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TYPOLOGIES OF INNOVATION BASED ON STATISTICAL ANALYSIS FOR EUROPEAN AND SPANISH REGIONS

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Abstract

This paper highlights the role of typologies for the analysis and policy-making related to regional innovation systems (RIS), explains the two main ways to develop RIS typologies (based on case studies and on statistical analysis) and makes an inventory of the existing typologies. Then it shows the main findings of a recent research done by the authors to obtain an innovation typology for the EU-25 regions and a brand new typology for the Spanish regions, as well as the position of Catalonia in those typologies and with regard to the other advanced Spanish regions. Finally, the paper explores the consequences of elaborating typologies based on statistical analysis with data coming from sources such as Eurostat, which do not provide information about key aspects of a RIS, such as the cooperation among regional agents, the regional governments' support, the regions' openness and so on. The main conclusion is that, even though not considering variables related to those key issues, the typologies obtained with available data are quite stable and would not change very much by incorporating variables that act as proxies for the missing aspects of a RIS.

Keywords. *Typology, Regional innovation system, cluster analysis, multiple factorial analysis, Spain, European Union, region, Catalonia*
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1. Introduction

Innovation is increasingly regarded as one of the key engines for economic growth and prosperity (Lundvall, 1992; Nelson, 1992; Nelson and Rosenberg, 1993; Verspagen, 1995). One of the most relevant level for the analysis and policy-making on innovation is the regional one (Lundvall and Borras, 1997) and the most influential strand for them is the Regional Innovation System (RIS) (Asheim and Coenen, 2005).

Typologies of RIS have been elaborated aiming at capturing the diversity and variety of regional patterns of innovation. So, they can help better understand causality and other relations in a systemic context (Lundvall, 2007) and design better suited policies to the characteristics and needs of each region (Cooke, 1998). Among the two approaches to obtain RIS typologies: conceptual typologies based on case studies and typologies based on statistical analysis, in this paper we have opted for the latter. There have been few attempts, covering all the regions of the EU-25; and even fewer regarding Spain (Navarro and Gibaja, 2009). This paper will display the main findings of our recent research to obtain a typology of innovation for the EU-25 regions (Navarro et al, 2009), will offer a new typology for the Spanish regions, will present the position of Catalonia in those typologies and will show the differences of the Catalonian RIS compared with the ones of the other economically and technologically advanced Spanish regions.

Probably the main obstacle for the development of RIS typologies based on statistical analyses is the lack of statistical data about core aspects of a RIS (Bruijn and Lagendijk, 2005). The shortage of data is more pronounced in some countries than in others, depending by and large on the level of decentralization existing in the country. In Spain, for instance, the availability of data is quite high and it allows us to take into consideration some issues (interactions, government policies, openness of the region and so on) that in typologies for many other countries –and, as a result, in typologies for all the EU regions– are unknown.

The second objective of this paper is, precisely, by exploiting the aforementioned data availability for Spanish regions, to explore the consequences of considering or not such issues when elaborating typologies for all the European regions. In order to this, we conducted a multiple factorial analysis. This statistical technique allows us to compare the two typologies of innovation obtained for the Spanish regions (the one obtained with available data from Eurostat; and the one obtained by adding to them data collected from other Spanish sources) and assess whether the data structure of both is stable and those typologies can be regarded as similar.

2. Regional typologies of innovation in the RIS literature

The RIS approach is a useful tool for studying regional economic and innovative performance and for policy-making (Asheim and Coenen, 2005; Mullers et al, 2008). Following Tödtling and Trippl (2005), we could distinguish the following components in the RIS:

- The knowledge generation and diffusion subsystem. Crucial actors are R&D organizations, educational bodies and technology mediating and other innovation supporting organizations.
- The knowledge application and exploitation subsystem. This subsystem refers to the region's business sector.
- The regional policy subsystem, composed of Government organizations and regional development agencies.
- Socio-institutional factors, specific for a region, that largely influence its innovation capacity
- The linkages with other RIS or national innovation systems.

The RIS components have particular characteristics in each territory. The relevance and nature of these components will depend on the innovation and learning mode prevailing in the region.

According to Jensen et al. (2007), two main modes can be distinguished: the STI and the DUI modes. The former based more on searching and exploring, related to a great extent to R&D activities; the latter on doing, using and interacting. As regions differ, so must their innovation systems and the policy stances adopted in pursuit of them (Cooke 1996).

As a result, several types of RIS can exist and the created typologies can shed some important light on both analytical terms and policy design (Asheim and Isaksen, 2002). Following Lundvall (2007), clustering procedures that result in dividing the population into different 'sub-species' or 'families' with common characteristics are more useful when it comes to study systems of innovation and search for causality, that statistical procedures that look for causality patterns that are general for the whole population. In this regard, typologies constituted an analytical tool to characterise regions according to their similarity in a certain combination of criteria. By allowing for a systematic comparison of economic and innovation activities across various regions, typologies serve as a general comparative classification to gain insight into the development patterns.

There have been two main approaches to obtain RIS typologies. The first one deals with authors who used case studies, sometimes as an iterative dialogue, very often in order to test previous conceptual works. A second group of authors have considered large groups of regions and have performed statistical data analyses –mainly factor and cluster analysis- on economic and innovation regional data in order to cluster regions with similar RIS characteristics.

A compilation of the main conceptual typologies can be found in Table 1.[1] Despite the specific differences in the factors describing the different typologies, all these case-study based classifications present the advantage of providing very detailed insights into the innovation processes accruing in different territories. They managed to clearly identify governance structures, types of knowledge and nuanced descriptions on the inter-linkages of the different innovative agents and innovation broker institutions. However, they fail to provide a comprehensive and quantitative measurement of the economic and innovation performance of the European regions.

Table 1: Review of RIS conceptual typologies based on case-studies

Author	Considered factors	Obtained typology	Regions analysed
Cooke (1992, 1998 and 2004)	1.- The type of governance infrastructure: where the process is initiated (local, regional, federal, supranational), who provides the funding (banks, government agencies...), which research competence prevails (basic, applied or near to the market), and t 2.- The type of business innovation: who is the prevailing firm (large or small, indigenous or multinational), the research reach of firms (internal or external), the innovation supporting infrastructure (public or private) and the degree of associational	3 categories according to the first dimension : grassroots, network and dirigiste 3 categories according to the second dimension: localist, interactive and globalized	Cooke (1992), Braczyk et al (1998) and Cooke et al. (2004): Tuscany (IT), Southest Brabant (NL), Catalonia (ES), Midi-Pyrenees (FR), Quebec and Ontario (CA), California (Silicon Valley/Hollywood) (US), Tampere (FI), the village economy of Denmark (DK), Ba
Asheim and Isaksen (1997 and 2002).	Extent to which they are internally and externally integrated: the location of knowledge organisations (locally or outside the region), the knowledge flow (interactive or more linear) and the stimulus for cooperation (geographical, social and cultural pro	3 Categories: Territorially embedded regional innovation networks, regional networked innovation systems and regionalised national innovation systems.	Asheim and Isaksen (1997 and 2002): Norvegian regions (especially Jaeren, Horten and Sunnmore).
SMEPOL research group: Kauffman and Tödtling (2000), Isaksen (2001), Nauwlaers and Wintjes (2002) and Tödtling and Trippl (2005)	Main barriers to innovation: organisational thinness, fragmentation and lock-in	Linked to organisational thinness: peripheral areas. Linked to fragmentation: fragmented regional clusters and metropolitan regions. Linked to lock-in: old industrial regions, and transition and raw material based peripheral areas	Regions investigated in the SMEPOL project: Upper Austria (AT), Wallonia (BE), Jutland (DK) Lombardy and Apulia (IT), Limburg (NL),northern and south-eastern (NO), Valencia (ES), Lee Valley and Hertfordshire (UK). Regions investigated in the REGIS project non high performers: Styria (AT), Tampere (FI), Wales (UK), Basque Country (ES), Wallonia (BE), Aveiro and Friuli (IT), Féjer (HU), and Lower Silesia (PL)

[1] In addition to them, Asheim has developed a distinction of RIS based on their knowledge base (see Asheim and Coenen, 2005 and 2006; Asheim and Gertler, 2005; Asheim et al, 2007a, 2007b and 2007c; Moodysson et al, 2008). This distinction could be somehow considered a RIS typology. Asheim proposes to distinguish three knowledge bases: the analytic, the synthetic and the symbolic, based on the nature of the knowledge (science, engineering and art based), the important knowledge type (know why, know how or know who), the way they mix tacit and explicit-codify knowledge and some other features.

In order to deal with this caveat and generate a RIS typology applicable to a broader number of regions, statistical analyses could be used. Until recently the RIS literature hardly ever worked with aggregated data coming from secondary sources, pertaining to a broad group of regions, (Malmberg and Maskell, 1997). In spite of the limitations in regional data availability to take into account interactions among agents and other important aspects related to the systemic nature of innovation processes, the analysis of traditional indicators available in secondary sources might help to shed some light on the relation between knowledge inputs, socio-economic characteristics of the territory, and innovation and economic outputs (Bruijn and Lagendijk, 2005). As a result, both for academic reasons and for helping policy makers in the design of regional and innovation policies, some researchers started recently a promising path of defining RIS based on statistical sources.

Table 2 presents synoptically a review of the works on statistical typologies of innovation for the EU regions: the type of publication (academic journal or report), the considered region, the source for data, the reference year for data, the statistical technique used, the considered variables and the obtained typology. A more detailed presentation of these typologies can be found in Navarro et al (2008 and 2009). The reason why we decided to develop our own typology of innovation for the European regions was twofold. On the one hand, many of the typologies did not span the whole EU-25, they contained few variables or they were referred to a distant year. On the other hand, even though many of them claimed to be based on a RIS framework, the model on which they relied was not explicit (that is the case of many of the report types typologies) or that connection was not direct (except in the Martinez-Pellitero's one).

Similarly, table 3 presents a review of the typologies of innovation for the Spanish regions. Actually, only the typologies of the IAIF group (Martinez-Pellitero, Buesa, Heijs and Baumert) and of Orkestra (Navarro and Gibaja) have been elaborated with statistical techniques. Although there are many differences between the ways to obtain typologies by these two teams, probably the most important is that a relatively high number of variables in absolute terms are used by the former, and practically all the variables are used in relative terms by the latter. The strange and, to our view, unsatisfactory final typology resulting from the IAIF team's work is probably due to fact that they consider a lot of variables in absolute terms. As for the typology offered by Navarro and Gibaja (2009), the typology elaborated in this paper does not work with 133 variables grouped into 29 factors (employed as variables in the subsequent factorial analysis), but directly with variables: firstly, with 21 variables taken from Eurostat, so as to make a typology more comparable with the ones elaborated by the RIS literature for European regions; secondly, with 31 variables, 10 of them taken from Spanish sources, related to key issues of the RIS literature that can't be studied with data coming from Eurostat (see table 4).

