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Regional innovation systems in EU-10: a typology and policy recommendations[ϕ].

Ricardo Aguado[1]
Juan José Gibaja[2]
Mikel Navarro[3]
Beñat Bilbao-Osorio[4]

Abstract

This paper depicts a typology of regions, capturing the diversity of regional innovation systems across the EU-10 (the enlargement member States). Following the Regional Innovation Systems (RIS) literature, our research selects 21 variables related to the ability of a region to generate and absorb knowledge, and its capacity to transform R&D into innovation and economic growth. Based on the results of principal components and cluster analyses, we identify 3 types of regional innovation systems where regions group together according to their sectoral specialisation, technological and economic capacity, and performance. For each group a number of policy recommendations are suggested, contingent to their local-specific characteristics. Moreover, the paper allows us to identify similar and more advanced regions so as to facilitate comparisons and benchmarking between homogeneous regions, thus enabling more accurate policy learning. In short the contribution of this paper is twofold. In the first place it provides the first RIS typology for the EU-10 regions completed using a large number of variables. Secondly, the conclusions obtained from the analysis may be used to lead policymakers' actions in the field of regional innovation policy in the EU 10, which groups the less developed countries in the European Union from the economic and technological points of view. Moreover, policy implications in this paper could give certain insights useful to policy makers in other parts of the world (always with a need to adapt them and take into account local social and economic conditions, institutions and development paths).

Key words: Enlargement Member States, Regional Innovation Systems, European Union, Typology, Principal Components Analysis, Cluster Analysis

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[1] Basque Institute of Competitiveness (ORKESTRA). C/Mundaiz, 50, E-20012 San Sebastian (Spain) and University of Deusto-La Comercial. C/Hermanos Aguirre,2. E-48014 Bilbao (Spain) raguado@orkestra.deusto.es
[2] Basque Institute of Competitiveness (ORKESTRA). C/Mundaiz, 50, E-20012 San Sebastian (Spain) and University of Deusto-ESTE. C/Mundaiz, 50, E-20012 Donostia-San Sebastian (Spain) jgibaja@orkestra.deusto.es
[3] Basque Institute of Competitiveness (ORKESTRA). C/Mundaiz, 50, E-20012 San Sebastian (Spain) and University of Deusto-ESTE. C/Mundaiz, 50, E-20012 Donostia-San Sebastian (Spain) mnvarro@orkestra.deusto.es
[4] OECD. 2, rue André Pascal. F-75775 Paris Cedex 16. France benat.bilbao-osorio@oecd.org

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Introduction

Both in literature and in policy implementation in the industrial, technological and regional fields there is a growing and converging tendency towards taking territory and innovation as primary objects of attention (Porter 1998, Malmberg and Maskell 1997, Cooke and Morgan 1998). Among all of the economic schools that have analysed the relationship between innovation and space, the Regional Innovation System (RIS) approach stands out due to its exceptional development since the early 1990s (Cooke *et al.* 2007).

However, this theoretical framework presents some conceptual ambiguities, and above all a clear bias in its empirical investigation towards case study analysis (MacKinnon *et al*. 2002, Doloreux 2004). The use of empirical analyses based on aggregated data from secondary sources has been selfdom used (Malmberg and Maskell 1997). One of the objectives of this work is to contribute to the creation of a more robust empirical research using quantitative methods. More precisely, this paper aims to obtain a typology of regions capturing the diversity of the regional innovation systems across the EU-10 (the enlargement Member States), and therefore to help design policies better adapted to the characteristics and needs of each region.

Although research in this field is relatively scarce, some previous studies have offered typologies of European regions based on their economic and technological capacities and performances. The typology coming up from this paper is differentiated by the use of a large number of variables (more than 20, extracted from the REGUE database[5]), its wide coverage, as the whole EU-10 in analysed, the use of recent data, as 2004 data are used, and by taking into account variables not considered by other works, such as peripherality.

Following Asheim and Gertler (2005: 299), the RIS could be defined as the "institutional infrastructure supporting innovation within the production structure of a region". As a result of this definition, the regions would be expected to group according to their technological development and productive structure. At the same time, the regional innovation systems and peripherality literatures suggest that central and urban regions, with a higher percentage of employment in financial and business services, present a greater innovative input and technological and economic performance (Scott and Storper 2003; Cooke *et al.* 2002; Schürmann and Talaat 2000; Spiekermann and Neubauer 2002).

The variables used in this analysis are showed in table 1.

[5] The REGUE dataset has been jointly developed by the IAIF and the Basque Institute of Competitiveness based on data contained in Eurostat-Regions and own estimations

TABLE 1: INDICATORS USED FOR THE ELABORATION OF THE TYPOLOGIES OF REGIONS

Indicator	Code	Securing	Numerator	Denominator
Per capita income (PPP)	pib_pc2	Direct	GDP	Population
Employment rate (%)	templeo	Direct	Employment	Population
Productivity (PPP)	pib_emp2	Direct	GDP	Employment
Neperian logarithm of the population density (inhabitants per km^2)	logdens	log (dens.)	Population	Area of the region in km^2
Peripherality index	Peripherality index	Direct	1	Accessibility index
Employment in primary sector (%)	ear	(ea)*100/(employment)	Employment in agriculture, livestock and fishing	Employment
Industrial employment (%)	ei1r	(ei1)*100/(employment)	Industrial employment (without construction)	Employment
Employment in business and financial services (%)	es2r	(es2)*100/(employment)	Employment in financial intermediation, real estate services, rents and other business services	Employment
Employment in medium-high and high technology manufacturing sector	et.m1r	(et.m1)*100/[(ei1)+(es)]	Employment in chemistry (NACE24), machinery (NACE29), office equipment (NACE30), electrical equipment (NACE31), telecommunications equipment (NACE32), precision instruments (NACE33), automobiles (NACE34), aircraft and other transportation (NACE35)	Industrial employment (without construction) and services
Employment in high-tech services	se_kis_htr	(se_kis_ht)*100/[(ei1)+(es)]	Employment in post and telecommunications (NACE64), information technology and software (NACE72) and R&D services (NACE73)	Industrial employment (without construction) and services
Youth educational level (%)	educ_terr	(educ.ter)*100/(reg_d2avg)	Students with 5 and 6 ISCED levels	Population 20-24 years
Population 25-64 with tertiary education (%)	pnive5y6r	(pnive5y6)*100/(pob25-64)	Population 25-64 years with 5-6 ISCED levels	Population 25-64 years
Population 25-64 participant in life-long learning (%)	plllr	(plll)*100/(pob25-64)	Population 25-64 years participating in life-long learning	Population 25-64 years
Human resources in science and technology core (%)	hrstcr	(hrstc)*100/ (pt)	HRST core	Population
Total R&D expenditure (% of GDP)	g_pib_t	Direct	Total R&D expenditure	GDP
Government R&D expenditure (% of GDP)	g_pib_ap	Direct	Governemt R&D expenditure	GDP
Higher education R&D expenditure (% of GDP)	g_pib_es	Direct	Higher education R&D expenditure	GDP
Business R&D expenditure (% of GDP)	g_pib_em	Direct	Business R&D expenditure	GDP
R&D expenditure per ooccupied in R&D (PPP)	gidpc	(g_pib_t)*1000000/((p_t_hc)	R&D expenditure	Personnel in R&D (headcounts)
EPO patents (million people)	paten_pc	Direct	Patents filed at the EPO, for year of priority, appointed to the inventor	Total population (million)
High-tech EPO patents (million people)	pat_ht_p	Direct	Patents filed at the EPO, for year of priority, appointed to the inventor	Total population (million)

