus viewed as spaces where the different agents may possibly make agreements of innovation (Fassin, 2000), in favor of local, regional or national development.

It is important to view innovation under this perspective as "open innovation" (Chesbrough, 2003; Gassmann, 2006; Hollanders and Cruysen, 2008). This concept was introduced for the business perspective and seeks to prove that the enterprises are growing more reliant on internal and external sources of innovation for the development of new products and services. This approach seeks to mobilize innovation sources inside and outside the enterprise (Bessant

and Tidd, 2007). The companies do not innovate in an isolated manner, cooperating with partners throughout the process of innovation (OECD, 2008), the introduction of the concept of "open innovation" is centered on giving emphasis not only to the importance of innovation but also the origin of useful knowledge, as well as the exploration of the enterprise's internal innovation along with external partners (OECD, 2008).

On the regional level, open innovation combines internal and external ideas to create values in systems and structures where requisites are defined by internal mechanisms which make it possible to reclaim part of this value (Chesbrough, 2003). In this perspective of "open innovation", the territory/region simultaneously looks at "in-out" and "out-in" scenarios.

According to Fuglsang (2008) and concerning the regions, on a systemic level, the open innovation, understood as a structured form of behavior, can make the territories seek information from partners while simultaneously hiding some of their own. Therefore, to be successful, the "open" approach to innovation requires a strong trust between the different actors/agents (Fonseca, 2010).

One decade ago, the triple helix approach was questioned as the exclusive engine behind the regional systems of innovation (see, Leydesdorff 2011). This approach rediscovers the concept of innovation in territorial standards different from the regional ones, alerting to the fact many countries on a global scale do not present dynamics of innovation based on the regions, but the industrial clusters within the different regions. As referred by Leydesdorff (2011) emerging systems can then be study in terms of potential synergies among three subdynamics (or perhaps more; cf. Carayannis & Campbell, 2009 and 2010), which go over the university-industry-government regional structural model and considers the existence these relations at a national level (Leydesdorff & Zawdie, 2010).

3. Hypotheses to Test and Methodology

Taking into account the literature previously mentioned, this study aims to investigate the regional dynamics of innovation in Europe and what are the factors influencing their performance. Starting from the issue raised in the recent work by Leydesdorff and Zawdie (2010) about the triple helix concept and its adaptation to all countries, it seeks to determine the existence of clear differences between the constituting regions of each European country studied.

Therefore, the dimensions influencing the territorial capabilities for innovation were considered as follows: the collective learning infrastructure of the region; the resources and financial support to innovation and acting in cooperation networks to innovate, which may have a positive influence on the regional capacity for innovation. The regional dynamics of innovation and their capacity to innovate are therefore conditioned by the behaviors and specifics of each region within these dimensions. Consequently, three hypotheses attempting to relate the independent variable with the dependant ones will be tested, with the RIS as the basis.

The capacity for innovation varies with each company (Hadjimanolis, 1999), with each sector and with each region. The materialization and operationalization of innovation can use several typologies: *product innovation, process innovation, organizational innovation and marketing innovation* (Sundbo, 1998; OCDE, 2005; CIS 2008). Therefore, according to the motivations and nature of the company and the behavior regarding innovation, the companies may adopt product/process innovations and/or marketing/organizational ones. The companies may even seek Resource efficiency innovators – Labor and Resource efficiency innovators – Energy.

Innovations may also be classified according to the level of novelty involving: radical or discontinuous innovation and incremental or continuous innovation (Barata, 1992; Tidd *et al.*, 1997). This context may be even presented in two forms: new to the company, also designated a local innovation (Tidd et al., 1997) or new to the market – global innovation (Tidd *et al.*, 1997; Von Stamm, 2005). The former refers to the occurrence of innovation in a given analytical unit (Portugal, for example), even if it had already occurred in other analysis units, while the latter concerns the first time a new product was launched in the market. The more radical or incremental type of innovation also denotes the most proactive or reactive posture of the company in regards to innovation.

The importance of investments of the company in activities promoting innovation, namely in improved structures, technologies, skills of employees and qualified personnel also evidences a greater capability of the companies to produce new innovations and a greater inclination to innovate (Weiss, 2003; Camacho and Rodriguez, 2005; Canepa and Stoneman, 2008; Elche and González, 2008).