Table 4: Variables used to obtain the innovation typologies of EU-25 and Spanish regions

COMPONENT OF THE MODEL	Code	Indicator	Available for EU-25 regions	SOURCE	REFERENCE YEAR
Economic output	GDPpc	GDP per capita (€)	Yes	Eurostat	2005
	GDPpw	GDP per worker (€)	Yes	Eurostat	2005
Innovation output	Patents	Patents (per million inhabitants)	Yes	Eurostat	2005
	PatHighTech	High tech patents (per million inhabitants)	Yes	Eurostat	2005
	NewSales	Sales of new-to-firm and new-to-market products (% of turnover)	No	Ine-Innovation Survey	2006
Business subsystem	GERD	Total R&D (% GDP)	Yes	Eurostat	2005
	BERD	Business R&D (% GDP)	Yes	Eurostat	2005
	NoR&Dinnov	Expenditure of innovative firms in Acquisition of machinery, equipment and software, and Acquisition of other external knowledge (% GDP)	No	Ine-Innovation Survey	2006
	Agric	Agriculture (% employment)	Yes	Eurostat	2005
	Ind	Industry (% employment)	Yes	Eurostat	2005
	HTManuf	High and Medium-High tech manufacture (% employment)	Yes	Eurostat	2005
	KIServ	Knowledge intensive serv. (% employment)	Yes	Eurostat	2005
	Special	Exports specialisation index (*)	No	Tax agency	2007
	RelVar	Exports related variety index (**)	No	Tax agency	2007
	Firms>500	Firms with 500 or more employees (%)	No	Ine-Dirce	2006
Infrastructure subsystem	HERD	High Education R&D (% GDP)	Yes	Eurostat	2005
	GOVRD	Government R&D (% GDP)	Yes	Eurostat	2005
	GERDpr	R&D per resarcher (m €)	Yes	Eurostat	2005
	FBServ	Financial and business serv. (% employment)	Yes	Eurostat	2005
Interactions	CoopInfra	Innovative firms co-operating with others firms*** (%)	No	Ine-Innovation Survey	2006
	CoopFirm	Innovative firms co-operating with S&T infrastructures**** (%)	No	Ine-Innovation Survey	2006
Government	RegGov	Innovative firms funded by regional or local Administrations (%)	No	Ine-Innovation Survey	2006
Socio-economic setting	Dens	Population density (natural logarithm)	Yes	Eurostat	2005
	Empl	Employment (% population)	Yes	Eurostat	2005
	HRST	HRST (% employment)	Yes	Eurostat	2005
	EducPop	Tertiary education (% 25-64 aged pop.)	Yes	Eurostat	2005
	EducYouth	ISCED 5_6 students (% total students)	Yes	Eurostat	2005
	LifeLong	Lifelong learning (%25-64 aged pop.)	Yes	Eurostat	2005
	Periph	Schurmann and Talaat' peripherality index	Yes	Schurmann&Talaat	2000
Internationalization	Export	Good exports (% GDP)	No	Tax agency	2007
	FDI	Stock of FDI in Spanish fixed assets and stock of Spanish firms' direct investment abroad (% GDP)	No	Industry Ministry	2006

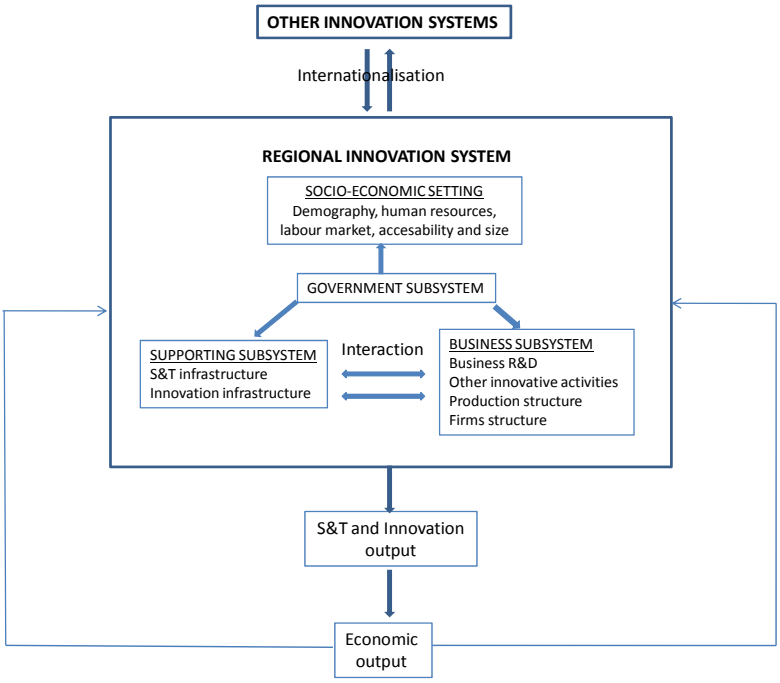
(*)The Balassa-Hoover index calculated for a exports breakdown of NACE 4 digit (See OECD 2007).
(**) Weighted sum of the entropy at the NACE4-digit level within each 2-digit class (see Frenken et al, 2007)
(***) With other national firms of the same group, with other national firms (suppliers, clients or competitors) or with foreign partners
(****) With universities, with government research centers or with technological centers.

Data, sources and methodology for our typology of EU-25 and Spanish regions

The variables that should nurture our statistical analysis were determined according to the components a conceptual RIS should have. In figure 1 the types of indicators used in our typology are shown, grouped according to its connection with the main components of a RIS and the effect of the RIS on innovation and economic output. Let us look at them briefly.

The most simple and ultimate indicators for competitiveness or economic output are GDP per capita and productivity (Porter et al, 2008). Although, as mentioned before, innovation is increasingly regarded as one of the key engines for economic growth or competitiveness (Lundvall, 1992; Nelson, 1992; Nelson and Rosenberg, 1993; Verspagen, 1995), reaching a critical mass of economic development might be a necessity before a region can increase its technological base (Clarysse and Muldur, 2001; Bilbao-Osorio and Rodríguez-Pose, 2004; Dory, 2008). Namely, the RIS affects the economic output, but it also conditions the RIS performance.

Figure 1: Aspects considered to build a RIS typology



Despite some weaknesses, patents are the most appropriate indicator for measuring technological output based on R&D (Jaffe, 1989; Feldman, 2000). But not all innovations come from R&D, and variables such as the percentage of sales due to new products can be used as indicators for the overall innovative activity (OECD, 2005; UNU-MERIT, 2009). Unfortunately, there is no available data for all European regions for this last indicator, because in most of European countries the innovation survey is not collected in a regional basis. However, the Spanish official statistical institute (INE) provided us with data on this variable for the Spanish regions.

As previously shown, several components could be differentiated within the RIS. First of all, the knowledge generation and diffusion subsystem, which in the figure, for short, has been named 'supporting system'. In this subsystem, according to the aforementioned distinction between STI and DUI modes, it is convenient to differentiate and collect indicators for the R&D infrastructure and for the innovation infrastructure (the public R&D infrastructure excluded). Additionally, unlike some other typologies, in the R&D infrastructure we make a distinction between two sources of public R&D: Government and universities. The reason is that the weight and role assigned to public administration or to university is different in each country; and, whereas tertiary education is more widespread, R&D activities linked to the public administration tend to concentrate in certain regions (Mowery and Sampat, 2005; Oughton et al, 2002). Besides, unlike other RIS typologies, this work has also taken into account the R&D expenditure per occupied person on R&D activities. As the *Key figures 2007 on Science, Technology and Innovation. Towards an European Knowledge Area* report 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. As for the innovation infrastructure, the percentage of employment in financial and business services will be used like an indicator, because these type of services is positively correlated with the summary index of European innovation and with the regional economic and technological performance (Arundel et al, 2007; Miles, 2005).

The analysis of the application and exploitation subsystem (for short, named business subsystem in the figure 1) should be split according to some factors that condition a firm's

innovative output. Firstly, as the literature on knowledge production function has shown since Griliches (1979), the firm's innovation inputs influence the innovation output. Once again, following the distinction between STI and DUI modes of innovation, we consider convenient to collect separate indicators for firms' R&D activities and for firms' innovative activities not based on R&D. If for the former almost all the typologies take the business R&D expenditure in percentage of the GDP, for the latter we could similarly take the innovation expenditure (the one in R&D excluded) in percentage of the GDP. Unfortunately, as it has been explained before, the innovation survey is not conducted in a regional basis in most European countries and therefore such indicator can't be used to obtain a typology of EU-25 regions. But the innovation expenditure (R&D excluded) can be obtained for the Spanish regions from the innovation survey.

Secondly, the size of the firm is another factor that conditions the innovation output. That is how it has been stated, since Schumpeter, by the Economics on innovation and taken into account explicitly by Cooke's and Asheim's typologies. Although the average size of manufacturing firms can be obtained from Eurostat for the EU-25 regions, an examination of the available data raised serious doubts about its comparability and therefore we decided to leave them aside from our EU-25 typology. On the contrary, firm size data for Spanish regions are elaborated with a uniform methodology that makes them truly comparable and thus were used to obtain the typology of Spanish regions.

Thirdly, the region's production structure affects its innovation performance, as acknowledged by all the RIS typologies. Usually, it has been taken into consideration by entering some indicators about the share of the main economic sectors (agricultural, industry or services) or the share of the technology or knowledge intensive industries into the statistical analysis. Nevertheless, the existing RIS typologies have not considered indexes of specialization or related variety, even though since the paper of Glaeser et al (1992) on the dynamic knowledge spillovers, the Geography of innovation has highlighted the relevance of these factors for innovation. The main reason is that Eurostat does not offer enough data breakdown by industry for all the European regions. Once again, the availability of export data for Spanish regions allows us to obtain these indexes and use them to obtain the typology of Spanish regions.

One of the major contributions and features of the innovation system framework to the understanding of innovation is its emphasis on interactions of the agents (Edquist, 1997). In fact, this is one of the main obstacles to the existence of a RIS (Kauffman and Tödlting 2000). But as Bruijn and Lagendijk (2005) state, limitations in regional data availability do not allow interactions among agents for EU-25 regional typologies to be taken into account. However, the existence of regional data in Spain for the innovation survey permits us to consider the percentage of innovative firms that cooperate with other firms or with science and technology (S&T) infrastructures.

With regard to the Government subsystem, despite the importance attributed to this element by the RIS literature and by the conceptual typologies developed by Cooke and Asheim, it has not been considered by typologies based on statistical analysis, due to the lack of data about the role played by regional governments. Here, again, the innovation survey conducted in Spain allows us to know the percentage of innovative firms funded by regional or local Administration. This variable will be used as a proxy to measure the involvement of regional Government in the RIS development.

According to Crescenzi et al (2007) and Rodríguez-Pose and Crescenzi (2008) there are three types of 'social filters' that, being part of the socio-economic setting, affect the regional ability to transform R&D into innovation and economic growth: demography, education and employment factors. As proxies for the first one we have taken population density; for the second one, HRST, percentage of students with 5 and 6 ISCED levels, percentage of aged 25-64 with tertiary education level and percentage of aged 25—64 with life-long learning; and for the third

one, the employment rate. As can be deduced from Table 1, all of them have been used for some other EU regional typologies of innovation. Additionally, considering that the proximity to markets and developed technological locations facilitates the presence of spill-over and external economies (Crescenzi et al, 2007), we have also incorporated the peripherality index - understood here not as an indicator of economic development, but as an indicator of accessibility.

Finally, in regard to the methodology of data analysis, the analysis –performed using R and the FactoMineR package– has consisted of principal components analysis (PCA) and cluster analysis, completed with a multiple factorial analysis (MFA). Although our research uses more than twenty indicators, it does not use synthetic indicators as some other typologies (see, for instance, Muller et al, 2008). Working with the original indicators facilitates the interpretation of the econometric results, and therefore the suggestions of policy recommendations, without losing much explanation capacity.

