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The Regional distribution of Knowledge-Intensive Services in Europe: a spatial approach

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Abstract

There is a rich debate in the innovation literature about to what extent innovation has become an international (or globalised) phenomenon, or, on the contrary, it maintains its local/regional character. As Koschatzky (2001) notes, given the fact that knowledge is commonly tied to personal capabilities; it has a clear geographical component. In the case of knowledge-intensive services (KIS) most of analyses come to the same conclusion: distance is particularly relevant when knowledge (mainly of a tacit type) is diffused. Starting from this premise, a burgeoning literature on the contribution of knowledge-intensive business services (KIBS) to regional innovation has emerged. Most of these papers adopt a national perspective, that is, analyse regions in a specific country. On the contrary, comparisons of regional features have been carried out in very few papers: Germany and the UK (Simmie and Strambach, 2006) or Germany and France (Muller and Zenker, 2001) are two examples. The objective of this paper is to take a step further and examine the distribution of knowledge-intensive services (KIS) in the European regions. For so doing we employ the data provided by the Regional Innovation Scoreboard (RIS) 2009. This database provides information on the innovation performance across 194 regions of the European Union and Norway. The methodology employed is known as spatial analysis and evaluates whether there are clusters in the location of KIS in the European regions, which involves three processes. First, to evaluate the existence of spatial autocorrelation by means of global statistics; the Moran's I and the Geary's C. Once verified the existence of positive spatial autocorrelation, it is possible to identify "clusters" of regions with high and low participations of KIS by using a local indicator of spatial autocorrelation (LISA). Finally, employing an econometric model, some potential explanatory factors for the concentration of KIS are examined.

The results obtained support the hypothesis that KIS are spatially concentrated and confirm that spatial clusters are different in northern/central and southern/eastern regions. Moreover, a close relationship between location of KIS and regional innovation performance is found.

Keywords: KIS, regions, innovation.

J.E.L. Classification: L80, O30, R12.

1. Introduction.

Nowadays, it is widely accepted that geography and space play a key role in regional economics. Nevertheless, mainstream economics and economic geography followed different paths until recent dates. It was in the eighties when Krugman, with his novel integration of the new international trade theory and the economic geography, gave place to the ascending participation of geography in economic literature. The most visible consequence of this combination has been the development of new theories, many of them related to innovation. In this paper we centre on those theories which relate regions and innovation.

Concerning the study of innovation, until recent dates, the service sector has been excluded from most of innovation analyses. Services were regarded as mere users of new technologies developed by the manufacturing sector and classified as “supplier-dominated industries” since Pavitt (1984) included them within this category in his widely-known taxonomy. The differences between manufacturing and services, both in terms of efforts (for example, most of innovation expenditures are not dedicated to R&D but to other activities such as training or the acquisition of new technologies) and in terms of results (patents, the most common indicator of innovation results, are scarcely used by services that prefer other methods like secrecy or copyright) contributed to reinforcing the belief that services do not innovate. Nevertheless, it is obvious that a high degree of heterogeneity exists among service industries. A group of highly innovative service industries can be distinguished: those called knowledge-intensive services (Table 1). These services are as innovative as high tech manufacturing industries and share many of their characteristics in what innovation performance refers (Licht et al., 1997).

Table 1. Eurostat classification of Knowledge-intensive services.

Knowledge-intensive services (KIS)	61 Water transport 62 Air transport 64 Post and telecommunications 65 to 67 Financial intermediation 70 to 74 Real estate, renting and business activities 80 Education 85 Health and social work 92 Recreational, cultural and sporting activities
Market KIS	61 Water transport 62 Air transport 64 Post and telecommunications 65 to 67 Financial intermediation 70 to 74 Real estate, renting and business activities
High-tech KIS	64 Post and telecommunications 72 Computer and related activities 73 Research and development

Source: Eurostat.