The dynamics of spaces of innovation involves three stages: space of knowledge, space or area of agreement and space of innovation (Etzkowitz, 2002; Lamas, 2007). Knowledge space has an essential role in the construction and promoting of the Innovation's Collective Infrastructures Training through Tertiary education, Life-long learning and Broadband Access (Natário *et al.,* 2010), allowing production of knowledge in economic and social development to be put into practice, therefore influencing the regional dynamics of innovation. It should be noted that the model Triple Helix (Dzisah and Etzkowitz, 2009) creates an infrastructure of knowledge through the institutional spheres which are interconnected, each adopting the other's role through hybrid and interfacing organizations.

The collective infrastructure of innovation is one of the determining factors of the national capacity to innovate (Suarez-Villa, 1990; Stern *et al.*, 2001; Asheim and Coenen, 2006, Vang-Lauridsen *et al.,* 2007). A strong source of knowledge, R&D capacity and good production of human resources are keys to the company's success (Lundvall and Nielsen, 1999), and crucial for the development of regions and nations. Educating and reinforcing the formation skills, is to give the people and organizations (Lundvall and Nielsen, 1999), the foundation to introduce innovation to regions and nations.

Highly qualified human resources and lifelong learning are fundamental to maintain a continuous process of innovation. Innovation growth depends on the quality and availability of knowledge. Innovation requires a proactive attitude in terms of education, once knowledge and education are cumulatively developed (Sharp and Pavitt, 1993). It was admitted that the dynamic of learning and training influence the innovative capacity of territories (Lundvall, 1992; Edquist, 1997; Doloreux, 2004; Lundvall *et al.,* 2006; Vang- Lauridsen and Chaminade, 2006; Vang- Lauridsen *et al*., 2007, Natário, *et al*., 2010). This dynamic of learning and training of the regions is related to the attitude of human resources in terms of qualification and participation in lifelong learning.

The highly qualified individuals (education) are key players in innovation (Belitz *et al.*, 2008). Consequently, the qualified human resources, in conjunction to an environment that stimulates intensive learning processes in R&D may combine previous knowledge and explore new possibilities (Laranja, 2001), stimulate innovation and creativity (Davenport and Prusak, 1998; PNUD, 2001).

Therefore, to test this hypothesis as the following variables were considered: population with tertiary education (percentage of 25-64 years age class); the participation in life-long learning per 100 population aged 25-64 and Broadband Access. The first hypothesis derives has the following configuration:

H1: The Innovation's Collective Infrastructures Training have a positive influence on the Regional Innovative Capacity.

In agreement space, the ideas and strategies are generated in a "Triple Helix" model of multiple and reciprocating relationships between the academic, public and private sectors (Etzkowitz, 2002). The companies require organizational support not only to promote their activity but also in the involvement of the government (with financing, regulations and public markets (McFetridge, 1995; Lipsey and Carlaw, 1998), other authorities and institutions of regional development, resulting in an area of innovation capable of articulating agreements, bringing new agents and financing for the regional development. Regarding agreement space, financing resources for innovation is fundamental in the form of Public R&D expenditures; Business R&D expenditures and non-R&D innovation expenditures (Natário *et al.,* 2010) as that influences the regional dynamics of innovation.

Financing, while not considered a strategic factor, comes up as one of the main obstacles to the survival and development of the companies (Silva, 2009) and the regions. Financing and public support helps to reduce the obstacles that companies face in regards to innovation (Tourigny and Le, 2004), and contribute to minimize the high risks associated with the process of innovation.

Public R&D expenditures act as a steering mechanism for the private sector (Hu and Mathews, 2005) and emerge as an important determinant of the degree of specialization of the countries and can be seen as a source of innovation (Mathews and Hu, 2007). Therefore R&D expenditures has got a significant effect on national innovative capacity of country and of a region.

Financing is not only important for R&D expenses, but also for the costs of other activities of innovation. Innovation is not limited to R&D activities, it also encompasses continuous improvements in the conception and quality of the products, the changes in the organization and management routines, creativity, marketing, and even changes in the production

processes which cut the costs, improve efficiency and ensure sustainable development (Mytelka and Farinalli, 2000). According to Community Innovation Survey (CIS 2010), other activities of innovation to be considered are acquisition of machinery, equipment and software, other external knowledge (purchase or licensing of the patent rights and/or non-patented inventions, know-how and other forms of knowledge, to other companies or institutions to develop new or significantly improved products and processes); the formation for activities of innovation; the introduction of innovations in the market.