3. Typology for the EU-25 regions

We developed a PCA with the twenty-one selected variables for the 188 regions of the EU-25. Figure 2 presents the positions of the variables regarding the first two principal components. The first principal component, measured in the horizontal axis, explains 43.2% of the variance and represents, to a great extent, the economic and technological development of the region. As shown by the coordinates of the variables, this factor is closely correlated with per capita GDP, productivity, accessibility, HRST, employment in knowledge intensive and financial-business services, inputs in R&D, results of R&D activities and agriculture employment. The second component, measured in the vertical axis, explains 14.1% of the variance and represents the regional sectoral specialisation, as shown by the coordinates of industrial employment and employment in medium-high and high tech manufacturing.

Figure 2: Results of the principal components analysis for the EU-25 regions

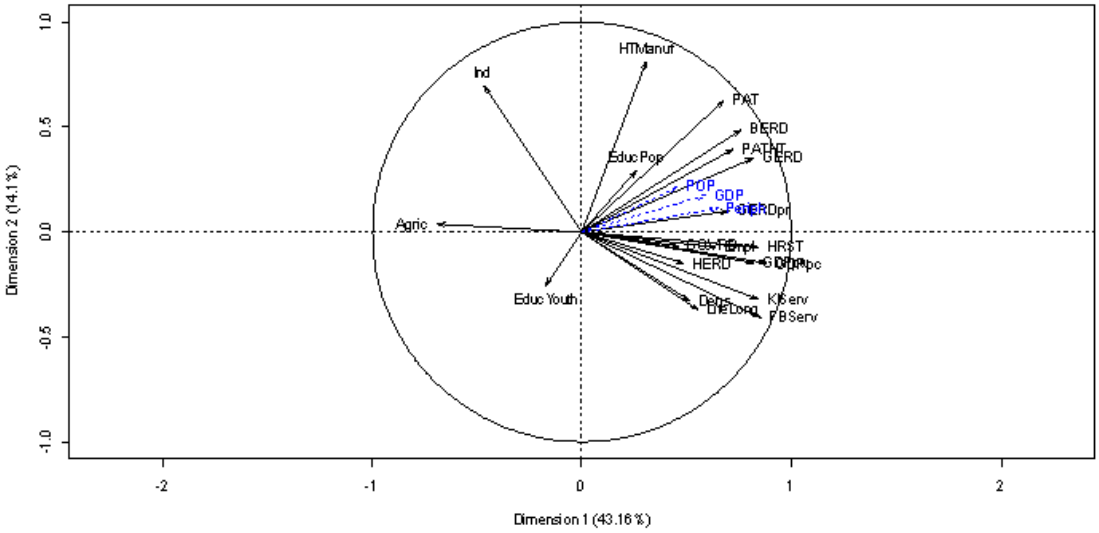


Table 4: Groups of EU-25 regions obtained through the cluster analysis

G 1	GR, PL, PT	Castilla-la Mancha (ES)	Extremadura (ES)	Anatoliki Makedonia, Thraki (GR)	Kentriki Makedonia (GR)	Dytiki Makedonia (GR)
		Thessalia (GR)	Ipeiros (GR)	Ionia Nisia (GR)	Dytiki Ellada (GR)	Sterea Ellada (GR)
		Peloponnisos (GR)	Voreio Aigaio (GR)	Notio Aigaio (GR)	**Kriti (GR) (G3)**	Dél-Dunántúl (HU)
		Észak-Alföld (HU)	Dél-Alföld (HU)	Lithuania (LT)	Latvia (LV)	Lódzkie (PL)
		Malopolskie (PL)	Slaskie (PL)	Lubelskie (PL)	Podkarpackie (PL)	Swietokrzyskie (PL)
		Podlaskie (PL)	Wielkopolskie (PL)	Zachodniopomorskie (PL)	Lubuskie (PL)	Dolnoslaskie (PL)
		Opolskie (PL)	Kujawsko-Pomorskie (PL)	Warminsko-Mazurskie (PL)	Pomorskie (PL)	Norte (PT)
		Algarve (PT)	Centro (PT)	Alentejo (PT)		
G 2	CZ, HU, SI	**Střední Cechy (CZ) (G3)**	Jihozápad (CZ)	Severozápad (CZ)	Severovýchod (CZ)	Střední Morava (CZ)
		Moravskoslezsko (CZ)	Közép-Dunántúl (HU)	Nyugat-Dunántúl (HU)	Észak-Magyarország (HU)	Západné Slovensko (SK)
		Stredné Slovensko (SK) (G1)	Východné Slovensko (SK)			
G 3	CY, EE, ES, IT, MT, SI	Burgenland (AT)	Cyprus (CY)	**Jihovýchod (CZ) (G2)**	Estonia (EE)	Galicia (ES)
		Principado de Asturias (ES)	Cantabria (ES)	La Rioja (ES)	**Aragón (ES) (G4)**	Castilla y León (ES)
		Comunidad Valenciana (ES)	Illes Balears (ES)	Andalucia (ES)	R. de Murcia (ES)	Canarias (ES)
		Corse (FR)	Valle d'Aosta (IT)	Umbria (IT)	**Marche (IT) (G4)**	Abruzzo (IT)
		Molise (IT)	Campania (IT)	Puglia (IT)	Basilicata (IT)	Calabria (IT)
		Sicilia (IT)	Sardegna (IT)	Malta (MA)	Mazowieckie (PL)	**Slovenia (SI) (G4)**
G 4	FR	Salzburg (AT)	**Tirol (AT) (G6)**	R. Wallonne (BE)	Brandenburg (DE)	Mecklenburg-Vorpommern (DE)
		Saarland (DE)	Sachsen-Anhalt (DE)	Schleswig-Holstein (DE)	**Pais Vasco (ES) (G5)**	Cataluña (ES)
		Itä-Suomi (FI)	**Champagne-Ardenne (FR) (G3)**	Basse-Normandie (FR)	**Bourgogne (FR) (G3)**	Nord - Pas-de-Calais (FR)
		Lorraine (FR)	Pays de la Loire (FR)	**Bretagne (FR) (G5)**	Poitou-Charentes (FR)	Aquitaine (FR)
		Limousin (FR)	**Attiki (GR) (G6)**	Közép-Magyarország (HU)	Liguria (IT)	P. A. Bolzano-Bozen (IT)
		P. A. Trento (IT)	Friuli-Venezia Giulia (IT)	Toscana (IT)	Friesland (NL)	Drenthe (NL)
		Zeeland NL)	**Lisboa (PT) (G6)**	Norra Mellansverige (SE)	Mellersta Norrland (SE)	Småland med öarna (SE)
G 5	AT, FR	Niederösterreich (AT)	Kärnten (AT)	Steiermark (AT)	Oberösterreich (AT)	Vorarlberg (AT)
		Vlaams Gewest (BE)	Niedersachsen (DE)	Nordrhein-Westfalen (DE)	Rheinland-Pfalz (DE)	Sachsen (DE)
		Thüringen (DE)	C.F. de Navarra (ES)	**Picardie (FR) (G4)**	Haute-Normandie (FR)	Centre (FR)
		Alsace (FR)	Franche-Comté (FR)	**Midi-Pyrénées (FR) (G7)**	Rhône-Alpes (FR)	Auvergne (FR)
		Piemonte (IT)	Lombardia (IT)	**Veneto (IT) (G4)**	Emilia-Romagna (IT)	Limburg (NL)
		Border Midlands and Western (IE) (G4)				
G 6	UK	**Bremen (DE) (G8)**	C. de Madrid (ES)	**Åland (FI) (G4)**	Languedoc-Roussillon (FR)	P. Alpes-Côte d'Azur (FR)
		Lazio (IT)	Overijssel (NL)	Gelderland (NL)	Flevoland (NL)	Övre Norrland (SE)
		Bratislavský kraj (SK)	North East (UK)	North West (UK)	Yorkshire and The Humber (UK)	East Midlands (UK)
		West Midlands (UK)	South West (UK)	Wales (UK)	Scotland (UK)	**Northern Ireland (UK) (G4)**
		Southern and Eastern (IE)				
G 7	DE. FO. SE	Baden-Württemberg (DE)	Bayern (DE)	Hessen (DE)	**Etelä-Suomi (FI) (G8)**	Länsi-Suomi (FI)
		Pohjois-Suomi (FI)	Noord-Brabant (NL)	Sydsverige (SE)	Västsverige (SE)	
G 8	LU, NL, DK	Wien (AT)	R. de Bruxelles (BE)	Praha (CZ)	Berlin (DE)	Hamburg (DE)
		Denmark DK)	Île de France (FR)	Luxembourg (LU)	Groningen (NL)	Utrecht (NL)
		Noord-Holland (NL)	Zuid-Holland (NL)	Stockholm (SE)	Östra Mellansverige (SE)	Eastern (UK)
		London (UK)	South East (UK)			

Regions in bold are the most distant from the centre of their group. On their right, in brackets, it is shown their next nearest group. Color red means that their nearest group has a lower economic and technological capacity; and color green, the opposite.

Based on the findings of the PCA, a cluster analysis was carried out in order to gather the regions in homogeneous groups. This analysis results in the creation of eight groups of regions named as follows: (G1) Peripheral agricultural regions with a strong economic and technological lag. (G2) Restructuring industrial regions with strong weaknesses. (G3) Peripheral regions with an economic and technological lag. (G4) Central regions with an intermediate economic and technological capacity. (G5) Industrially restructured regions with a certain economic and technological capacity. (G6) Service oriented regions with a certain economic and technological capacity. (G7) Technologically advanced regions with an industrial specialisation. (G8) Service oriented Innovative and capital regions. (See regions in each group in Table 4).

The grouping of regions reveals three blocks of regions at different levels of technological and economic development: Low, for regions in groups 1, 2 and 3; medium, for regions in groups 4, 5 and 6; and high, for regions in groups 7 and 8. Moreover, within the extreme blocks (G1 and G2, on the one hand; and G5, G6, G7 and G8, on the other) regions can be grouped according to their economic structure: G1 agricultural; G2 industrial; G5 and G7 industrial; G6 and G8 services). Whereas in regions with medium-low level of development (G3 and G4) the sectoral specialization seems less relevant for their allocation. It could be understood as if to get a significant level of economic and technological development regions tends to opt for an industrial or service orientation.