The objective of this paper is to take a first step in the integration of the lines of analysis mentioned above by carrying out a spatial analysis of KIS in 194 European regions. In particular, starting from the results obtained by the KISSIN network (Knowledge-Intensive Services and Innovation) during the years 1995 and 1996, we try to evaluate two main hypotheses: firstly, that the share of KIS is higher in more innovative regions, and, secondly, that there is spatial dependence in the regional distribution of these activities, and more concretely positive spatial autocorrelation.

The structure of the paper is as follows. In the second section we briefly review the evolution of those theories that relate innovation and space, from the traditional location theories to the most recent ones like the learning regions. This latter will be our starting point when describing in the third section the functions that KIS can carry out in

fostering regional innovation. In this section we also comment on the results obtained by previous empirical studies about the impact of KIBS on regional innovation performance. The fourth section is devoted to the empirical analysis: we carry out a descriptive analysis of the spatial distribution of KIS in the European regions and a correlation analysis between the share of KIS and several innovation indicators. We also calculate two statistics in order to evaluate the presence of global spatial autocorrelation: the Moran-I and the Geary-C and examine the existence of local clusters. Later, we analyse the relationship between the concentration of KIS and some innovation indicators by means of a spatial econometric model. Finally, in the last section we summarise the main conclusions reached.

2. Economics, geography and innovation: a brief review of the existing literature.

Concepts like cluster or agglomeration are widely used not only in geography and economics but also in politics. Almost in any field we can speak of the existence of clusters or agglomeration economies. Nevertheless, we must take into account that the terms “cluster” or “agglomeration” can have very different connotations (in fact they are used in a wide range of disciplines without a commonly agreed definition). The objective of this section is to carry out a brief review of the origins and the evolution of the theories on geographical concentration and regional clustering, from traditional location theories to the most recent ones, among which we find theories that link innovation and regional clusters.

The origins of the interest on the location on productive activities is found in Von Thünen’s (1826) pioneering work on the location of food producers around markets: because of the trade-off between the profit obtained and the distance-related costs food producers located around the markets in order to maximise profits. In the XXth century the first works on location appeared, retaking the arguments concerning the importance of proximity to markets and customers or stressing the role played by transport costs (Alonso, 1964; Hoover and Vernon, 1959; Isard, 1949; Lösch, 1954; Weber, 1928). Marshall (1890, 1919) was the one who elaborated the pillars of the main theories on the concentration of innovation (Becattini, 2002) like the industrial districts (Becattini, 1979), the cluster approach of Porter (1990) or the new economic geography of Krugman (1991a). The central idea of Marshall, more complex than traditional location theories, was based on the emergence of benefits coming, not from the proximity to consumers or markets, but from the co-location of firms. Starting from Marshall’s work, Krugman described the existence of three types of externalities (Krugman, 1991a):

- *Economies of specialisation*: the presence of a high number of firms is reflected in the outsourcing of complementary activities and into closer cooperation. Firms obtain benefits by sharing resources and competences. These benefits are particular noticeable when they share innovation costs.
- *Economies of labour pooling*: the availability of a high qualified labour force not only attracts more specialised labour and more firms but also generates two main types of advantages:
 - A high concentration of firms allows a higher mobility of labour depending on demand fluctuations. More concretely, the concentration of a great number of employers reduces the risk of unemployment which translates into lower wages (workers will accept lower wages due to the higher stability in their income).
 - Moreover, employees are more likely to invest time in training because many potential employers will value their efforts.

- *Technological externalities or knowledge spillovers*: the concentration of firms facilitates the emergence of knowledge spillovers, because knowledge flows more easily locally than over long distances, especially tacit knowledge.

Most of theoretical works centre on this latter type of externality. Following a chronological order we can differentiate several approaches. Firstly, we find the Italian and French theories on the industrial districts and the milieu innovateur, respectively. Secondly, in the nineties, the works by Porter and the New Economic Geography appeared. Finally, we can mention new contributions known as the new industrial spaces theories.