Literature on Regional Innovation Systems

In the competitiveness, innovation and economic development literature, as well as in the management of industrial, technological and regional development policies, the need to focus on the sub-national level has become increasingly important. In the competitiveness literature, there is a growing tendency to give priority to micro aspects over macro, whether such micro aspects are of a general nature (territory diamond) or specific nature (cluster diamond). These micro aspects are considered to be largely determined at the sub-national level (Porter 1998 and 2003). The recent innovation literature abandons the linear model of innovation and portraits innovation as the result of an iterative process of highly localised social actors and their interactions (Lundvall 1992). These localised interactions between agents are largely due to the physical proximity needed for the transmission of tacit knowledge (Braczyck *et al*. 1998, Malmberg and Maskell 1997, Maskell and Malmberg 1999). Finally, the regional development literature recognises the importance of endogenous development and the impact that innovative capacity has on the territory (Cooke and Morgan 1998, Morgan 2004). In short, in recent years, analysts and industrial, technological and regional policy makers have realised that competitiveness and innovation are primarily determined at the regional and local levels (OECD 2001 and 2007).

In the economics literature, there are several schools or trends that analyse innovation at the regional and local levels, developing theoretical frameworks: industrial districts, innovative *milieu*, local production systems, learning regions, technological districts, etc. (Moulaert and Sekia 2003). Among those trends, the regional innovation systems (RIS) approach has particularly stood out thanks to the development of a vast literature and its wide acceptance among policy makers and international institutions dealing with economic development (European Commission, OECD, World Bank).

The term RIS was employed for the first time by Cooke (1992) at the beginning of the 1990's, a few years after the term national innovation system had been used first by Freeman (1987). Although there is not a fully accepted definition of regional innovation system, following the already mentioned definition by Asheim and Gertler (2005: 299), a regional innovation system is "the institutional infrastructure supporting innovation within the production structure of a region". Or as the father of the term notes, "a regional innovation system consists in subsystems of generation and exploitation of knowledge that interact with other regional, national and global systems for the commercialisation of new knowledge" (Cooke *et al.* 2004: 3).

Although the previous definition of regional innovation system seems clear and without interpretation problems, reality shows it is not the case. The RIS literature has been criticised for lack of precision, clarity and rigour in many of its concepts (Doloreux 2004, Hommen and Doloreux 2003, MacKinnon *et al*. 2002, Andersson and Karlsson 2004, Fernández-Satto and Vigil-Greco 2007). The concept of RIS is a clear example of what Markusen (2003) calls "fuzzy", "characterizations lacking conceptual clarity and difficult to operationalize". To understand better the difficulties that this concept poses, the next lines will disentangle the three terms of the concept, i.e. region, innovation and system, and analyse each of these three complex concepts.

For the term *region*, Cooke and Morgan (1998: 64) state: "Formalistically speaking, region is a territory less than its state(s) possessing significant supralocal administrative, cultural, political or economic power and cohesiveness differentiating it from its state and other regions". (See also Cooke 2005 134; Cooke *et al*. 2007147). However, authors like Doloreux and Parto (2004) stress the ambiguity or vagueness in the definition. From the cultural and functional perspective, one may wonder when a territory has enough cohesion and homogeneity to be considered a region. There are numerous authors who criticise the definition for being highly unrealistic in treating regions as homogeneous entities (Bathelt 2003, Mackinnon *et al*. 2002, Muscio 2006, Sharpe and Martínez-Fernández 2006…). Moreover, from the administrative perspective, favoured by Cooke because of its accuracy, there are countries that have only state and local administrative levels, but not regional ones. A simple glance at the territorial units that, from an administrative or statistical perspective, have been used in the empirical studies for comparing RIS clearly shows that the term has been applied to cities, metropolitan areas, industrial districts, NUTS II and even higher levels of aggregation (Doloreux and Parto 2004). In other words, there is a wide variety in the spatial scale and the same mechanisms are applied to explain agglomeration phenomena operating at very different scales (Salom 2003, Malmberg and Maskell 2001).

The term *innovation* varies substantially depending on the author[6]. On the one hand, in the work of the authors who advocate for a very narrow definition of innovation, innovation analysis concentrates on the institutions and organisations involved in "searching" and "exploring", and on the determinants of radical innovations. On the other hand, in the work of those defending a broader definition of innovation, in addition to research and exploration, learning by experience ("by doing," by using" and "by interacting") is also important. If the learning capabilities and competence generation are considered to be crucial, as in Lundvall (2007), we can not forget education, training activities and even the labour markets. In general, although most RIS analysts are in favour of a broad interpretation of innovation, in reality their empirical analyses tend to be more restrictive, as there is a tendency of RIS in Europe to be quite "institutional" (or dependent on public interventions). Moreover, Sharpe and Martinez-Fernandez (2006) stress out that the RIS literature has paid little attention to the analysis of non-technological innovation, despite its growing importance.

The term *system* is not homogeneously used in the innovation system literature. There are authors like Nelson (1992:365), who employ this term in a purely pragmatic way understanding by a system "a set of institutions whose interactions determine the innovative performance…(with) no presumption that the system is consciously designed, or even that the set of institutions involved works together smoothly and coherently". Conversely, authors such as Bathelt (2003), based on the modern theory of systems, consider that a system must be able to replicate its basic structure and distinguish what is in or out of it. This condition could not be met virtually by any RIS. Most analysts would be somewhere in between these two extremes. Their most prominent representative, Edquist (2005), considers that a system is composed of a set of components (organisations and institutions), with linkages among themselves, which play a specific function, and with limits or boundaries that distinguish them from the rest. In the case of a RIS:

- Members would be the organizations and institutions in the region belonging to the aforementioned subsystems.

- The relationships between them, to be systemic, must involve a certain degree of interdependence. RISs are open, not self-sufficient systems.

[6] See, for example, the different meanings applied to the concept by well-known authors in the analysis of innovation systems such as Nelson and Rosenberg (1993), Freeman (1987), Lundvall (2007) or Cooke (1998).