Figure 3. Location of the EU-25 regions regarding the two first principal components: Regional typology according to the cluster analysis

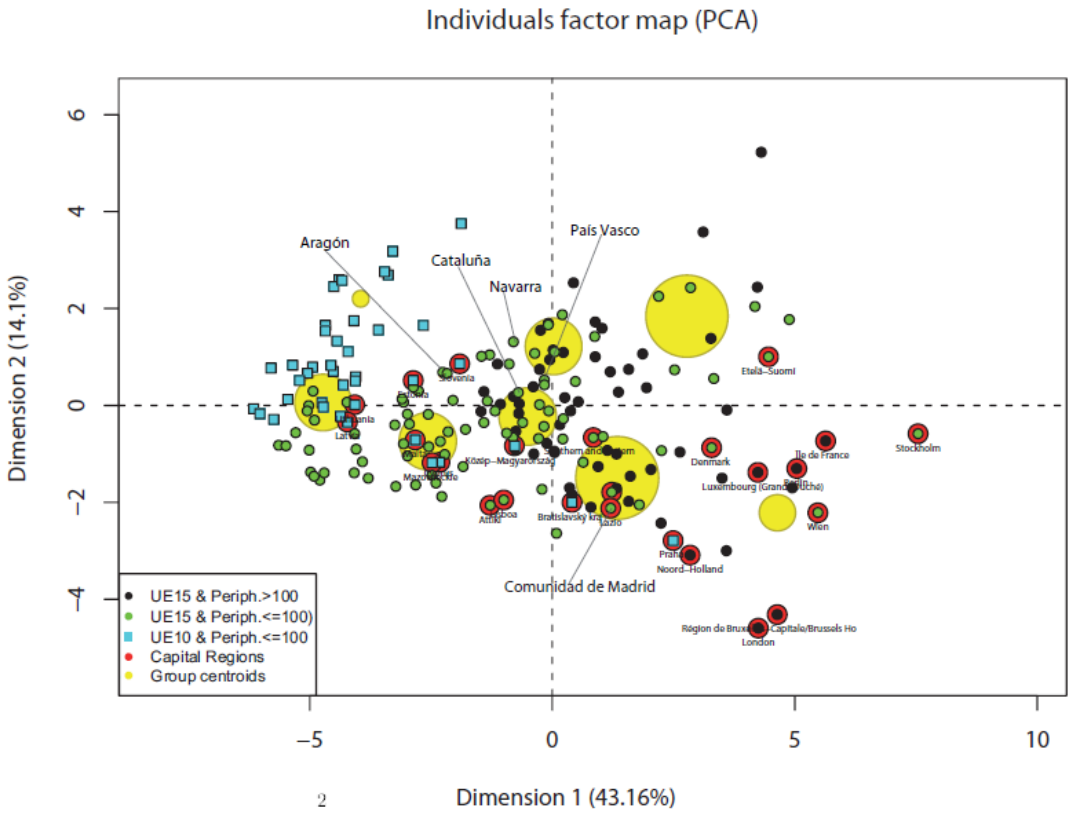


Figure 3 positions the EU-25 regions regarding the two principal components. The centre of gravity of each of the eight groups of regions identified in the cluster analysis is also illustrated. The size of each centroid represents the population size of the regions pertaining to each group. Moreover, the regions belonging to the EU-10 accession countries and to the EU-15 countries that formed the Union before the enlargement appear with distinctive symbols and colours. Finally, the peripheral regions are highlighted. In short, the figure can be interpreted as such: regions with high levels of economic and technological development will be located on the extreme right of figure 3; regions with high percentage of industrial employment and of employment in medium-high or high-tech manufacturing will be placed in the upper part of the figure.

Figure 3 also reveals a relationship between economic and technological development and peripherality. Although there is not a complete determinism, regions with more accessibility tend to concentrate on the right part of the point cloud, i.e. developed regions. On the other hand, regions with low accessibility tend to concentrate on the left part, related to low levels of development and innovation (peripheral regions). The main exceptions to this rule are Nordic countries, showing that geographical peripherality is not always incompatible with high economic and technological development levels.

It is possible to see, also, that regions belonging to the newly acceded countries are prone to concentrate in the left part of figure 3. Finally, figure 3 shows that the EU-25 capital-regions[2] are mainly located in the lower part, what makes clear the low level of employment in industrial activities in this type of region, being the main exception the Finish Etela-Suomi. Capital regions

[2] We speak about capital-regions only if the country has sub-national administrative levels. In this paper we exclude from this category the cases of Luxemburg, Denmark, Cyprus, Estonia, Latvia, Lithuania, Malta and Slovenia.

pertaining to the EU-15 are in the right corner (except Lisbon and Athens), and those pertaining to the accession countries in the left (except Prague and Bratislava). All of them are located on the right of the rest of the regions of their countries, which makes explicit the link between being a capital-region and achieving a high level of economic and technological development.

Finally, as for the position of the Spanish regions in this European regional typology, table 4 and figure 3 show that:

- Castile-La Mancha and Extremadura are in G1, the group of peripheral agricultural regions with a strong economic and technological lag, along with a large number of regions of the south of the EU-15 and pertaining to the EU-10 accession countries.
- Galicia, Asturias, Cantabria, La Rioja, Aragon, Castile-Leon, Valencia, Balearic Islands, Canary Islands, Andalusia and Murcia are in G3, the group of peripheral regions with an economic and technological lag, along with some regions from Italy and from some EU-10 accession countries.
- Catalonia and the Basque Country are in G4, a group that displays a similar economic output and a lower technological input and output than the European average. This group is composed of a large number of regions from the EU-15 countries, mainly from France. Compared to Catalonia, the Basque Country is more distant from the centre of the group and near to be included in the more advanced G5 group.
- Navarre is located in G5, a group of industrial regions of EU-15 countries, with an economic output above the European average, but technological input and output slightly below that average.
- Madrid is in G6, a group of service oriented regions, along with some capital regions from intermediate countries (Rome and Bratislava), not being able to join the group of advanced capital regions.
- None of the Spanish regions is in G7 and G8 groups, the most economically and technologically advanced from the EU-25.

4. Typologies for the Spanish regions

This section aims at offering a new typology for Spanish regions and, above all, exploring how a typology might be affected by leaving aside some variables about which there is no available data in Eurostat or other international data-sources, even though they are considered as key aspects of a RIS by the literature. In order to conduct that analysis we will start looking at the typology of Spanish regions obtained with data taken from Eurostat and then will replicate the analysis by adding some new variables taken from other Spanish sources.

The PCA carried out for the 17 Spanish regions (Ceuta and Melilla excluded, due to the lack of data on them for a high number of variables), based on data from Eurostat, lets us again identify two factors that explain even higher percentages of the variance of the variables: 63% and 14%, respectively. As in the EU-25 regions, the first factor, measured in the horizontal axis, represents to a great extent the economic and technological development of the region; and the second factor, measured in the vertical axis, the regional manufacturing specialisation. The differences between the results of both principal components analysis (see figures 2 and 4) could be labelled as minor.

Figures 5 and 6 represent the dendrogram of the cluster analysis of the Spanish regions and the location of Spanish regions regarding the two first principal components of the factor analysis. The dendrogram shows a clear cut in four groups of regions:

- (G1) Capital region specialized in advanced services: Madrid
- (G2) Medium-high tech industrial regions: Basque Country, Catalonia and Navarre

- (G3) Medium-low tech regions: Aragon, Asturias, Cantabria, Valencia, La Rioja, Galicia, Castile-Leon
- (G4) Agricultural or touristic less developed regions: Balearic Islands, Canary Islands, Castile-La Mancha, Andalusia and Murcia

On the other hand, leaving aside the capital region, a positive relation appears between the specialization in manufacturing and the level of economic and technological development, perhaps because, apart from Barcelona (in Catalonia), there are not big Spanish cities or high population density to foster the development of advanced services.

Figure 4: **Results of the principal components analysis for the Spanish regions carried out with data taken from Eurostat**

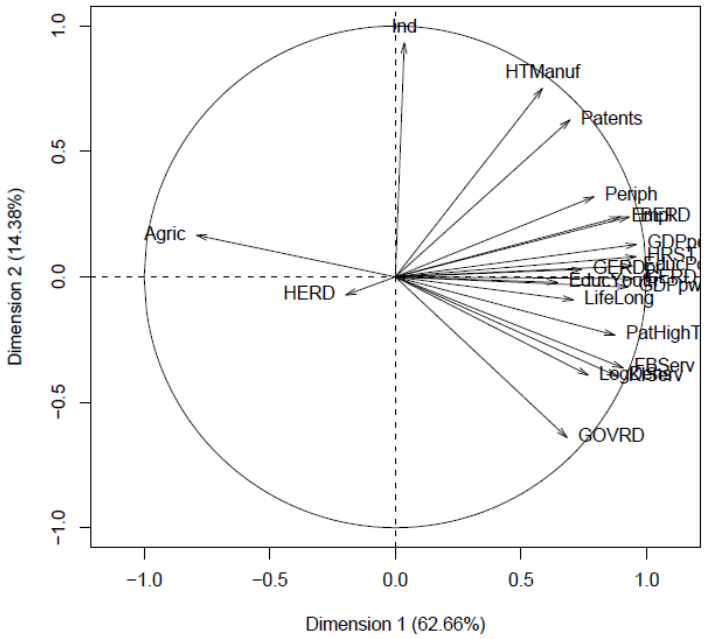


Figure 5: **Dendrogram of Spanish regions, obtained with data taken from Eurostat**

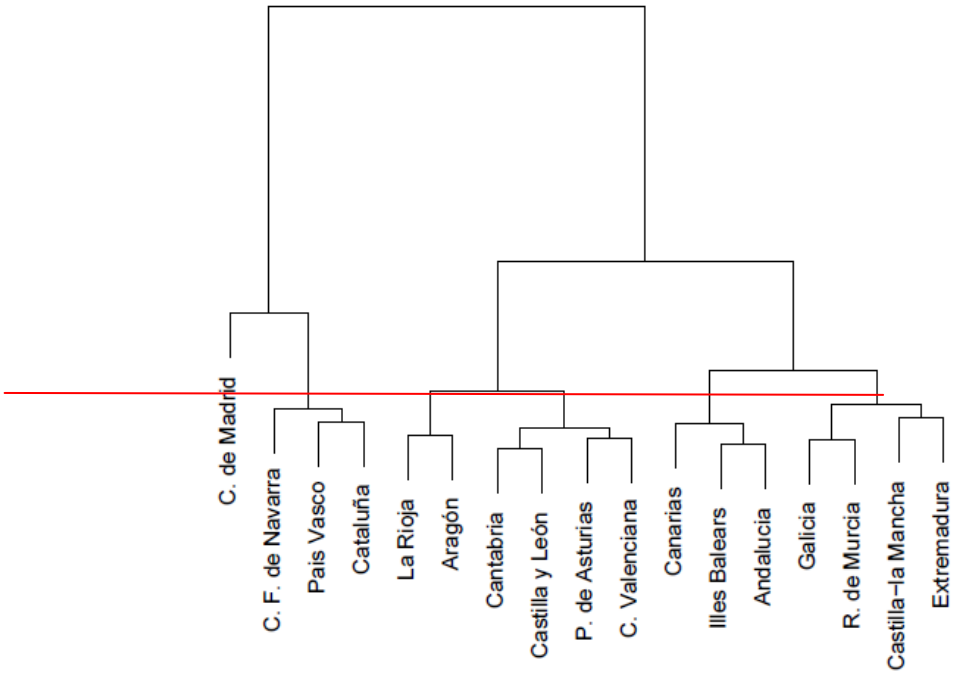
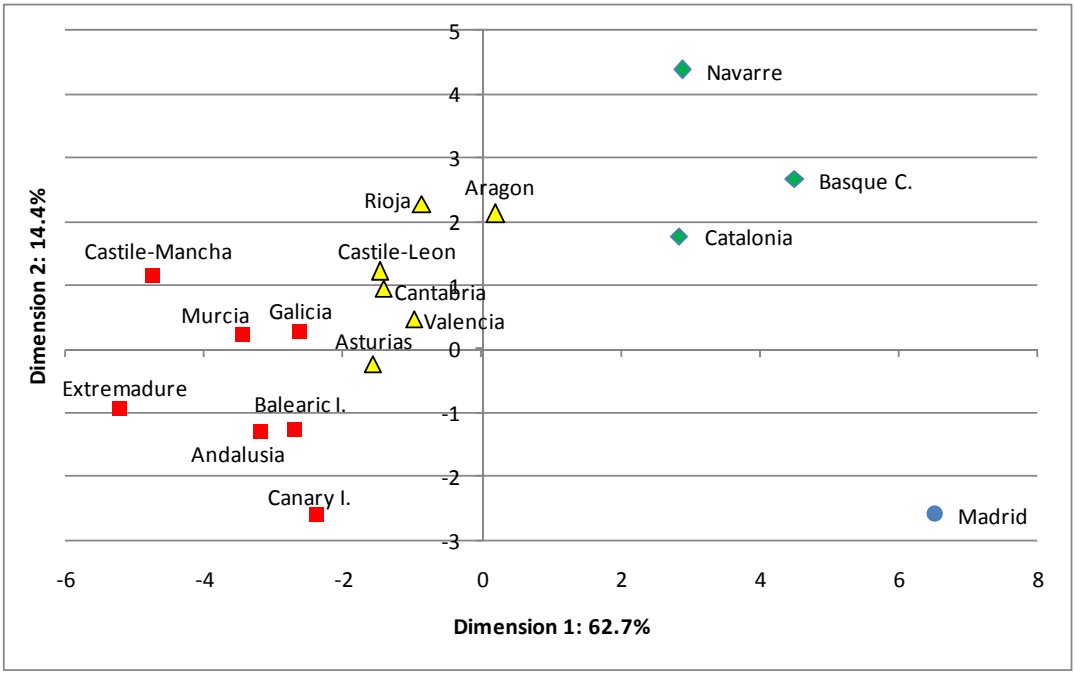