In the case of the industrial districts theory, it appeared in the end of the seventies, when the success of some Italian cities and regions captured the attention of scholars like Becattini (1979). The industrial district is defined as a cluster or agglomeration of firms with a peculiar relationship and interaction among them. More concretely, following Brusco (1990) this relationship is the result of a balance between cooperation and competition: whereas competition takes place among firms that produce the same product or develop the same activity, cooperation, on the contrary, occurs among firms in different stages of the vertical product chain. These interactions are part of what is called “common cultural background” (Becattini, 1979, 1990), that is to say, not only interactions among firms are important, but also the existence of adequate institutional and market conditions. In this sense, the institutional environment, in combination with “informal” relationships, are key elements for firms’ success. Taking a similar perspective, the French group GREMI elaborated in the eighties the milieu innovateur approach (Aydalot, 1986; Camagni, 1991; Ratti, 1992). This theory also highlights the relevance of the relationships among firms and especially between firms and their environment. The firm is analysed not as an isolated unit but as part of a milieu with a common innovative capacity.

In late eighties, the Porter’s cluster approach emerges. After the publication of several studies on the national competitiveness of various industrialised countries, Porter published his famous book “The Comparative Advantage of Nations” in 1990. Although in this book he used the concept cluster, the geographical dimension will be introduced in 1998 in “On Competition”. In this book he affirms that competitive advantages are closely related to geography and more concretely to the institutions and the knowledge spillovers described by Marshall.

As has been mentioned, Krugman will be the main architect of the New Economic Geography approach during the nineties¹ (Krugman, 1991a, 1991b, 1998a, 1998b, 2000; Fujita et al., 1999). This theory was the result of the combination of the new international trade theory, developed in the eighties, whose main novelty was the incorporation of aspects like increasing returns or imperfect competition, and the traditional economic geography. Its main objective was to model agglomeration by simultaneously combining centripetal and centrifugal forces. That is, building on the core-periphery model, it explained how the interaction between increasing returns and transportation costs could lead to a particular geographical production structure². Currently, one of the main lines of analysis is the concentration of specific industries

¹ An exceptional dialogue about the past, present and future of economic geography can be found in Fujita and Krugman (2004).

² In the introduction of their book *The Spatial Economy* (1999), Fujita, Krugman and Venables identify what they called the three basic modelling tricks of economic geography: “Dixit-Stiglitz, icebergs, evolution and the computer”. The Dixit-Stiglitz term refers to their model of monopolistic competition, Samuelson’s “iceberg” form implies that a fraction of a good shipped simply melts away or evaporates in transit, and finally, the computer highlights willingness to turn where necessary to computer-assisted thinking.

not included in the core-periphery model (Krugman and Venables, 1995; Venables, 1996). It is important to note that, in difference with Porter, Krugman (1991a) affirmed that although knowledge spillovers can be important in some activities, like high-technology industries, they are not a key factor for explaining agglomeration.

More recent works, known as the “new industrial spaces” (Storper, 1995; Storper and Scott, 1988, 2003) combine, in accordance with Moulaert and Sekia (2003), ideas from different theories: the industrial districts (Becattini, 1979), the flexible production systems (Piore and Sabel, 1984), the social regulation (Boyer, 1990) or the transaction costs (Williamson, 1975, 1985). The central point is that the interactions among firms, along with political, economic and cultural practices, are integrated within the social and institutional environment and determine the success (or failure) of regions.

We can affirm, therefore, that the integration of economic geography in “mainstream economics” is quite recent, especially in the innovation domain. Nowadays we can distinguish three main approaches in regional innovation: the geography of innovation, the regional innovation systems and the learning regions.