- Much of these interdependencies take place in businesses and organizations of other innovation systems: regional, national and international

The role of RIS is to collaborate in the generation and exploitation of knowledge.

However this conception of the system too is somehow inaccurate to be applied to real situations: what is, for example, the critical level of innovative enterprises, or of interrelationships among the organisations and institutions of the system, which enable to affirm it is an innovation system? (Doloreux 2004). Even if researchers are cautious with their analyses and results, the lack of the above mentioned precise criteria defining a regional innovation system, makes most regions unqualify to be considered as “innovation systems” (see Navarro 2007, Morgan 2004).

In addition to the conceptual problems of the RIS, the development of the RIS literature has been hampered by the lack of indicators and sources to analyse the RIS empirically. This may explain the current bias of the literature towards the theory and the lack of empirical studies (MacKinnon *et al*. 2002). Moreover, the scarce empirical literature has mainly developed based on case studies, mostly limited to successful regions (Doloreux 2004, Howells 2005, Sharpe and Martínez-Fernández 2006). These case studies provide a static snapshot rather than the dynamic adjustment processes enabled by longitudinal studies (Doloreux and Parto 2004, MacKinnon *et al*. 2002, Salom 2003). In this regard, Malmberg and Maskell (1997) have criticised the lack of studies in the RIS literature that use aggregated data for a large number of regions, usually taken from secondary sources. This article aims precisely to bridge this existing gap in the literature.

Data, sources and typology of European regions

Among all of the aspects in which the RIS literature has tried to advance empirical studies, this article focuses on obtaining a typology of European regions for the enlargement member States. This will help capture the extraordinary diversity and richness of this empirical phenomenon and conduct benchmarking studies for the design of better adapted policies to the characteristics of each territory.

There have been two approaches for obtaining a RIS typology. The first one deals with authors who used case studies, sometimes as an iterative dialogue, in order to test previous conceptual works. Cooke (1998) combined three types of RIS governance (grassroots, network and interventionist) with other three dimensions of entrepreneurial innovation (localist, interactive and globalised). As a result, he achieved a typology of 9 groups of RIS. Asheim (2007) distinguished between three types of RIS: territorially embedded, regionally networked and regionalised nationals. Lastly, Tödtling and Trippl (2005) classify the regions in peripheral, mature industrial and metropolitan regions. The second way to create RIS taxonomies has used statistical analysis for a wide set of regions. A brief summary of the empirical work in this field has resulted in the RIS typologies listed in table 2. Our approach goes in line with this type of econometric studies.

AUTHORS	CONSIDERED REGIONS	STATISTICAL TECHNIQUE	DATASOURCE	CONSIDERED VARIABLES	OBTAINED TYPOLOGY
Clarysse and Muldur (1999)	EU-15: NUTS 1 (BE, DE, UK) and NUTS 2 (rest)	Factorial and cluster	Eurostat Regions	GDP per capita, agricultural employment, total R&D, patents, GDP variation, patents variation, unemployment variation	6 groups: industry leaders, clampers-on, slow grower, economic catcher-up, lagers behind
ECOTEC (2005)	EU-27: NUTS 2 (most) and NUTS 1 (if NUTS 2 not available)	Two different methods: (1) Z-score analysis; (2) three cluster analysis: rescaled data for four individuals, two compound indicators and average of the six indicators	Eurostat Regions (Supplemented with contacts at national statistics agencies)	3 indicators of R&D: R&D expenditure, R&D staff, HRST core. And 3 indicators of innovation: Employment medium and high-tech manufacturing, employment in knowledge-intensive services, population with tertiary education	(1) Z-score analysis: 5 types of areas: lack of capacity, average capacity, rich innovation, rich R&D and knowledge centres. (2) Cluster analysis: 5 clusters in each of the three analyses
Hollanders (2003)	EU-15: 171 regions (NUTS 1 and 2)	Cluster	Eurostat Regions and CIS II innovation survey)	14 variables: tertiary education, life-long learning, medium and high tech manufacturing employment, employment in knowledge-intensive services, public R&D expenditure, business R&D expenditure, patents, high-tech patents, innovative companies in manufacturing, innovative companies in services, innovation costs in manufacturing, innovation costs in services, sales of products new to the firm in manufacturing and per capita GDP	6 groups: 2 high-tech groups with 3 regions each; and 4 others with a much higher number of regions, especially those located close to the EU average or below this
Brujin and Lagendijk (2005)	EU-15: NUTS 2	Factorial and cluster	Eurostat Regions	Level and variation of: per capita GDP, GDP per employee, workforce with tertiary education, students of tertiary education, R&D expenditure, employment in high-tech manufacturing, employment in technology-intensive services, employment in life-long learning, patents	6 groups: with very strong diversified position, with strong position in knowledge-intensive services, with strong growth in knowledge-intensive services, with a strong position in high-tech sectors, with strong growth in high-tech sectors and those who stay behind
Muller and Nauwelaers (2005)	EU-12 (enlargement)	Double factorial: (1) with five variables included in knowledge creation; (2) with the factor of knowledge creation and the 20 remaining variables	Eurostat Regions; PATDPA own holdings, SCI, eEuropesources by Fraunhofer ISI; and Merit	25 variables arranged in five groups: knowledge creation, knowledge absorption, diffusion of knowledge, demand of knowledge and governance	5 groups: capitals, with tertiary growth potential, qualified manufacturing platforms, with industrial challenges, agricultural laggards
Hollanders (20007)	EU-25: 206 regions NUTS 1 and 2	Hierarchical clustering	Eurostat Regions	6 indicators: HRST, life-long learning, public R&D expenditure, business R&D expenditure, employment in medium and high-tech manufacturing, employment in high-tech services, patents	12 groups for innovation performance
Martínez-Pellitero (2007)	EU-15: NUTS 1 and 2	Factorial and cluster	IAIF-RIS (EU) base made from Eurostat Regions (with estimates of missing values), supplemented by Infostate and Economic Freedom	29 variables, grouped into 6 factors: national environment, regional environment, innovative companies, universities, public administration and demand	10 groups, grouped in turn by the author into three categories: atypical (for highlighting positively in some of the factors), intermediate and least developed

TABLE 2: REVIEW OF TYPOLOGIES OF EUROPEAN REGIONS OBTAINED FROM SECONDARY SOURCES

Regional innovation researchers in Europe face a constant challenge due to the lack of available regional data related to innovation. As a result, the type of variables and concepts that RIS researchers use in their statistical analyses are highly influenced by the cross-regional available data. RIS analysts have complained about the lack of internationally comparable statistical sources that provide regional data for a significant number of countries. Lately, the data availability has improved substantially, thanks to the fact that access to this information has become free, the *Regions* database of Eurostat has expanded to include more variables, and the ESPON base has come up to supplement the previously available information for some fields. In fact, most of the researchers listed in table 2 have used regional data published by Eurostat, supplemented in some cases with author's own exploitations of other non-official sources.