Figure 6: Location of Spanish regions regarding the two first principal components of the PCA conducted with Eurostat's data



Figures 7, 8 and 9 show the same analyses, but conducted with some more variables taken from Spanish sources added to the ones taken from Eurostat.

Figure 7: Results of the principal components analysis for the Spanish regions carried out with data taken from Eurostat and from Spanish sources

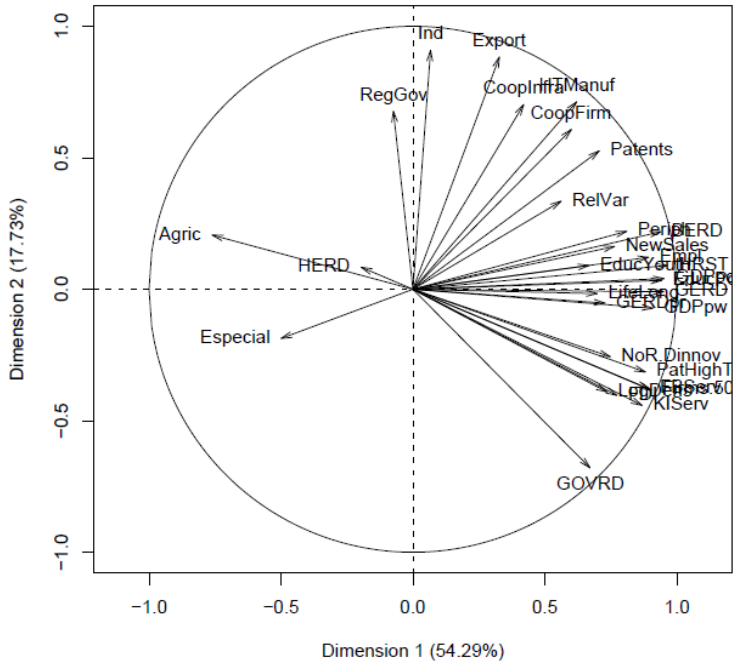


Figure 8: **Dendrogram of Spanish regions, obtained with data taken from Eurostat and from Spanish sources**

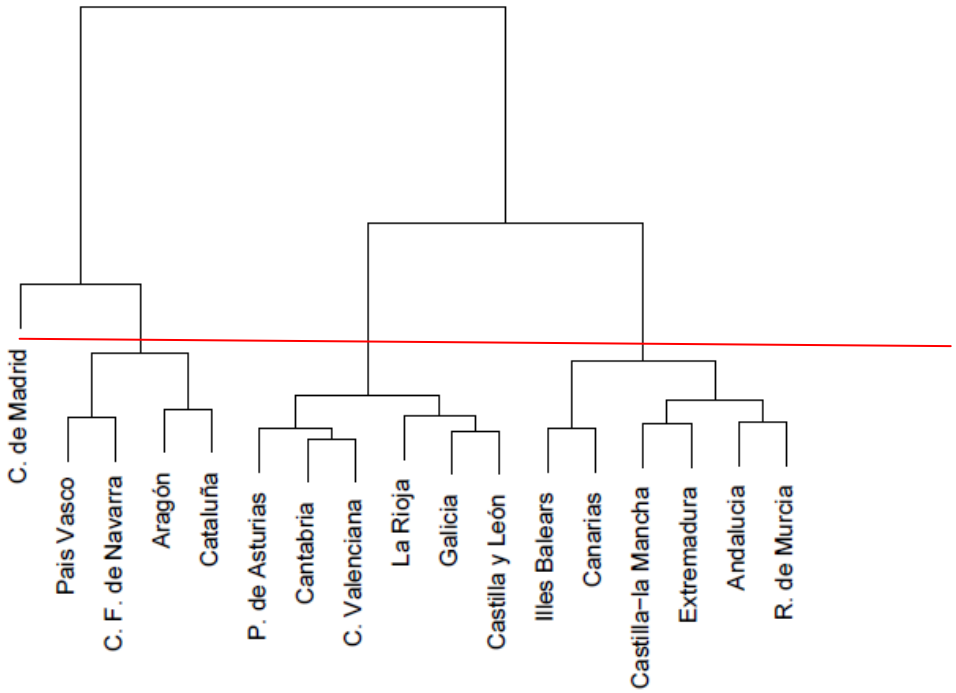
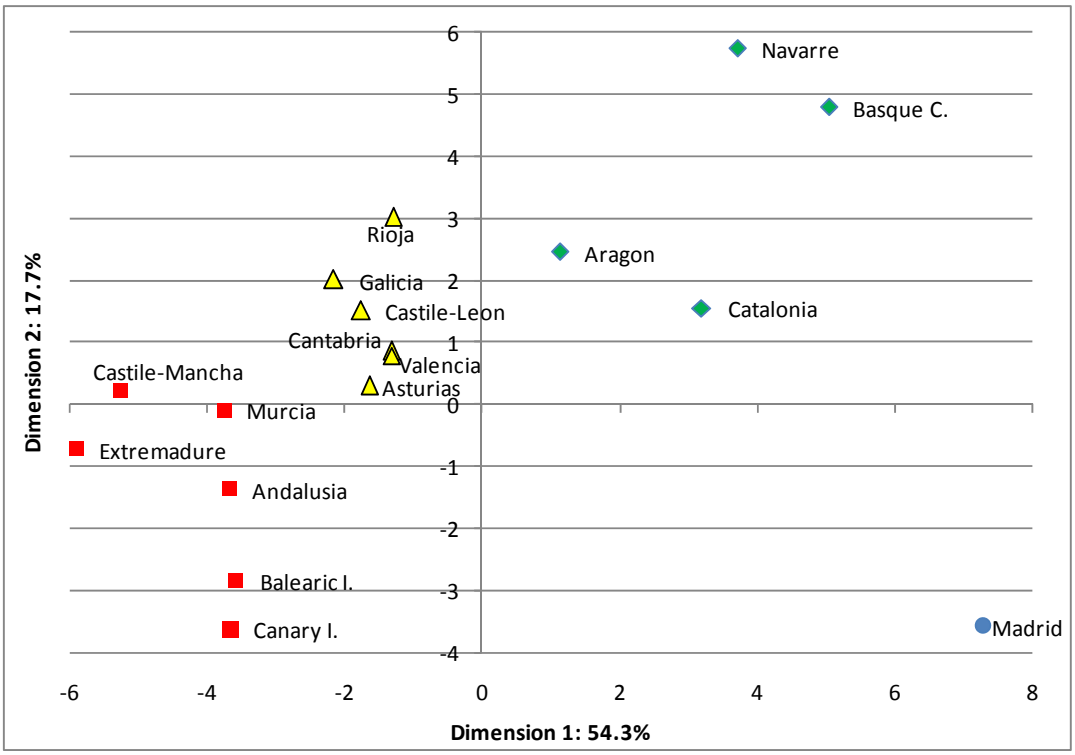


Figure 9: **Location of Spanish regions regarding the two first principal components of the factorial analysis conducted with data taken from Eurostat and Spanish sources**



In comparison with the previous factorial analysis, the percentage of the variance of variables explained by the two main components is a bit lower now (72% versus 77%), which seems reasonable, due to the higher number of variables considered in this new analysis. On the other hand, the weight of the second component increases (from 14.4% to 17.7%), because several of the new variables taken into account (mainly, good exports, cooperation in innovation, and regional Government's financial support to innovative firms) appear positively correlated with specialization in manufacturing industry. On the other hand, as could be expected, percentages of sales of new products, direct investment, firms' size and non R&D innovation expenditure are positively correlated with high level of economic and technological development. Finally, indexes of specialization and related variety do not have high loadings and therefore they do not seem so relevant to explain differences between Spanish regions; and if the related variety index tends to be more linked to high economic and technological development, in the specialization index it is just the opposite.

From the point of view of the cluster dendrogram, there are some changes. As in the previous cluster dendrogram, the number of groups that seems preferable is four. But, some regions move from one group to another: Aragon from G3 to G2; and Galicia from G4 to G3. Also, regions are often put together differently within each main group. Overall the new classification suits better our perception about the characteristics of the Spanish regions and actually shows a quite clear geographical arrangement (see figure 10). By and large, leaving aside the capital region (located in the middle of Spain), the most advanced regions are located in the north (middle and east) of Spain and less developed ones in the south and Islands.

Figure 10: Geographical location of Spanish regions, and their cluster pertaining

(G1) blue: Madrid.
(G2) deep green: Basque Country and Navarre; light green: Catalonia and Aragon.
(G3) deep yellow: Asturias, Cantabria and Valencia; light yellow: Galicia, Castile-Leon and Rioja
(G4) deep red: Murcia, Andalusia, Castile-La Mancha and Extremadura; light red: Balearic and Canary Islands

5. Position of Catalonia in the Spanish typologies and comparison with the other Spanish advanced regions.

The two dendrograms of the Spanish regions (see figures 5 and 8) show a clear cut between more and less technologically and economically developed regions. The group of advanced regions is composed of Madrid, Navarre, Basque Country, Catalonia and Aragon. This last one is a borderline case, and only appears included within the group of advanced regions in figure 8, when the typology is elaborated taken into account also data from national sources such as cooperation of innovative firms with other agents, financial support from regional governments and so on. The regions economically and technologically lagging behind are Valencia, Cantabria Asturias, La Rioja, Galicia, Castile-Leon, Murcia, Andalusia, Balearic Islands, Canary Islands, Castile-La Mancha and Extremadura.

Let us focus on the first group and see the differences between Catalonia and the other advanced regions (see table 5).