Thus, in order to test this hypothesis, we considered as measurement variables the Business and Public expenditures on R&D (percentage of GDP) and Non-R&D innovation expenditures (% of GDP). These considerations lead us to frame the second hypothesis of the work as presented bellow:

H2. The financing resources for innovation have a positive influence on the Regional Innovative Capacity

Still in the context of the Triple Helix model, it is fundamental to see innovation as "open innovation" (Chesbrough, 2003; Gassmann, 2006; Bessant and Tidd, 2007; Hollanders and Cruysen, 2008), stimulating multiple and reciprocal relationships between government, higher education institutions and business. The companies do not innovate by themselves, cooperating with partners throughout the process of innovation (OECD, 2008). The cooperation between different agents facilitates production and transfer of knowledge, access to different sources of information (Nieto and Santamaría, 2007), influences the companies' capacity to innovate (Silva *et al.*, 2009), their innovating performance and influence the territorial process of innovation (Grabher, 1993).

The process of innovation is an interactive (Lundvall, 1992; Edquist, 1997; Kaufmann and Tödtling, 2001), complex and associated with great uncertainty. To lower the risks and costs related to this process, and to share and access knowledge and information, the network relationships between different agents or agreements of cooperation/collaboration are fundamental.

Collaboration, its continuity and diversity of partners have a positive impact on creating innovation (Nieto and Santamaría, 2007), being considered a good method to improve the capacity to innovate (Miotti and Sachwald, 2003; Faems *et al*., 2005). Fair collaboration and

partnership agreements may be the solution to assess resources, capabilities, skills (Das and Teng, 2000; Belderbos *et al*. 2004; Tsai, 2009), and knowledge unavailable inside the company and the region. It is important to mobilize territories to seek internal and external sources of innovation which act as generators of positive dynamics.

The logic of open innovation is that enterprises need to open their innovation process, searching outside their boundaries and working towards a set of network relationships (Bessant and Tidd, 2007). The network relationships of cooperation facilitate the production and transmission of the knowledge flow, the innovative performance determination of the companies and the territorial innovation process influence. Developing networks represents a method to increase the amount of accessible knowledge and improves innovation capacity (Schiuma and Lerro, 2008; Huang and Shih, 2009).

According to Trippl (2006) the networks, partnerships and cooperation reflect: the second dimension of the RIS - knowledge exploitation, which reproduces the corporate dimension and the business in the regional innovation system, encompassing the companies, their clients, their suppliers, their competitors and their partners of industrial cooperation; plus the 4th dimension of the RIS - the dimension of local interactions, types of relations within and between the RIS which facilitate the continuous exchange of knowledge and the processes of knowledge transferring.

To analyze this matter, SMEs innovating in-house and Innovative SMEs collaborating with others were considered. In face of these considerations the following hypothesis was established:

> **H3: The collaboration for innovation in the cooperative network has a positive influence on the Regional Innovative Capacity**

The works of Lundvall (2007) and other scholars of innovation systems (Edquist 2005; Niosi 2005; Malerba 2007) provide important conceptual frameworks of innovation that can be regarded as a process of interaction between a firm and its external environment. Their contributions emphasize that innovation cannot be produced in isolation, by relying exclusively on internal resources within the firm, depending on regional and national actors as promoters of innovativeness. The triple helix model tries analyze the university-industry-government relations and their impact on innovation systems. Nevertheless, some critical

questions remain unanswered and the hypothesis presented above tried to contribute to their answer.

4. Methodology and Results

The main source of data used to evaluate the regional capabilities of innovation was the RIS Database (Attachment 1) which integrates approximately 300 NUTS II (Nomenclature of Territorial Units for Statistics), of which only 193 were used, owing to the absence of data for certain variables in some regions.

The methodology used for the analysis is based on the application of multivariate statistics: clusters analysis to group the regions according to their capacity and dynamics of innovation, and in terms of their innovating output, the number of patents. To verify the formulated hypotheses, we resorted to tests of multiple differences of means to distinguish the unique characteristics of each cluster and assess the principal admeasurements of the regional innovation capacity.