Most of the cited studies have punctually come to Eurostat and selected the variables relevant for their analyses. Some other research teams, however, using data based largely on Eurostat, have tried to develop their own databases on regional innovation indicators for the EU, including a significant number of variables. One of those teams is the Institute for Industrial and Financial Analysis (IAIF) from the Complutense University of Madrid, which have developed the IAIF-RIS (EU) database for 146 regions of the EU-15. This database includes 65 variables grouped into the following categories: patents, innovative effort, structural conditions in the region, human resources in science and technology, and support elements to innovation, for the period 1995-2001[7]. In order to fill the existing data gaps from the *Regions* database, the IAIF team estimated[8] some of the data for some variables, regions and years. Recently the IAIF-RIS dataset has been updated by the IAIF in cooperation with the Basque Institute of Competitiveness, increasing the number of variables to 175 (not counting the variables expressed in constant euros). This new dataset, called REGUE, covers the 1995-2004 period. Moreover, in addition to the EU-15 countries, it includes the 10 new Member States countries after the 2004 enlargement.

The new available data have helped this investigation to answer to issues posed in the critical review of the concept of regional innovation system, specially for the EU-10 countries and regions.

The first answer related to the selection of the geographical scope related to the "region" concept. The study of the sub-national territorial organisation of the EU requires the assessment of the regulatory and functional criteria in the NUTS system[9]. In this analysis, it was decided to include only those geographical areas with a political and administrative equivalence. Based on these criteria, the following geographical units were identified for analysis:

- NUTS 2: Czech Republic, Hungary, Poland, Slovak Republic.

[7] In parallel to the IAIF-RIS (EU) database the team from IAIF have developed the IAIF-RIS (Spain) database specifically for Spanish regions, using a similar management scheme but with a greater wealth of variables. This database has been exploited by members of the IAIF in numerous publications, among which we should underline Buesa *et al.* (2002), Buesa *et al.* (2003a and 2003b), Martinez-Pellitero (2002), Martinez-Pellitero and Baumert (2003) and Buesa *et al.* (2007).

[8] A complete description of the database is in the doctoral thesis of Baumert (2006).

[9] See Baumert (2006), especially pages 79-88 and 233-247.

- Countries where there are no subdivisions, because of small territorial extension: Cyprus, Estonia, Latvia, Lithuania, Malta, Slovenia.

The geographical area covered in this research is the EU-10. Although the works of Ecotec (2005) and Hollanders (2007) offer typologies for the EU-25 (or EU-27), these typologies are based on a smaller number of indicators than the ones proposed in this paper.

The second factor relates to the concept of *system*. Secondary data sources do not provide data about the interactions between the components of the system, let alone the linkages with members of other systems of innovation (regional, national or international). As Fritz (2002) rightly points out, it is precisely the interaction, the density and quality of the network operations among the elements of the system that are decisive. As a result, and bearing in mind the limitation that these unavailable data impose, the use of statistical techniques can only offer regional patterns of innovation, rather than types of RIS.

The Community Innovation Survey is the first dataset that could somehow provide some information about these linkages. Evangelista *et al*. (2002) give an example of its exploitation for the study of the RIS in Italy. Another example can be found for the RIS in the Basque Country (Navarro and Buesa, 2003)[10] (Aguado, 2007). The problem is that in most countries the survey is not designed to be operated regionally, and therefore such RIS studies for all European countries are impossible.

Finally, the lack of regional data on non-technological innovation and labour mobility of researchers, scientists and technicians makes this analysis impossible. There are many other basic indicators of innovation which are not available for regions. An example of this is the fact that the *European Innovation Scoreboard 2006* has been calculated for national states based on 26 indicators, while the *European Regional Innovation Scoreboard* (2006 RIS) has been calculated only with 7 indicators: human resources in science and technology, participation in lifelong learning, employment in medium-high and high-tech manufactures, employment in high-tech services, public expenditure on R&D, business expenditure on R&D and patents registered at the EPO[11].

Muller and Nauwelaers (2005) identify two types of key indicators that have been used in the different studies of EU RIS: first, those indicators closely related to R&D and technology, and second, those indicators related to the degree of regional economic development. The innovation capacity of a region depends on its absorptive and knowledge creation capacities, and on their social, political and economic characteristics, as they can be innovation filters or powers that hamper or enhance the

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[10] To measure the relationships Evangelista *et al.* (2002) take into account sources of information for innovation declared by firms (competitors, conferences and exhibitions, clients, suppliers and universities and research centres), the barriers to innovation (lack of information about technologies and markets, legislative constraints and lack of technological services) and technological attraction (percentage of expenditure in innovation by non-resident firms). Navarro and Buesa (2003), in addition to taking from the innovation survey data related to sources and obstacles of business innovation, also obtain from that survey information on ownership and the markets in which businesses operate, the way they finance their innovative activity and the interactions in R&D and cooperation in innovation projects.

[11] See Hollanders 2007, cited in table 2

regional ability to transform their R&D investment into innovation and economic growth (Bilbao-Osorio and Rodriguez-Pose 2004).

In our research, 21 indicators have been selected. Twenty of these indicators belong to the REGUE database, while one, the peripherality index, has been taken from the Schürmann and Talaat (2000) study.

Table 1 presents a description of these indicators. The first 10 indicators were selected to reflect the socio-economic characteristics of a region. They include indicators such as *per capita* GDP and productivity, which can be considered as proxies of the stock of knowledge of a country (Bilbao-Osorio and Rodriguez-Pose 2004) and the degree of sophistication of its demand (Muller and Nauwelaers 2005). As table 3 shows, both of them (especially the GDP per capita) have been used in the construction of other typologies.

The employment rate and other productive structure related indicators are proxies of the "social filters" of a region, of the regional ability to transform R&D into innovation and economic growth (Rodriguez-Pose 1999, Crescenzi *et al*. 2007). These indicators have been also widely used in other studies, especially in those linking employment to the technological level of the productive sectors. The only indicator which has not been previously used is the employment in business and financial services. This variable may be the best proxy for knowledge intensive business services. These type of services are positively correlated with the summary index of European innovation (Arundel *et al. 2007)* and with the regional economic and technological performance (Miles 2005).

Population density, as indicated by Sterlacchini (2006) or Crescenzi *et al.* (2007), can be regarded as a proxy for the economies of agglomeration. As for the peripherality index -understood not as an indicator of development, but as an indicator of accessibility- its introduction is justified as the proximity to markets and developed technological locations, facilitates the presence of spill-overs and external economies (Crescenzi *et al*. 2007). This paper is the first to take account the peripherality index in order to generate a EU-10 RIS typology[12].