Table 5: Average values of indicators for the advanced Spanish regions

		Aragon	Navarre	Basque Country	Madrid	Catalonia
Economic weight	GDP (million €)	30696	16921	61783	176376	187594
	Population (thousands)	1251	585	2108	5880	6860
Economic output	GDP per capita (€)	22262	26271	26592	27220	24814
	GDP per worker (€)	45,8	48,2	53,9	52,3	49,0
Innovation output	Patents (per million habitants)	31,4	67,7	44,1	21,4	48,7
	High tech patents (per million inhabitants)	4,4	1,0	1,0	6,8	3,6
	Sales of new-to-firm and new-to-market products (% of turnover)	21,1	23,84	8,59	15,89	16,05
Business subsystem	Total R&D (% GDP)	0,8	1,7	1,5	1,8	1,4
	Business R&D (% GDP)	0,4	1,1	1,2	1,0	0,9
	Non R&D innovation expenditure	1,34	0,36	0,80	1,59	0,41
	Agriculture (% employment)	7,7	5,1	2,6	0,5	2,7
	Industry (% employment)	33,0	39,0	36,0	22,9	33,4
	High and Medium-High tech manufacture (% employment)	8,8	9,4	9,6	4,1	8,2
	Knowledge intensive serv. (% employment)	8,9	7,8	10,4	17,0	12,3
	Exports specialisation index	0,9	1,0	1,0	1,0	0,6
	Exports related variety index	182,9	184,8	224,1	204,3	254,2
	Firms with 500 or more employees (%)	0,048	0,066	0,059	0,139	0,064
Infrastructure subsystem	High Education R&D (% GDP)	0,19	0,52	0,27	0,31	0,34
	Government R&D (% GDP)	0,15	0,06	0,06	0,46	0,15
	R&D per resarcher (m €)	62,3	86,1	101,5	109,7	103,5
	Financial and business serv. (% employment)	24,4	25,1	30,7	36,7	28,0
Interactions	Innovative firms co-operating with others firms (%)	12,1	16,8	23,2	8,0	7,1
	Innovative firms co-operating with S&T infrastructures (%)	14,8	22,3	28,6	13,4	12,5
Government	Innovative firms funded by regional or local Administrations (%)	19,1	26,6	34,0	6,9	6,7
Socio-economic setting	Population density (natural logarithm)	26,2	56,3	291,4	732,4	213,6
	Employment (% population)	48,6	54,5	49,4	52,0	50,6
	HRST (% employment)	28,9	34,8	38,2	36,6	29,2
	Tertiary education (% 25-64 aged pop.)	53,0	56,8	60,0	60,8	50,8
	ISCED 5_6 students (% total students)	19,5	19,3	20,9	23,5	18,5
	Lifelong learning (%25-64 aged pop.)	11,3	12,1	12,7	12,2	10,0
	Schurmann and Talaat' peripherality index	37,8	41,3	38,3	43,2	37,5
Internationalization	Good exports (% GDP)	19,3	28,1	24,2	8,1	21,5
	Stock of inward and outward FDI (% GDP)	15,9	14,1	34,6	98,4	24,7

Source: Orkestra, REGES database (elaborated based on Eurostat and national sources)

Catalonia compared to Aragon

The economic weight of Catalonia is about six times the one of Aragon. Catalonia overcomes Aragon in R&D, patents and economic output, but is below Aragon in non R&D innovation expenditure and product innovation. As for the production structure, Catalonia shows a higher focus in services (at the expense of agriculture), a more diversified and related industry, and bigger and more internationalized firms. Although firms' cooperation with other firms and S&T infrastructures is quite low in both regions, are much lower in Catalonia than in Aragon. The support of regional and local Administrations to innovative firms is very small in Catalonia, in

comparison with Aragon. Finally, the socio-economic setting is quite similar in both regions, except for population density, where Catalonia prevails over Aragon clearly.

Catalonia compared to Navarre

The difference in weight is even higher between Catalonia and Navarre: the former is more than ten times bigger than the latter. The indicators of innovation input, innovation output and economic output are, by and large, better in Navarre than in Catalonia, being the relevance of the high education R&D one of the most outstanding features of the Navarrese RIS. Compared to Catalonia, the production structure of Navarra is relatively more oriented to the agriculture and industry sectors, is less diversified, and lacks knowledge intensive and advanced services. Due probably to its more pronounced industrial specialization, Navarre shows a higher export ratio and its firms' size is a bit bigger; but from the foreign direct investment (FDI) perspective, Navarre is less internationalized than Catalonia. Navarrese innovative firms cooperate with other firms and S&T infrastructures much more than the Catalonian ones, and receive much more financial support from the regional and local Administrations for innovation activities as well. Finally, as for the social filters (demography, labor-market and education), Navarre displays better outcomes than Catalonia, being the population density the only exception to this trend.

Catalonia compared to the Basque Country

Catalonia is roughly three times bigger than the Basque Country, from an economic point of view. Regarding to economic and technological input and outputs, the position of view of these two regions varies according to the kind of indicator taken into account. First, from the point of private innovation input, the Basque Country performs better than Catalonia, but in public R&D it is just the opposite. The reason is that the Basque Government opted for developing a network of non state owned technological centers (accounted as firms, in R&D statistics), as a means to provide Basque firms with technological inputs, while the Catalonian Government relied more in research institutes linked to the university. Second, as for the innovation output, the Basque Country shows a worse set of indicators than Catalonian. But third, surprisingly, in spite of that, the Basque Country achieves higher scores in indicators of economic output.

Moving into the comparison of the production structure, the Basque Country presents quite similar relative weights to Catalonia in the aggregate economic sectors, though the Basque economy relies a little more on manufacturing and Catalonia on some knowledge intensive services (health and education, and communications above all, since in financial and business services the Basque Country overcomes Catalonia). Despite the Catalonian firm's average size is bigger than the Basque one, the export ratio is higher in the Basque Country, and so is too the Basque firms' direct investment abroad in percentage of GDP. As a result of it, even though Catalonia attracts a higher percentage of inward FDI, the superior rate of outward FDI of the Basque Country allows it to overcome Catalonia in the total (inward and outward) stock of FDI as a percentage of GDP.

One of the main features of the Basque regional innovation system is the superior percentage of firms that cooperate with other agents (S&T infrastructure agents or other firms). The Basque RIS is even more remarkable for the vast financial support that the regional and local Administrations provide Basque firms, thanks to financial resources than the *Economic Agreement* makes available to them and to the more proactive industrial and technology policy that it has borne in mind since the early eighties.

Finally, the socio-economic setting is, by and large, more favorable in the Basque Country than in Catalonia. Despite having a stronger university, the qualification of the population and working force seems to be worse in Catalonia than in the Basque Country.

Catalonia compared to Madrid

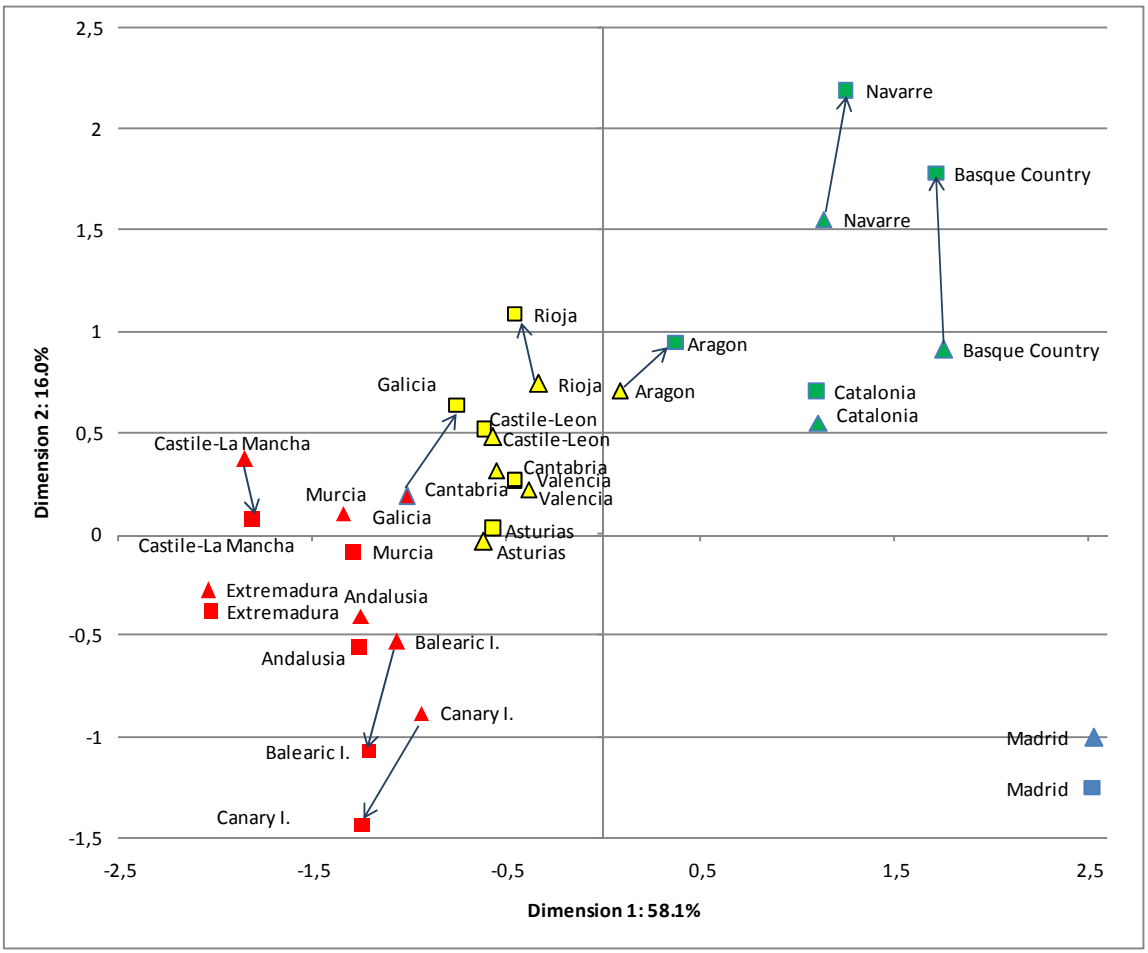
Even though the economic size of Catalonia exceeds lightly the one of Madrid, Catalonia has not been able to exploit the agglomeration economies that might result from that size and in almost all the innovation related indicators Madrid overcomes Catalonia. This is partly explained by the benefits that Madrid receives from being a capital region. Related to this capital region nature, the Government R&D is concentrated in Madrid; the headquarters of many companies are based there too (what, among other things, affects the business R&D and the stock of FDI); a vast demand for financial and business services, human capital and investment in accessibility stems from that concentration of political and business power.

Most of the few items in which Catalonia achieves a better score than Madrid are related to the higher development of the industry sector in Catalonia: patents are usually applied by industrial firms; exports of goods are made mainly by industrial firms; and a large industrial sector tends to be linked to an elevated related variety index in exports. The only item that seems to depend on choices adopted by regional governments in which Catalonia slightly overcomes Madrid is the university R&D. But even in this field, Catalonia is beaten by Navarre, and the low percentage of Catalonian innovative firms cooperating with S&T infrastructures raises some doubts about to the extent that such a strong university is helping the Catalonian RIS to be innovative and competitive.