This methodology of cluster analysis proved adequate and the variables of accomplished objectives used to categorize the regions were all significant to the final result, as seen by the results of the ANOVA analysis, constant in table 1.

Table 1: ANOVA Analysis

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df	Mean Square	df
2.3.1 EPO patents	2,217	4	0,002	188	904,169	0,000

Applying the previously described methodology of cluster analysis resulted in four groups: the first, constituted by 31 regions with a value of 0.243; the second, with 52 regions and a value of 0.592; the third group, with 48 regions and a value of 0.426; a fourth with 43 regions and a value of 0.139 and a final group with 19 regions and a value of 0.814, as seen in table 2.

Table 2: Regions by Cluster

1 0,241 (n=31)	2 0,592 (n=52)	3 0,426 (n=48)	4 0,139 (n=43)	5 0,814 (n=19)
cz01	be1	de4	bg3	de11
cz02	be2	de5	bg4	de12
cz05	be3	de8	cz03	de13
cz06	dk	deb2	cz04	de14
cz08	de22	ded1	cz07	de21
ee	de24	ded3	gr11+gr13+gr14	de23
gr3	de3	dee	gr12	de25
es11	de6	ie01	gr2	de26
es12	de72	ie02	gr4	de27
es13	de73	es21	es43	de71
es24	de91	es23	es63	dea2
es41	de92	es3	es64	deb3
es42	de93	es51	es7	fr1
es52	de94	fr2	fr9	nl41
es53	dea1	fr3	itf5	fi18
es61	dea3	fr5	lv	fi19
es62	dea4	fr6	lt	se11
itf3	dea5	fr8	hu21	se22
itf4	deb1	itc1+itc2	hu23	se23
itf6	dec	itc3	hu31	
itg1	ded2	itd1	hu33	
itg2	def	itd2	pl11	
cy	deg	ite1	pl12	
hu1	es22	ite2	pl21	
hu22	fr4	ite3	pl22	
hu32	fr7	ite4	pl31	
mt	itf1+itf2	nl11	pl32	
pt11	itc4	nl12	pl33	
pt16	itd3	nl13	pl34	
pt17	itd4	nl23	pl41	
sk01	itd5	nl34	pl42	
	lu	si01	pl43	
	nl21	si02	pl51	
	nl22	fi13	pl52	
	nl31	se32	pl61	
	nl32	ukc	pl62	
	nl33	ukd	pl63	
	nl42	uke	pt15	
	at1	ukf	pt18	
	at2	ukg	pt2+pt3	
	at3	uki	sk02	
	fi1a	ukk	sk03	
	se12	ukl	sk04	
	se21	ukm		
	se31	ukn		
	se33	no02		
	ukh	no05		
	ukj	no07		
	no01			
	no03			
	no04			
	no06			

In terms of greater results of innovation, the fifth group stands out with the highest value and includes mainly regions in Germany, Finland and Sweden; followed by the second group with regions located mainly in Germany, Holland, Italy, Norway, Sweden, Belgium, Austria; the next one is the third group with regions in the United Kingdom, Italy, Germany and France, then the first group with regions in Spain, Czechoslovakia, Italy, Hungary and Portugal, and finally the fourth group with regions in Poland, Hungary, Greece, Portugal and Spain.

To verify the factors differentiating the five regional groups, we resorted to the ANOVA along with tests of mean differences. Based on table 3, we see the results of the ANOVA prove the five groups vary in terms of type of innovation, which are more focused on products or marketing processes as well as organizational aspects. Regarding the type of innovation, the tests of mean differences concluded that groups two and five have greater product and process innovation than group four, while group two supersedes the rest in relation to marketing and organizational innovations.