In addition to these ten socio-economic indicators, the present research also introduces indicators to proxy the knowledge and technological absorptive capacity of a region: The four indicators related to education and human resources in science and technology virtually match those included in the *European Innovation Scoreboard 2006*, and distinguish, as Ecotec (2005), between general education and the qualification of human resources linked to R&D activities.

Unlike other RIS typologies, this work has also taken into account the R&D expenditure per occupied person in R&D activities. As the *Key figures 2007 on Science, Technology and Innovation. Towards an European Knowledge Area* shows, R&D workers' compensations are much lower in less developed regions. If we look only at R&D expenditure, differences between developed and less developed regions could be magnified.

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[12] In the following pages, we will use the name "peripheral region" (or not easily accessible) to refer to a region with a value in the index lower than or equal to 100 and not peripheral (or accessible) for those with a value greater than 100.

Indicators on expenditure on R&D and patents, as in most other studies (see table 3), are included as proxies for knowledge creation. Although in other studies, R&D in tertiary education and public administration have been included in the category of public R&D, in our research, we have distinguished the two types of R&D, as they may carry out different types of research. Besides, the weight and role assigned to the public administration or the university is different in each country (Mowery and Sampat 2005). Although tertiary education is more widespread, R&D activities linked to the public administration tend to concentrate in certain regions (Oughton *et al.* 2002).

To sum up, this study considers 21 indicators to build a typology of the EU-10 RIS. Our research, as those of Muller and Nauwelaers (2005) and Martinez-Pellitero (2007), use more than twenty indicators, but does not use synthetic indicators as in these cases. Working with the original indicators facilitates the interpretation of the econometric results, and therefore the suggestions of policy recommendations.

The indicators are calculated for 2004, except for the peripherality index, which refers to 2000. Clarysse and Muldur (1999), Muller and Nauwelaers (2005) and Bruijn and Lagendijk (2005) use dynamic indicators to build their groups. Our research initially considered both annual indicators and growth rates, but the results were not satisfactory and the contribution of the growth rates to the characterisation of the regional groups was minimal. Moreover, they made the interpretation of the factors less intuitive and therefore it was decided not to include them in the analysis. Moreover, a multiple factor analysis for the years 2000, 2002 and 2004 was conducted, showing very little volatility during the five years where complete data were available for all analysed regions.

TABLE 3: INDICATORS EMPLOYED BY THE TYPOLOGIES OF EUROPEAN REGIONS

	Clarysse and Muldur (1999)	Hollanders (2003)	Bruijn and Lagendijk (2005)	Muller and Nauwelaers (2005)	Ecotec (2005)	Hollanders (2007)	Martinez-Pelletero (2007)	This work (2008)
Number of indicator	7	13	14	25	10	7	29	21
Per capita GDP	x	x[1]		x			x	x
GDP per worker							x	x
Unemployment rate	x			x				
Employment rate							x[8]	x
GDP							x	
Gross Added Value							x	
Compensations of employees							x[8]	
GFCF per worker							x[8]	
Population density				x			x[8]	x
Accessibility index								x
Venture Capital							x[9]	
Technology diffusion infrastructure				x				
Scientific parks					x			
Business innovation centres					x			
Universities and public research institutes					x			
Participation in European Programs				x				
Broadband penetration							x	
Firms using e-Administration				x				
Firms using e-Banking				x				
Web presence in the region				x				
Households using www.				x				
Employment in agriculture, livestock and fishing	x			x				x
Industrial employment				x[5]				x
Employment in business and financial services								x
Employment in medium and high-tech services		x	x[2]		x	x		x
Employment in hig-tech services		x	x[3]	x	x	x		x[13]
Students in tertiary education			x					x[14]
Research students							x	
Population 25-64 with tertiary education		x	x[4]	x	x			x
Population 25-64 with secondary education				x				
Population 25-64 with secondary and tertiary education				x				
Life-long learning		x	x	x		x		x
HRST					x	x	x[10]	x
R&D personnel				x	x			
Business R&D personnel							x[11]	
Higher Education R&D personnel							x[11]	
Total R&D expenditure	x		x	x	x		x	x
Public R&D expenditure		x				x		
Business R&D expenditure		x		x		x	x	x
HIgher Education R&D expenditure				x			x	x
Government R&D expenditure								x
R&D expenditure per occupied person in R&D								x
Expenditure on innovation in manufacturing		x						
Expenditure on innovation in services		x						
Domestic innovative SMEs								
Innovative manufacturing companies		x						
Innovative service companies		x						
Sales new to the firm in manufacturing		x						
Patents	x	x	x	x[6]		x	x[12]	x
High-tech patents		x			x		x[12]	x
Publications				x[7]				
Var. of per capita GDP	x							
Accumulated var. of GDP				x				
Var. of demographic density				x				
Var. of unemployment	x							
Var. of employment in medium and high tech manufacturing			x					
Var. of employment in high-tech services			x					
Var. of tertiary education			x					
Var. of life-long learning			x					
Var. of students in tertiary education			x					
Var. of R&D expenditure			x					
Var. of patents	x		x					

x1: not used in RIS. Used to describe clusters of regions
x2: employment in high-tech sectors
x3: employment in knowledge intensive services
x4: employees with tertiary educational level
x5: employment in manufacturing
x6: patents inventors concentration
x7: two subtypes: concentration in life science and in nanosciences
x8: expressed without relativising: population, employment and GFCF.
x9: two subtypes: seed and startup, and development
x10: three subtypes: in services, in knowledge intensive services and in high-tech
x11: two subtypes: in number of people and in FTE
x12: two subtypes: per inhabitant and per working population
x13: in knowledge intensive
x14: two subtypes: population 25-64 and employees with upper secundary or tertiary educational level

Methodology of Data Analysis

Data analysis was performed using SPSS v.15 and SPAD v5.5. This analysis has gone through three phases, which are presented as a function of the multivariate techniques employed:

- Principal components analysis on original variables and growth rates.
- Principal components analysis and cluster analysis on original variables, peripherality index and index of administrative decentralization.
- Multiple factor analysis on original variables.

A review of the empirical literature about RIS typologies recommends the inclusion of not only the levels of the variables chosen, but also their growth rates. Nevertheless, results obtained from elaborating a principal components analysis (PCA) on the levels and growth rates of the variables were not too good in terms of percentages of variability collected in the first two components. The consideration of growth rates allowed us to detect a catch-up effect in the less developed regions, which also showed a tendency to be associated with higher values in growth rates. However, the contribution of the latter to the characterization of the groups of regions was minimal.