6. Approach to the consequences of elaborating typologies by working just with regional data available in Eurostat,

As mentioned in section 4, the typology elaborated with only regional data available in Eurostat is a bit different from the typology obtained taken into account, in addition to data from Eurostat, data from some national sources, such as cooperation of innovative firms with other agents of the RIS, relevance of the regional and local Government for the funding of business R&D, firms' size and internationalization, and so on. Both typologies differ not only in the number of preferable groups, but also because some regions are put together differently in one and other typology. Anyway, when we look at the location of the Spanish regions with respect to the two main components of the PCA the differences in the results between the two analyses (only with data from Eurostat, on the one hand; and with data from Eurostat and from other Spanish sources, on the other) are less evident than in the dendrograms. Some apparently strong movements from one group to another in the cluster dendrograms (e.g. Aragon and Galicia) turn out to be relative small shift from borderline regions in the individual factor maps. In fact, the individuals factor map seems more appropriate to understand the similarities of regions than the cluster dendrogram.

Figure 11: Comparison between the regions location regarding the two principal components, in the two factors analyses (with data only from Eurostat, and from Eurostat and other Spanish sources)



Note: The triangle shows the region location according to data coming only from Eurostat; and the square, coming from Eurostat and other Spanish sources

In order to go deeply into the matter of at what extent has really changed the first typology of Spanish regions, elaborated with data taken only from Eurostat, when adding to them new variables related to RIS issues about which Eurostat does not offer information, we carried out a multiple factorial analysis. MFA is used to analyze a set of observations described by several groups of variables. The analysis derives an integrated picture of the observations and of the relationships between the groups of variables (the different principal component analyses).

Figure 11 shows the regions' positions regarding the two main dimensions of this multiple factorial analysis. When the position is signaled by a triangle, it means that only the 21 variables taken from Eurostat are considered; when signaled by a square, that all the 31 variables are considered (those coming from Eurostat and from other sources).

Figure 11 allows us to see that, in general, regions do not move away from their first positions. Besides, regional changes occur mainly in the dimension 2 and are more evident in some regions than in others. Changes are outstanding and upwards in the dimension 2 in the Basque Country and Navarre (regions with strong regional Governments, specialized in manufacturing and advanced technologically), and to a lesser extent in Galicia, La Rioja and Aragon. Changes are evident too, but downwards in the dimension 2, in the Balearic Islands, Canary Islands, and Castile-La Mancha. By and large, the differences among regions in dimension 2 have

increased, because regions with a higher score in this factor go even upwards; and regions with lower score, go downwards.

In addition to this visual depiction, the multiple factorial analysis permit to measure the similarity between the two PCAs by looking at the stability of factors by means of RV and Lg coeficients. This is a more accurate and appropriate way of comparing the structure of the two typologies than the traditional one based on a correspondence analysis of the coordinates obtained by the regions in the two factorial analyses conducted (the one with the 21 variables from Eurostat, and the one with all the 31 variables).

Table 6 shows that the groups of the two typologies have a similar dimensionality (as can be seen by the coefficients of the main diagonal in the L matrix) and an internal structure practically equal (as the coefficients of RV matrix confirm). In short, the typology of Spanish regions does not undergo significant changes for operating with a large number of variables connected to the system nature of a RIS about which Eurostat does not provide information for. That suggests that, when operating with sources that do not allow those aspects to be taken into consideration, the resulting typology would not deviate so much from which would be obtained considering such aspects.

Table 6: Relation coefficients between groups

Lg coefficients

	1	2	AFM
1	1.079		
2	1.096	1.156	
AFM	1.089	1.127	1.110

RV coefficients

	1	2	AFM
1	1.000		
2	0.981	1.000	
AFM	0.995	0.995	1.000

7. Conclusions

Typologies of RIS allow the diversity and variety of regional patterns of innovation to be captured and, therefore, help better understanding and policy-making. To obtain RIS typologies there have been two main approaches: initially, conceptual typologies based on case studies were developed; more recently, some researchers have developed regional typologies of innovation based on statistical analysis (factorial and cluster analysis). The first approach presents the advantage of providing very detailed insights into the innovation processes, but fails to provide comprehensive and quantitative measurement of the economic and innovation performance of all regions. The second approach, working with data coming from secondary sources, can deal with all the regions and shed some light on the relation between knowledge inputs, socio-economic characteristics of the territory and innovation and economic outputs, but the current limitations in regional data availability do not let important aspects of a RIS to be taken into account. Table 2 offers a synthetic review of the existing conceptual typologies and tables 3 and 4 of the typologies for the EU and Spanish regions based on statistical analysis.

This paper has reviewed the main results of a recent innovation typology developed for the EU-25 regions by Navarro et al (2009) and has developed a brand new typology for the Spanish regions. Among the principal findings of the former could be mentioned that, in order to classify regions, in addition to the level of economic and technological development is important the kind of sectoral specialization of the region, except for regions with medium-low level of development. On the other hand, the EU-25 typology work highlighted the relevance of accessibility and being capital regions to be well positioned in the typology of regions. Additionally, despite of decades of national targeted policies and EU structural funds (case of Greece, Portugal, Spain and Italy) or since their embracement of market mechanisms (case of

accession countries), most of the regions of the mentioned countries have not been able to reverse their initial adverse situation, which raises questions about the adequacy of these policies.

As for the Spanish regions typology, the analysis confirmed the existance of two main factors, representing to a great extent the regional economic and technological development and the regional manufacturing or services specialization. According to the new typology, Spanish regions could be classified in four groups: capital region (Madrid), medium-high tech industrial regions (Basque Country, Navarre, Catalonia and Aragon), medium-low tech regions (Asturias, Cantabria, Valencia, La Rioja, Galicia and Castile-Leon) and agricultural or touristic less developed regions (Balearic Islands, Canary Islands, Castile-La Mancha, Andalusia and Murcia). After having left aside the capital region, the analysis also revealed a positive relation between the specialization in manufacturing and the level of economic and technological development; and a clear geographical pattern: the most advanced Spanish regions are located in the north (middle and east) and less developed ones in the south and Islands.

With regard to the typology of UE-regions Catalonia appears allocated, like the Basque Country, to the group G4, which displays a similar economic output and a lower technological input and output than the European average, and not a clear sectoral specialization. But, whereas the Basque Country is quite distant from the centre of this group and one of the aims of the Basque innovation policy should be to migrate towards groups G5 and G7 (in order to move to groups with a more pronounced industrial specialization and more economically and technologically advanced), Catalonia is closer to the center of G4 and it is not clear whether this region should try to move to groups G5 and G7 (like the Basque Country and, even more clearly, Navarre), or, preferably, based on the agglomeration economies and specialization in knowledge intensive services existing in Barcelona, should try to move towards groups 6 (where Madrid is located) and 8, composed of service oriented advanced regions.

From the benchmarking of the Catalonian RIS with the ones of Aragon, Navarre, Basque Country and Madrid it could be deducted that the main strengths of Catalonia rely on the agglomeration economies derived from its size, on the related variety existing in its production structure, on its specialization in knowledge intensive services and on its strong university system. Anyway, it is unclear that those strengths could be considered unique and indisputable: the Catalonian university system should be more linked to the production system, financial and business services need to be strengthened within the knowledge intensive services, Barcelona must increase its attractiveness for firms' headquarters and human talent. On the other hand, among the weaknesses which Catalonian policy makers should try to neutralize or correct are the little involvement of the regional government in the RIS, the low level of cooperation of innovative firms with other agents of the RIS, the insufficient outwards direct investment of Catalonian firms, the qualification of the population and working force and the accessibility of the region.

The higher regional data availability in Spain allows us to analyze the effects of adding to the current available data from Eurostat data about some other variables that, despite being closely connected to the system nature of a RIS, were not available in the European statistical office. Based on additional Spanish regional sources, some aspects more connected with the DUI mode of innovation and learning could have been considered such as:

- sales of new products and innovation expenditure different from R&D, proxies for the innovation output and input respectively

- export specialization and related variety indexes, proxies for agglomeration economies and characterization of the firm subsystem

- firms' size, proxy for the climate of competition or monopoly and characterization of the firm subsystem as well

- firms' cooperation in innovation with other firms and with S&T&i supporting infrastructures, proxies for the RIS internal interactions

- regional and local governments' financial support to innovative firms, proxy for the regional government involvement in the RIS development

- propensity of goods' export and weight of foreign direct investment, proxies for the internationalization and linkages of the region with foreign innovation systems.

In the new typology obtained by adding the aforementioned variables the weight of the second principal component increases, because some of the new variables taken into account (good exports, cooperation in innovation and regional governments' support to innovative firms) appear positively correlated with specialization in manufacturing. Regions that move upwards along the second axis are by and large those that had a high score in that axis in the previous typology (i.e. regions specialized in manufacturing); and regions that move downwards, the opposite. Somehow unexpectedly, specialization and related variety indexes do not appear related to this second principal component (that reflects broadly the orientation towards manufacturing or services) but to the first principal component (that reflects broadly the level of economic and technological development). Anyway, these two indexes do not appear so relevant to explain differences in this factor among Spanish regions, and if the latter is more linked with high economic and technological development, in the former is the opposite, as it positively related to low economic and technological development.

Finally, the paper has shown the utility of multiple factorial analyses to compare different typologies and assess the similarity existing among them. When applied to Spain, the typology of regions do not undergo significant changes for operating with a larger number of variables connected to the system nature of a RIS about which Eurostat does not provide information. It suggests that, when operating with sources that do not allow those aspects to be taken into consideration, the resulting typology would not deviate so much from which would be obtained considering such aspects.

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Table 2: Review of the statistical analysis based typologies for the EU regions