Table 3: ANOVA Analysis and Mean Differences Test

	F	Sig.	1	2	3	4	5	Average Differences
3.1.1 Product and/or process innovators	12,49	0,000	0,457	0,653	0,492	0,313	0,824	2,5>4
3.1.2 Marketing and/or organisational innovators	6,25	0,000	0,487	0,728	0,478	0,409	0,571	2>1,3,4,5
3.1.3a Resource efficiency innovators - Labour	1,27	0,288	0,373	0,390	0,455	0,386	0,318	
3.1.3b Resource efficiency innovators - Energy	1,11	0,357	0,399	0,384	0,433	0,429	0,298	
3.2.1 Employment medium-high & high-tech manufacturing	12,22	0,000	0,323	0,454	0,379	0,326	0,614	5>1,2,3,4 ; 2> 1,4 ; 1>4
3.2.2 Employment knowledge-intensive services	28,88	0,000	0,0334	0,0414	0,0336	0,0312	0,0637	2,5>1,4 ; 2,3>1,4
3.2.5 New-to-market sales	2,84	0,043	0,523	0,537	0,480	0,444	(a)	2>4
3.2.6 New-to-firm sales	4,18	0,008	0,541	0,344	0,466	0,393	(a)	1,3>2,4

(a) Without data

Regarding the types of innovation more focused on costs or energy savings, the ANOVA analysis was not significant in there being differences between the groups and the mean difference tests proved this situation.

As to effects of innovation in terms of employment, differentiating high technology for the industry and intensive knowledge in the area of services, differences were confirmed between the groups, with group five standing out from the rest with the highest levels of employment, followed by group two and group one superseding group four.

In terms of contributing to the sale of new products for the market or within the company, group two stands out in the first case, relative to group four while in the second case, groups one and three supersede groups two and four.

Seeking to analyze the variables that could differentiate the groups in terms of explanatory factors of the innovation levels, table 4 presents the values of the ANOVA and the tests of mean differences in relation to the educational and financial aspects of the process of innovation in the companies from the studied regions.

In terms of educational factors, tertiary education and lifelong learning are considered as base indicators, along with electronic access to information as a proxy to the educational level of the population as a whole.

Table 4: ANOVA Analysis and Mean Differences Test

	F	Sig.	1	2	3	4	5	
1.1.3 Tertiary education	9,74	0,000	0,361	0,464	0,481	0,294	0,523	2,3,5>1,4
1.1.4 Life-long learning	28,40	0,000	0,406	0,559	0,591	0,283	0,550	2,3,5>1,4 ; 1>4
1.2.4 Broadband access	29,13	0,000	0,334	0,597	0,504	0,284	0,585	2,5>1,3,4 ; 3>1,4
1.2.1 Public R&D expenditures	9,46	0,000	0,472	0,567	0,534	0,373	0,583	2,5>1 ;1,3>4
2.1.1 Business R&D expenditures	90,62	0,000	0,412	0,600	0,489	0,284	0,801	5>1,2,3,4 ; 2>1,3,4 ; 3>1,4 ; 1>4
2.1.3 Non-R&D innovation expenditures	0,66	0,583	0,472	0,567	0,534	0,373	0,583	
2.2.1 SMEs innovating in-house	13,53	0,000	0,540	0,636	0,501	0,280	0,844	5>1,2,3,4 ; 1,2,3>4
2.2.2 Innovative SMEs collaborating with others	13,02	0,000	0,461	0,614	0,530	0,393	0,928	5>1,2,3,4 ; 2>4

The results showed that groups one and four have lower values than the rest in the three measurements used, while group one supersedes group four in terms of lifelong learning.

In financing, public R&D and company investments, as well as innovation expenses unrelated to R&D as measurements of the type of financial resources available to each one of the group studied was considered.

The results show a similar situation to what was observed previously in educational aspects, namely lower levels in the case of companies in the regions belonging to groups one and four, with exceptions in the innovation expenses unrelated to R&D which did not display significant differences between the groups.

Aspects related to process of innovation considered the levels of in-house innovation and in collaboration to other companies, such as measurements of the type of employed process. The results of the ANOVA analysis and the tests of mean differences point to group five (with greater ability to innovate) standing out from the others in terms of in-house innovation, and that group four presents lower values than the remaining groups. In reference to collaboration with other SME, group five stands out in relation to the remaining groups and that group four is below group two.