Because of this, we opted to use the PCA technique on the levels of variables. To these variables were added two others as a result of the review of the literature: the peripherality index, which is an indicator of accessibility of the regions; and the administrative decentralization variable[13]. With this set of variables a PCA was elaborated for all regions of the EU-10. The data considered were, in all cases, those referring to the year 2004 (except the peripherality index, which refers to 2000; but because of its structural nature this index will not experience substantial changes). After each PCA, the correspondent cluster analysis was conducted. This cluster analysis let us establish the present typology of regions in the EU-10.

Finally, in order to include the evolutionary effect, we used multiple factor analysis (MFA). According to Abascal and Landaluce (2002) MFA is effective to analyse the stability of results obtained using a PCA. With this goal in mind a MFA was made on the regions of the EU-10. The data taken into account were those relating to the years 2000, 2002 and 2004. The result of MFA assured the stability of the results: the original variables are of a structural nature – very little volatility – and non-significant differences were observed between European regions in the five-year period under consideration. The results of these analyses are presented below, in the next section.

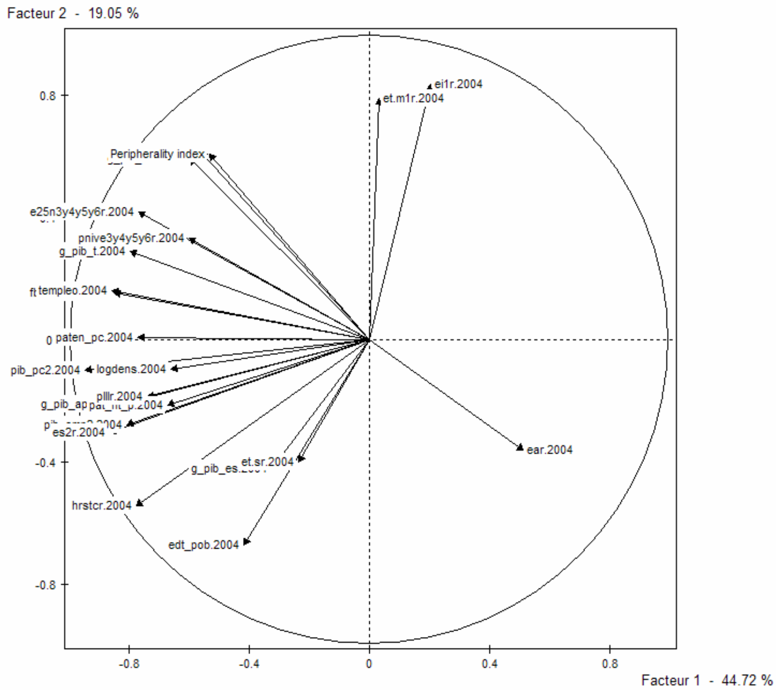
Typologies for the EU-10 regions

We develop a principal components analysis with the 21 variables that have been summarised in table 1 for regions of the EU-10. In figure 1 the positions of the variables regarding the first two principal components are shown. The first principal component, measured in the horizontal axis, explains 44.72% of the variance and represents, to a great extent, *economic and technological development*, as it is shown by the coordinates

[13] The PCA showed the irrelevance of the administrative decentralisation variable to explain the differences between European regions. Because of that reason it was finally excluded from the analyses.

of *per capita* GDP, productivity, population density, employment in high-tech services, employment in financial and business services, inputs in R&D and results of R&D activities. The second principal component, measured in the vertical axis, explains 19,05% of the variance and represents the *regional sectoral specialisation*, as it is shown by the coordinates of industrial employment, employment in the primary sector and employment in medium-high and high-tech manufactures.

Figure 1. Results of the principal components analysis for the EU-10 regions



In figure 2 the position of the EU-10 regions regarding the two principal components is displayed. The centre of gravity of each of the three groups of regions that have been identified in the cluster analysis is also illustrated. The size of each centroid represents the number of regions belonging to each group. Moreover, the peripheral regions (those that do not exceed 20 in the peripherality index) are highlighted in dark blue, while non-peripheral regions are displayed in red. In short, the figure can be interpreted as such: regions with high levels of economic and technological development will be located in the extreme left of Figure 2; regions with a low percentage of industrial employment and employment in medium-high or high-tech manufactures will be placed in the lower position; regions situated in the upper part will have a high percentage of employment in these two sectors. Employment in high-tech and advanced services is linked with the level of economic and technological development.

Figure 2. Location of the EU-10 regions regarding the two first principal components: Regional typology according to the cluster analysis