AUTHORS	TYPE OF PUBLICATION	CONSIDERED REGIONS*	DATA SOURCE	YEAR OF DATA	STATISTICAL TECHNIQUE	CONSIDERED VARIABLES	OBTAINED TYPOLOGY
Clarysse and Muldur (2001)	Academic journal**	102 regions from EU-15: NUTS 1 (BE, DE, UK) and NUTS 2 (rest)	Eurostat	1995 (variables of level); 1989-1995 (for variation variables)	Factorial and cluster	5 variables of level and 3 of variation: GDP per capita, agricultural employment, total R&D, patents per capita, unemployment rate, GDP variation, patents variation, unemployment variation	6 groups: industry leaders, clampers-on, slow growers, technological catchers-up, economic catchers-up, lagers behind
Hollanders (2003)	Report	171 regions from EU-15: NUTS 1 (UK, BE) and 2 (the rest)	Eurostat and CIS II innovation survey)	From 1995 to 2000, depending on the variable	Cluster	14 variables of level: 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 GDP per capita	8 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
Hollanders (2006)	Report	206 regions from EU-25: NUTS 1 (BE, UK, POL) and 2 (the rest)	Eurostat	From 2002 to 2004 (or last available), depending on the variable	Cluster (hierarquical)	8 variables of level: 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, ranked according their innovation performance
Brujin and Lagendijk (2005)	Academic journal	206 regions from EU-15: NUTS 2	Eurostat	From 2000 to 2002 (variables of level) and 1995-2000, 1998-2001 and 1999-2002 (for variation variables)	Factorial and cluster	7 variables of level and 7 of variation (for the same variables): 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
Ecotec (2005)	Report	About 150 regions (varying depending the cluster) from EU-15: NUTS 1 (BE, UK) and NUTS 2 (for the rest). Not included DK and IRL	Eurostat and ESPON.	From 1999 to 2002, depending on the variable	Two different methods: (1) Z-score analysis; (2) three cluster analysis: re-scaled data for four individuals, two compound indicators and average of the six indicators	(1) 6 variables of level for the z-score analysis and the third cluster analysis: 3 of R&D capacity: R&D expenditure, R&D staff, HRST core; and 3 of innovation: employment medium and high-tech manufacturing, employment in knowledge-intensive services, population with tertiary education. (2) 4 variables of level for the cluster analysis: business R&D intensity, HRSTC, patents per capita and high-tech employment.	(1) Z-score analysis: 5 types of areas: lack of capacity, average capacity, rich innovation, rich R&D and knowledge centres. (2) First analysis (5 clusters): worst R&D performance, lowest share in high-tech employment; mediocre R&D performance, strong HRSTC base; mediocre R&D performance, average share of high-tech employment; second best R&D performance, average share of high-tech employment; top R&D performers, strong HRSTC base, highest share of hig-tech employment. Second analysis (5 clusters): low R&D capacity, low innovative capacity; medium R&D capacity, low innovative capacity; medium R&D capacity, medium innovative capacity; high R&D capacity, medium innovative capacity; high R&D capacity, high innovative capacity. Third analysis 85 clusters): very high capacity for R&D and innovation; high capacity for R&D and innovation; above average capacity for R&D and innovation; average capacity for R&D and innovation; below average capacity for R&D and
Technopolis et al (2006)	Report	215 regions from EU-25	MERIT, based on Eurostat data	Mostly referring to 2002 or 2003	Factorial and cluster	16 variables: GDP per capita and 15 additional variables reduced into 4 factors: (1) public knowledge (higher education, HRSTC core, high-tech services employment and public R&D expenditure); (2) Urban services (value-added share services, value-added share industry, employment government administration and population density); (3) private technology (high and medium-high-tech manufacturing employment, value-added share agriculture, business R&D expenditure and HRSTO occupation); (4) learning families (population share under 10, life-long learning and activity rate females)	11 types of regions, grouped in 4 strategic goups: (1) Global consolidation regions (Science & service centre and Nordic high-tech learning); (2) Sustaining competitive advantage regions (Learning, Centro techno and High techno); (3) The boosting entrepreneurial knowledge regions (Local science and services, and Aging academia); (4) The entering knowledge economy regions (Southern cohesion, Rural industries, Eastern cohesion, Low-tech government).
Martínez-Pellitero (2007)	Academic journal	146 regions from EU-15: NUTS 1 (BE, D, UK) and 2 (for the rest)	IAIF-IRIS (EU) base made from Eurostat (with estimates of missing values), supplemented by Infostate and Economic Freedom	Average of 1998-2000	Factorial and cluster	28 variables of level, grouped into 6 factors: (1) National environment (Employment, population, BPG, gross added value, compensation of employees, gross fixed capital formation, HRST in services, HRST in knowledge-intensive services, HRST in high-tech); (2) Regional environment (venture capital, economic freedom index, seed and start-up capital, ITC penetration); (3) Innovative companies (business R&D, business R&D headcount personnel, business R&D FTE personnel,patents high-tech per GDP, patents high-tech per capita, patents per GDP, patents per capita); (4) Universities (university R&D headcount personnel, university R&D FTE personnel, university R&D expenditure, postgraduate students); (5) Public administration (Government R&D headcount personnel, Government R&D FTE personnel, Government R&D expenditure); and (6) Demand (GDP per worker, GDP per capita)	10 groups, grouped in turn by the author into three categories: atypical (for highlighting positively in some of the factors), intermediate and least developed
Dory (2008)	Report	189 regions from EU-25: NUTS 1 (BE, D, UK) and 2 (for the rest)	Eurostat	2002	Factorial and cluster	13 variables of level: some on the knowledge creation and absorption capacity (business R&D intensity, volume of R&D, business R&D personnel, educational qualifications, HRST) and some on the economic structure and industrial specialisation (level of regional income, sectoral specialisation, labour market characteristics, degree of aglomeration)	7 region types were identified, 3 of which have 2 subtypes each. Types 1A and 1B were called predominantly agricultural and diversified agro-industrial; type 2, tourism-based; type 3, re-industrialising or industrial catchers-up; type 4A and 4B, newly industrialised and diversified; type 5, restructuring industrial; type 6, high-income industrial leaders; type 7A and 7B, diversified industry-based high-income economies and diversified service-based high-income economies.
Muller et al (2008)	Academic journal**	55 regions from EU-12 (enlargement): NUTS 2	Eurostat; PATDPA own holdings, SCI, eEuropesources by Fraunhofer ISI; and Merit	From 2001 to 2004 (most variables of level) 1998-2001 (two additional variables of level) and 1995-2001 (for variation variables)	Double factorial: (1) with five variables included in knowledge creation; (2) with the factor of knowledge creation and the 20 remaining variables	23 variables of level and 2 variables of variation, arranged in five groups: (1) knowledge creation (R&D expenditures, R&D employees, patents, plublications in Life Sciences, publications in Nanosciences); (2) knowledge absorption (business R&D, university R&D, tertiary education, secondary education, secondary and tertiary education, lifelong learning, IS population; (3) Diffusion of knowledge (technology diffusion infrastructure, empleoyment in high-tech services, employment in manufacturing industries, employment in agriculture, IS enterprises; (4) Demand of knowledge (GDP per capita, cumulated growth of GDP, unemployment rate, population density, change in population density); and (5) Governance capacity (participación to EU initiatives, E-Government and web-presence of regions)	5 groups: capitals, with tertiary growth potential, qualified manufacturing platforms, with industrial challenges, agricultural laggards
Navarro et al. (2009)	Academic journal	188 regions from EU-25: NUTS 1 (BE, D, UK) and 2 (for the rest)	Eurostat and Schurmann Talaat index	2005	Factorial and cluster	21 variables of level: GDP per capita, employment, GDP per worker, population density, peripherality index, agricultural employment, industrial employment, employment in business and financial services, employment in medium-high and high technology manufacturing, employment in high-tech services, youth educational level, tertiary education, life-long learning, HRSTC, total R&D expenditure, Government R&D expenditure, university R&D expenditure, business R&D expenditure R&D expenditure per personal occupied en R&D, patents, high-tech patents.	8 groups: (G1) Peripheral agricultural regions with a strong economic and technological lag; (G2) Restructuring industrial regions with strong weaknesses; (G3) Peripheral regions with an economic and technological lag; (G4) Central regions with a certain economic and technological lag; (G5) Industrially restructured regions with an increasing technological capacity; (G6) Service oriented regions with average economic and technological capacity; (G7) Technologically advanced region with an industrial specialisation; (G8) Innovative capital regions, specialised in high added value

(*) In Denmark, Ireland, Luxemburg, Estonia, Cyprus, Latvia, Lithuania, Malta and Slovenia data correspond to the whole country in all the works. The same in Ireland, except for Hollanders (2003 and 2006) and our typology.

(**) There have been previous versions in the form of reports or working-papers.

Table 3: Review of the statistical analysis based typologies for the Spanish regions

AUTHORS	DATASOURCE	YEAR OF DATA	STATISTICAL TECHNIQUE	CONSIDERED VARIABLES	OBTAINED TYPOLOGY
Coronado and Acosta (1999)	INE and OEPM	1989-1995 (average)	No	7 variables: Spanish patents, total R&D expenditure, total R&D personel, total researchers, business R&D expenditure, business R&D personel and business R&D researchers	3 groups: technologically outstanding region (Madrid), technologically over average regions (Catalonia, Basque Country, Navarre and C. of Valencia) and technologically peripheral regions (all the others)
Martinez-Pellitero (2002), Buesa et al (2002a), Buesa et al (2002b)	IAIF database (created based on data from INE, EPO, CINDOC, CDTI, FEDIT, Departamento de aduanas e impuestos especiales, webcapitalriesgo.com)	1996-98 (average)	Factorial and cluster analysis	33 variables grouped into 4 factors: (F1) 7 variables related to regional environment (VA* and employment* in manufacturing of high and medium technology, VA* and employment* in manufacturing of low technology, Exports* in high and medium-high tech, Exports* in medium-low tech and Exports* in low-tech, CDTI's R&D projects*, GDP*, number* and percentage of patent in Spain, number and percentage of patents* in Europe); (F2) 8 variables related to Administration (Government R&D expenditure, personnel and researcher, stock of scientific capital *, stock of scientific capital per habitant, stock of technological capital*, investment in venture capital* and venture capital in % of total; (F3) 8 variables related to Universities (university R&D expenditure, personnel and researchers, students enrolled in tertiary education, students finishing tertiary education, students enrolled in doctoral programs, students reading the thesis, university's quality index); (F4) 7 variables related to firms (business R&D expenditure, personnel and researchers, stock of business technological capital*, HRCT, number and turnover of technological centers*)	5 groups, from which four has only one region: Madrid, Catalunia, Basque Country, Navarre and the rest

Buesa et al (2007), Buesa and Heijs (2007).	IAIF database (created with data from INE, EPO, CINDOC, CDTI, FEDIT, Departamento de aduanas e impuestos especiales, webcapitalriesgo.com)	1994-2004 (every year)	Factorial and cluster analysis	23 variables, grouped into 5 factors: (F1) 6 variables related to regional environment (employment* in low tech industry, employment* in high and medium-high technology and exports*, CDTI's R&D projects*, venture capital* and GDP*); (F2) 5 variables related to innovative firms (R&D expenditure, personnel and researchers, innovation expenditure and stock of business R&D); (F3) 4 variables related to Government (R&D expenditure, personnel and researcher, and stock of scientific capital); (F4) 6 variables related to university (R&D expenditure, personnel and researchers, students enrolled in tertiary education, students enrolled in doctoral programs and university's research quality); (F5) 2 variables related to supporting institutions (number* and turnover* of technological centers)	5 groups, from which four has only one region: Madrid, Catalunia, Basque Country, Navarre and the rest
Navarro and Gibaja (2009)	REGES database (created with data from INE, Eurostat, OECD, OPE, D.G. Aduanas, Minstry of Industry, SABI-Informa, Fedit, APTE, ASCRI, Madri+d, Schurmann and Talaat	2006	Factorial and cluster analysis	133 variables, grouped into 29 factors, responding to 8 areas: (A1) 2 factors of economic output (economic output and profitability); (A2) 2 factors of S&T&i output (S&T output and innovation output); (A3) 6 factors of the business subsystem (business R&D, innovation expenditure, structure of services and agriculture, manufacturing structure, industry's technological level and size and firms' group); (A4) 5 factors of the supporting subsystem (university R&D, government R&D, technological centres and parks, venture capital and business services, and ICT); (A5) 8 factors of the socio-economic setting (demography, educational attainment, labour market, road and railroad infrastructure, air transport infrastructure, seaport infrastructure, accessibility, region' size); (A6) 3 factors of Government (regional and local Administration support, central and European Administration support and public funding of R&D); (A7) 1 factor of firm cooperation; (A8) 2 factor of internationalization (trade internationalization and productive internationalization)	5 groups (G1) Agricultural lagers behind (Extremadura, Castile-La Mancha); (G2) Peripheral, touristic without manufacturing and a technological lag (Canary Islands, Balearic Islands and Andalusia); (G3) Intermediate regions with certain economic and technological lag (Murcia, Valencia, Galicia, Asturias, Cantabria, Castile-Leon, La Rioja, Aragon); (G4) Economically and technologically developed industrial regions (Basque Country and Navarre); (G5) Developed regions with high urbanization (Madrid and Catalonia)

(*) The asterisk means that the variable has been taken in absolute terms.