5. Discussion and Conclusions

A paradigm change is now underway, promoting new patterns of collaboration among university linkages, industry consortia and government agencies, with an emphasis on a knowledge based promotion. Increasing evidence all over the world demonstrates that controlled collaboration of government, academia and industry facilitates creative development and innovation and simultaneously provides leverage between knowledge, social benefit and profit motivations (Asheim and Coenan, 2004; Leydesdorff, 2005). This trilateral collaboration when consider at a regional level is in the origin of the triple helix concept. Over the past decade, consensus has been growing regarding this model, supported by several researches produce regarding university-industry-government network (Campbell, 2005; Campbell, Koski, and Blumenthal., 2004; Etzkowitz, 2002; Leydesdorff, 2003; Shapira, 2002). The majority of literature in this field to date concentrates on the effects of the triple helix in regional base terms. Nevertheless, the latest research produce examine the question: How are regional innovation systems different from national ones? And regional innovation systems make sense for all countries?

Thus, this work attempts throughout the examination of the regional innovation systems of European countries contribute to shed some light in this matter. Considering the purpose of this study, it was concluded that the overall objectives were achieved, as it was possible to identify how the different regions behave in terms of innovation, in this particular case considering the number of variables for classification of the activities of innovation related to effective capacity for registering and protecting innovations as criteria to define the level of innovation and not just the importance of innovation disclosed by the companies when asked.

Through this work it was possible to group the European regions in terms of innovation and characterize the type of innovation, namely in terms of typology and effects on employment and creation of new products. However, it was found that the majority of regions of different countries were in the same cluster, indicating the existence of a supra-regional pattern. This inference is consistent with what was suggested in the study by Leydesdorff (2011) regarding certain European countries as was the case in Holland and Hungary.

We can even conclude that the variables selected to explain the differences on the levels of innovation in different categories (education, financing and process of innovation) were significant in determining the process of innovation. Thus, this allows us to conclude that a triple helix of overlapping spheres of academia-industry-government is a knowledge-based process, rather than the periphery process, of national, regional, and multinational innovation systems (Etzkowitz, 2003).

Therefore, we concluded that this study gives a better understanding theoretically of the variables influencing the process of innovation, advancing with measures for the different components of the innovation system. Analysis of the results made it possible to confirm hypotheses formulated in the many components of the system of innovation, showing their relevance in understanding the differences of innovation in territorial terms.

In terms of type of innovation, the more innovating regions were made up of companies which innovated more clearly in products and processes and less in marketing or organizational aspects, where investments were in some way channeled more for tradable goods or their production.

As implications of these results for the managers, we underline the existing relationship between a greater degree of innovation and the development of in-house R&D and in collaboration with other companies and the sharing of public and business R&D expenses in the more innovating regions. The educational aspects also revealed their importance in determining the higher levels of innovation in the regions. Implications arose in terms of orientation of a policy of innovation related to the need to foster educational aspects and promote a regional policy of public R&D financing and promoting innovation projects with coordination between the companies.

Limitations of this study included the aggregation in which some key elements in the process of innovation were handled from the available data of the analysis development, suggesting the need to develop other research studies which could benefit from more disaggregated data, or data collected from business surveys, or even an analysis of specific cases to identify the dynamics of the details related to the process.

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Appendix.