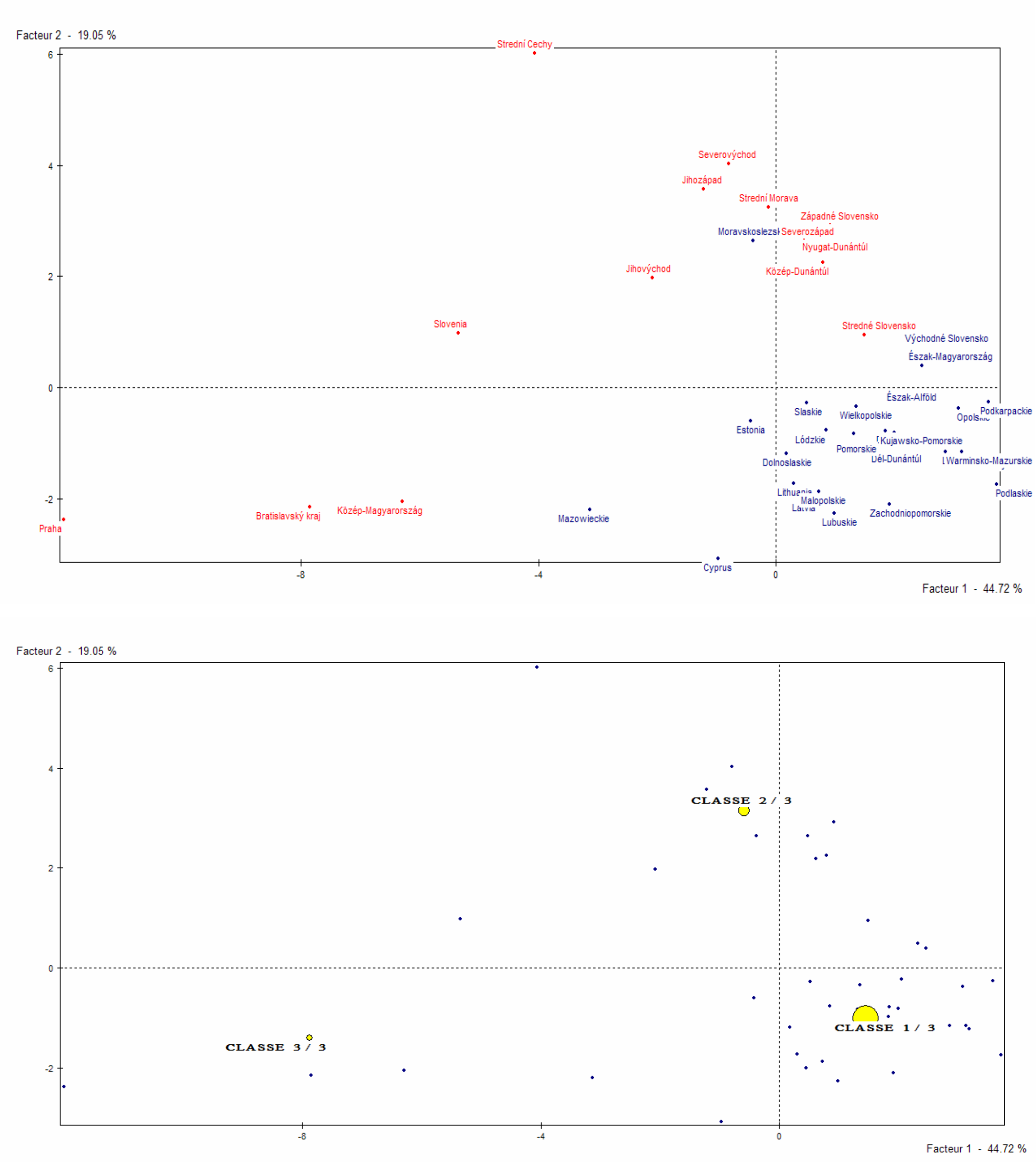


Figure 2 reveals a relationship between economic and technological development and peripherality. Although there is not a complete determinism, regions with more accessibility tend to concentrate in the left part of the point cloud (more developed regions). On the other hand, regions with low accessibility tend to concentrate in the right part, related to low levels of development and low levels of R&D output. It is possible to see, also, that a majority of regions are prone to concentrate in the right part of figure 2. However, some other regions have achieved a good performance and are part of groups 3. They tend to locate in the lower and left part of figure 2. This means they are not specialised in industry but in high value-added services. Finally, figure 2 shows that the EU-10 capital-regions are mainly located in groups 1 and 3, depending on their levels of development. In group 3 it is shown the link between being a capital-region and achieving a high level of economic and technological development. It can be seen, also, the low level of employment in industrial activities in this type of region.

Membership of each group is shown in table 4. The features of the three groups are summarised in the following titles:

- G1: Regions with a weak economic and technological performance
- G2: Restructuring industrial regions with strong weaknesses
- G3: Capital-regions, specialized in high value-added services

Table 4: Groups of EU-10 regions obtained through the cluster

<u>GROUP 1: Regions with a weak economic and technological performance</u>

Cyprus	Estonia	Dél-Alföld
Dél-Dunántúl	Észak-Alföld	
Észak-Magyarország	Lithuania	Latvia
Dolnoslaskie	Kujawsko-Pomorskie	
Lódzkie	Lubelskie	Lubuskie
Malopolskie	Mazowieckie	
Opolskie	Podkarpackie	Podlaskie
Pomorskie	Slaskie	
Swietokrzyskie	Warminsko-Mazurskie	Wielkopolskie
Zachodniopomorskie	Stredné Slovensko	
Východné Slovensko		

<u>GROUP 2: Restructuring industrial regions with strong weaknesses</u>

Jihovýchod	Jihozápad	Moravskoslezsko
Severovýchod	Severozápad	
Strední Cechy	Strední Morava	Közép-Dunántúl
Nyugat-Dunántúl	Západné Slovensko	

<u>GROUP 3: Capital-regions, specialized in high value-added services</u>

Praha	Közép-Magyarország	Slovenia
Bratislavský kraj		

In this typology, the principal components that distinguish the groups of regions are related to economic and technological development on the one hand, and to sectoral specialisation on the other. In the taxonomies offered by other authors the features that determine the groups of regions differ. In some typologies only the technological capacity and development are considered (Ecotec 2005, Hollanders 2003, Hollanders 2007). In others, technological capacity, development and sectoral specialisation are considered (Brujin and Lagendijk 2005 and Muller and Nauwelaers 2005). In some of them, apart from economic and technological development and sectoral specialisation, the evolutionary tendency of these factors is taken into account (Clarysse and Muldur, 1999). Finally, in some of the typologies (Martínez-Pellitero, 2007) the main explanatory factor of the regional groups is the regional size, included in the “regional environment factor". This occurs because the value of some regional variables such as GDP, population, employment and so on has not been divided by the regional size. The typology presented in this paper is close to those that take into account both sectoral specialisation and economic and technological development. That is the case, especially, of the typology proposed by Muller and Nauwelaers, although this was elaborated only for the most recent members of the European Union.

Finally, we have noted the existence of other typologies arising from theoretical frameworks and confronted with case studies. Some of these (for example, those of Cooke and Asheim) are not directly comparable with that presented in this paper, because they consider entrepreneurial innovation types and the relationships between agents and governance. In other typologies (Tödtling and Trippl), the categories of regions (peripheral, metropolitan and old industrial) are linked with the ones obtained in this paper. Peripherality, industrial weight and service and urban development are distinctive features of the groups that we have obtained.

Following this presentation and comparison of regional typologies, we will analyse in-depth the different groups achieved.

Type 1: Regions with a weak economic and technological performance

This group is formed by 26 regions, almost 2/3 of total regions in EU-10. The main feature that defines the majority of regions of this group is the low level of economic and technological development. The *per capita* income of these regions is lower than the EU-10 average (with some exceptions, such as Estonia). The same happens with R&D intensity, tertiary education, employment rate, life-long learning and human resources in science and technology. Besides, these regions have a low population density and low accessibility. With some exceptions, the least developed regions of EU-10 are in this group. The weight of industry is very light in this group: some regions rely on the service sector (mainly tourism) while others rely on agriculture.

These regions should focus their efforts on achieving a critical mass of technological capacity in those areas where their economy could exploit some competitive advantages. These areas could vary from region to region, depending on the regional productive specialisation (Aguado, 2005). The indicators regarding R&D show us that the regional innovation systems of these territories are at a very early stage or just do not exist. A first step to foster development could be to improve the education levels from secondary education to tertiary education, promote life-long learning, enhance accessibility with the rest of Europe and set the base of an RIS that could absorb, adapt and transfer technology and knowledge from the rest of the world to the region. We should not ignore the fact that, first, these regions need to develop a certain absorptive capacity. This capacity will have a bigger impact in GDP growth than R&D expenditures or patents. In peripheral regions like the ones of this type, the R&D activities done by universities have a more positive impact and, if this R&D has a more applied focus, it may compensate the lack of private R&D (Bilbao-Osorio and Rodríguez- Pose, 2004).