Table 1a. Regions in the sample

Region/Country	Code	Region/Country	Code	Region/Country
Belgium	be	Braunschweig	de91	Cataluña
Région de Bruxelles-Capitale	be1	Hannover	de92	Comunidad Valenciana
Vlaams Gewest	be2	Lüneburg	de93	Illes Balears
Prov. Antwerpen	be21	Weser-Ems	de94	Andalucia
Prov. Limburg (B)	be22	Düsseldorf	dea1	Región de Murcia
Prov. Oost-Vlaanderen	be23	Köln	dea2	Ciudad Autónoma de Ceuta (ES)
Prov. Vlaams Brabant	be24	Münster	dea3	Ciudad Autónoma de Melilla (ES)
Prov. West-Vlaanderen	be25	Detmold	dea4	Canarias (ES)
Région Wallonne	be3	Arnsberg	dea5	**FRANCE**
Prov. Brabant Wallon	be31	Koblenz	deb1	Île de France
Prov. Hainaut	be32	Trier	deb2	Bassin Parisien
Prov. Liège	be33	Rheinhessen-Pfalz	deb3	Champagne-Ardenne
Prov. Luxembourg (B)	be34	Saarland	dec	Picardie
Prov. Namur	be35	Chemnitz	ded1	Haute-Normandie
BULGARIA	BG	Dresden	ded2	Centre
Severna i iztochna Bulgaria	bg3	Leipzig	ded3	Basse-Normandie
Severozapaden	bg31	Sachsen-Anhalt	dee	Bourgogne
Severen tsentralen	bg32	Schleswig-Holstein	def	Nord - Pas-de-Calais
Severoiztochen	bg33	Thüringen	deg	Est
Yugoiztochen	bg34	**ESTONIA**	ee	Lorraine
Yugozapadna i yuzhna centralna Bulgari	bg4	**IRELAND**	IE	Alsace
Yugozapaden	bg41	Border, Midlands and Western	ie01	Franche-Comté
Yuzhen tsentralen	bg42	Southern and Eastern	ie02	Ouest
CZECH REPUBLIC	CZ	**GREECE**	GR	Pays de la Loire
Praha	cz01	Voreia Ellada (excl. kentriki Makedonia)	gr11+gr13+gr	Bretagne
Strední Cechy	cz02	Voreia Ellada	gr1	Poitou-Charentes
Jihozápad	cz03	Anatoliki Makedonia, Thraki	gr11	Sud-Ouest
Severozápad	cz04	Kentriki Makedonia	gr12	Aquitaine
Severovýchod	cz05	Dytiki Makedonia	gr13	Midi-Pyrénées
Jihovýchod	cz06	Thessalia	gr14	Limousin
Strední Morava	cz07	Kentriki Ellada	gr2	Centre-Est
Moravskoslezsko	cz08	Ipeiros	gr21	Rhône-Alpes
DENMARK	dk	Ionia Nisia	gr22	Auvergne
GERMANY	DE	Dytiki Ellada	gr23	Méditerranée
Stuttgart	de11	Sterea Ellada	gr24	Languedoc-Roussillon
Karlsruhe	de12	Peloponnisos	gr25	Provence-Alpes-Côte d'Azur
Freiburg	de13	Attiki	gr3	Corse
Tübingen	de14	Nisia Aigaiou, Kriti	gr4	French overseas departments (FR)
Oberbayern	de21	Voreio Aigaio	gr41	**ITALY**
Niederbayern	de22	Notio Aigaio	gr42	Piemonte + Valle d'Aosta
Oberpfalz	de23	Kriti	gr43	Abruzzo + Molise
Oberfranken	de24	**SPAIN**	ES	Piemonte
Mittelfranken	de25	Galicia	es11	Valle d'Aosta/Vallée d'Aoste
Unterfranken	de26	Principado de Asturias	es12	Liguria
Schwaben	de27	Cantabria	es13	Lombardia
Berlin	de3	Pais Vasco	es21	Provincia Autonoma Bolzano-Bozen
Brandenburg	de4	Comunidad Foral de Navarra	es22	Provincia Autonoma Trento
Bremen	de5	La Rioja	es23	Veneto
Hamburg	de6	Aragón	es24	Friuli-Venezia Giulia
Darmstadt	de71	Comunidad de Madrid	es3	Emilia-Romagna
Gießen	de72	Castilla y León	es41	Toscana
Kassel	de73	Castilla-la Mancha	es42	Umbria
Mecklenburg-Vorpommern	de8	Extremadura	es43	Marche

Table 1a. Regions in the sample (second part)

Region/Country	Code	Region/Country	Code	Region/Country	Code
Lazio	ite4	Lubelskie	pl31	**UNITED KINGDOM**	UK
Abruzzo	itf1	Podkarpackie	pl32	North East (ENGLAND)	ukc
Molise	itf2	Swietokrzyskie	pl33	Tees Valley and Durham	ukc1
Campania	itf3	Podlaskie	pl34	Northumberland, Tyne and Wear	ukc2
Puglia	itf4	Wielkopolskie	pl41	North West (ENGLAND)	ukd
Basilicata	itf5	Zachodniopomorskie	pl42	Cumbria	ukd1
Calabria	itf6	Lubuskie	pl43	Cheshire	ukd2
Sicilia	itg1	Dolnoslaskie	pl51	Greater Manchester	ukd3
Sardegna	itg2	Opolskie	pl52	Lancashire	ukd4
CYPRUS	cy	Kujawsko-Pomorskie	pl61	Merseyside	ukd5
LATVIA	lv	Warminsko-Mazurskie	pl62	Yorkshire and The Humber	uke
LITHUANIA	lt	Pomorskie	pl63	East Yorkshire and Northern Lincolnshire	uke1
LUXEMBOURG	lu	**PORTUGAL**	PT	North Yorkshire	uke2
HUNGARY	HU	Norte	pt11	South Yorkshire	uke3
Közép-Magyarország	hu1	Algarve	pt15	West Yorkshire	uke4
Közép-Dunántúl	hu21	Centro (PT)	pt16	East Midlands (ENGLAND)	ukf
Nyugat-Dunántúl	hu22	Lisboa	pt17	Derbyshire and Nottinghamshire	ukf1
Dél-Dunántúl	hu23	Alentejo	pt18	Leicestershire, Rutland and Northants	ukf2
Észak-Magyarország	hu31	Região Autónoma dos Açores (PT)	pt2	Lincolnshire	ukf3
Észak-Alföld	hu32	Região Autónoma da Madeira (PT)	pt3	West Midlands (ENGLAND)	ukg
Dél-Alföld	hu33	Regiãos Autónoma dos Açores + Madeira (PT)	pt2+pt3	Herefordshire, Worcestershire and Warks	ukg1
MALTA	mt	**ROMANIA**	RO	Shropshire and Staffordshire	ukg2
NETHERLANDS	NL	Nord-Vest	ro11	West Midlands	ukg3
Groningen	nl11	Centru	ro12	Eastern	ukh
Friesland (NL)	nl12	Nord-Est	ro21	East Anglia	ukh1
Drenthe	nl13	Sud-Est	ro22	Bedfordshire, Hertfordshire	ukh2
Overijssel	nl21	Sud - Muntenia	ro31	Essex	ukh3
Gelderland	nl22	Bucuresti - Ilfov	ro32	London	uki
Flevoland	nl23	Sud-Vest Oltenia	ro41	Inner London	uki1
Utrecht	nl31	Vest	ro42	Outer London	uki2
Noord-Holland	nl32	**SLOVENIA**	si	South East	ukj
Zuid-Holland	nl33	Vzhodna Slovenija	si01	Berkshire, Bucks and Oxfordshire	ukj1
Zeeland	nl34	Zahodna Slovenija	si02	Surrey, East and West Sussex	ukj2
Noord-Brabant	nl41	**SLOVAKIA**	SK	Hampshire and Isle of Wight	ukj3
Limburg (NL)	nl42	Bratislavský kraj	sk01	Kent	ukj4
AUSTRIA	AT	Západné Slovensko	sk02	South West (ENGLAND)	ukk
Ostösterreich	at1	Stredné Slovensko	sk03	Gloucestershire, Wiltshire and Bristol/Bath area	ukk1
Burgenland (A)	at11	Východné Slovensko	sk04	Dorset and Somerset	ukk2
Niederösterreich	at12	**FINLAND**	FI	Cornwall and Isles of Scilly	ukk3
Wien	at13	Itä-Suomi	fi13	Devon	ukk4
Südösterreich	at2	Etelä-Suomi	fi18	Wales	ukl
Kärnten	at21	Länsi-Suomi	fi19	West Wales and The Valleys	ukl1
Steiermark	at22	Pohjois-Suomi	fi1a	East Wales	ukl2
Westösterreich	at3	Åland	fi2	Scotland	ukm
Oberösterreich	at31	**SWEDEN**	SE	Northern Ireland	ukn
Salzburg	at32	Stockholm	se11	**NORWAY**	NO
Tirol	at33	Östra Mellansverige	se12	Oslo og Akershus	no01
Vorarlberg	at34	Småland med öarna	se21	Hedmark og Oppland	no02
POLAND	PL	Sydsverige	se22	Sør-Østlandet	no03
Lódzkie	pl11	Västsverige	se23	Agder og Rogaland	no04
Mazowieckie	pl12	Norra Mellansverige	se31	Vestlandet	no05
Malopolskie	pl21	Mellersta Norrland	se32	Trøndelag	no06
Slaskie	pl22	Övre Norrland	se33	Nord-Norge	no07