Type 2: Restructuring industrial regions with strong weaknesses

This group is formed by 10 regions, 25% of total EU-10 regions. These regions have low levels of agricultural and service sector employment. On average, the weight of the manufacturing sector is high, and in comparison with the EU-10 average there are high levels in secondary and tertiary education, industrial employment, employment in medium-high and high technology manufacturing and business expenditures on R&D.

These regions could benefit from the delocalisation processes that are taking place in the most developed areas of EU-15. As Muller and Nauwelaers (2005) have highlighted, their challenge is to take advantage of exogenous development opportunities (international foreign investment and relocation of industrial activities from the rest of the EU) in order to create internal forces to support a sustainable economic development. A first step in this direction should be the rationalisation of the industrial facilities in order to optimise cost structures. Following Porter (1990 and 1998) we can conclude that these regions are in a development stage based on the low cost of labour. They should advance to the next competitive stage based on efficiency and investment, depending among other factors on the absorptive, adaptive and diffusion capacity of technologies developed outside. In order to achieve this goal they should link foreign investment to the regional economy by proper cluster initiatives, so that the regional economic tissue could benefit from that foreign investment. Otherwise, foreign investments will not be anchored to the region and its attractiveness based on lower labour costs will disappear in the future.

Besides, measures that may enhance the absorptive capacity of these regions should be taken in order to improve their situation in tertiary education, life-long learning, etc... As Sterlacchini (2006) or Clarysse and Muldur (1999) show, the bare augmentation of R&D expenditures might not generate the effects desired in the less developed regions because they do not have the necessary absorptive capacity to take advantage of R&D activities and of knowledge diffusion activities. In some regions it is necessary to develop a certain social capability as a result of increases in the levels of productivity and *per capita* income rather than increases of R&D intensity and number of patents. This means that in the less developed regions, the policy stress should be put not on measures that simply stimulate R&D activities, but in policies oriented to increment that absorptive capacity. We cannot forget that companies are the ones who innovate and not policies by themselves. That is why policies that enhance investments and the creation of technological demand by firms are also needed.

Type 3: Capital-regions, specialized in high value-added services

This group of 4 members (10% of total EU-10 regions) is composed mainly by regions that encompass national capitals. These capitals have been denominated by the *State of European Cities Report* of the European Commission (2007) as “re-invented capitals”, considered as champions of the economic transition and engines of the economic activity of the new Member-States. Those cities have taken advantage of the deep restructuring processes that they have gone through, as it is shown by their remarkable levels of economic growth with no population increment. These reinvented capitals show much higher levels of *per capita* income and growth than the national average, they are the engines of their national economies and contribute positively to the general competitiveness of Europe.

Together with economic development, the regions of this group have reached a level of technological development above the EU-10 average. This position is due to the concentration of national public research facilities and the concentration of the headquarters and R&D activities of big companies (nationals and especially foreign companies) located in each country. In general, their population density is also high, with high levels of income, education and human resources in science and technology. They tend to specialise in high-tech services and financial and business services.

Regarding policy issues, the challenge for this group is to enhance the R&D conducted by companies and achieve a true transmission of knowledge and technology between public research facilities, universities and firms. This interaction between the RIS agents is especially important due to the high concentration of public research infrastructure in these regions. In addition to this point, these regions should move beyond their current position based on the concentration of economic and political power, reinforcing their international connectivity and trying to deepen in knowledge intensive activities and high-tech services.

Conclusions

The objective of this study was to provide a typology of regions capturing the diversity of regional innovation systems across the EU-10, and therefore help design better adapted policies to the characteristics and needs of each region. In addition, this research will contribute to the relatively scarce empirical literature on the study of the interrelations between innovation and the territory, i.e. regional innovation systems, from a statistical point of view, with the use of aggregated data from secondary sources.

Our research covers 40 regions of the EU-10 and it includes twenty non-synthetic indicators from the REGUE data set, and a peripherality index calculated by Schürmann and Talaat (2000). The selected twenty-one indicators characterise the ability of a region to generate and absorb knowledge, and their capacity to transform R&D into innovation and economic growth, e.g. their social and economic characteristics.

Based on a cluster analysis following an initial principal components analysis, the following key findings are identified:

- There are two main factors that characterise EU-10 regions: their level of economic-technological development and their sectoral specialisation. The typologies that do not take this last factor into account ignore a key element that is decisive for the economic development of a region and for the design and implementation of adequate policies to strengthen its regional innovation system.

- Accessibility is another key element that affects positively the economic and technological capacity of a region, and therefore should not be neglected.

- The economic and technological development factor identified in our research seems in line with the theory of the stadiums of competitive development proposed by Porter (1990). At the rear of the spectrum are regions with a development model based on low costs of production factors. In the middle are regions that compete on the basis of investment and efficiency. They are capable of absorbing and adapting foreign technologies, but have limited ability to generate their own. Finally, at the top are regions that compete in the stadium of innovation, thanks to an economic specialisation in high-tech and knowledge-intensive services.

- There is a clear differentiation between regions with a notable industrial profile and regions with a strong either agricultural or service sector. Due to these production and sectoral specialisations, the regions would create and rely on different knowledge bases.

- Less developed regions, within different groups, should aim at policies allowing them to migrate from the lower competitive and innovation stadium to the most advanced one. In order to do so, they should be aware of their productive and knowledge bases. Our typology could serve as a guideline for regions to identify other regions in higher stages of competitive and innovative stadium with similar profiles, from which to learn and benchmark. Best practices in these regions should be analysed in order to identify the possibility of implementing similar policies in their territories. A warning note must be stressed at this point, as copying policies in could turn into negative results. Policies should be contingent to the level of development of each region and the specific characteristics of each context, including its restrictions and weaknesses.

- In order to foster the economic and technological profile of these less developed regions, the mere increase of R&D inputs and patent production may not the best means to increase their capacity to absorb and adapt knowledge. Rather, overall increases in their productivity growth and income per capita levels may yield better results. Therefore, the primary objective of their development policies should focus on increasing their absorptive capacity, tackling their weaknesses in education, life-long learning and other negative characteristics of these regions. Moreover, these regions are characterised by a poor degree of accessibility, which should also be corrected.

- EU-10 regions in general could benefit from the re-localisation of industrial activities within the EU. This could trigger an economic and productivity growth process resulting in an enhanced capacity to absorb and adapt knowledge. However, there is the risk that these *foot-loose* companies may decide to relocate after a few years in other areas where competitive costs become more advantageous. Therefore, cluster policies that anchor these companies to the territory and that allow local firms to create linkages with the newcomers should be favoured at the same time. Other policies, such as educational or research policies, addressing the local weaknesses of the regional innovation system should be equally implemented. Regional actors should get involved in EU learning networks in order to strengthen the technological catch-up resulting from such relocations.

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