The geography of innovation embraces a group of works aimed at measuring knowledge spillovers starting from the knowledge production function introduced by Griliches (1979). For so doing, patent and R&D data are used (Acs and Audretsch, 1988; Audretsch, 1998; Audretsch and Feldman, 1996; Feldman, 1993, 1994, 1999, 2000; Feldman and Florida, 1994). The regional innovation systems and the learning regions are very similar to Porter’s approach. The regional innovation system concept³ is considered heir to the innovation systems literature (Cooke, 1992; 2001; Cooke and Morgan, 1998; Cooke et al., 1997; Cooke et al., 2003). Recently, the emphasis has been placed on learning processes and regional institutional dynamics, giving birth to the learning regions literature. Accordingly to these works, knowledge is the most relevant resource and learning is the most important process in a region (Asheim, 1996; Florida, 1996; Lundvall and Maskell, 2000; Simmie, 1997). The starting hypothesis is that tacit knowledge is the base for innovation. Given the fact that this type of knowledge cannot be transmitted over long distances because it requires face to face contact among individuals with certain common features (use of the same language, common conduct codes and behaviour rules, etc.), the regional domain acquires a key role. Following Maskell and Malmberg (1999, p. 181): “it is region’s distinct institutional endowment that embeds knowledge and allows for knowledge creation which-through interaction with the available physical and human resources- constitute its capabilities and enhances or abates the competitiveness of firms in the region. The path-dependence nature of such localised capabilities makes them difficult to imitate and they thereby establish the basis of sustainable competitive advantage.”

3. The role of KIS in regional innovation: some insights.

As was pointed out in the introduction, services have traditionally been ignored in innovation studies, given their assumed “non-innovative nature”. The absence of adequate statistics, unable to report the major part of services expenditures on innovation (that is, training and acquisition of new technologies and knowledge), in addition to the scarce use of patents, have caused services to be characterised as a sector with low innovation efforts and few innovation results. It was not until the second half of the nineties that the first in-depth studies on the potential innovative role of services

³ For an exhaustive review of regional innovation systems literature, see Asheim and Gertler (2003).

appeared. These studies pointed out the important impact of services in innovation not only at the country or firm level, but especially at the regional level.

Why to choose the regional level? If we accept the arguments exposed in recent theories on regional innovation (regional innovation systems and learning regions), knowledge, and in particular tacit knowledge, flows adequately at short distances. Moreover, user-provider interactions in services are carried at the local level (Wood, 2002). This supports the choice of the region as the main scenario for the analysis of the impact of services on innovation. In this sense Strambach, in her pioneering paper on the role of services on regional innovation performance (Strambach, 1998), employs the learning regions theory to describe the two major types of effects (direct and indirect) that KIS carry out in innovation. The direct effects refer to the development of own innovations (product, process or organisational). Nevertheless, the effects specific to KIS are the indirect ones, which are divided into four types:

- *Knowledge transfer.* KIS diffuse knowledge in the form of expert technological knowledge and management know-how. As a result of the increase in the amount of information and knowledge and the vertical disintegration in firms, KIS are closely linked, not only to knowledge diffusion, but more generally to the modernisation and rationalisation of production, management and sale methods.
- *Integration of different stocks of knowledge and competences.* The problems associated with innovation processes require in many occasions the combination of knowledge of different functional areas. This explains why formal and informal networks and cooperation play a key role in KIS performance: because they are able to integrate very different types of specialised knowledge.
- *Adaptation of existing knowledge to the specific needs of their clients.* KIS maintain long-term relationships with their clients which allow them to acquire both tacit and explicit knowledge about their client firms. This knowledge is used to adapt solutions for innovating problems to the specific structure and culture of client firms.
- *Production of new knowledge.* During the development of their activity KIS collect, reorganise and create new knowledge, especially of a tacit type.

Taking arguments from evolutionary and institutional theories, Simmie and Strambach (2006) justify how KIBS are at the heart of interactive learning processes. In particular, they point out that concentration of KIS in metropolitan regions offers important advantages in terms of knowledge diffusion and the generation of knowledge spillovers. Nevertheless, in spite of the considerable importance of these functions, there are very few empirical studies about the role of KIS in regional innovation performance. We can highlight, because of its pioneering nature, the one developed by the KISINN network (Knowledge-Intensive Services and Innovation) during the years 1995 and 1996. Research centres from nine European countries participated in this project: Belgium, France, Germany, Greece, Italy, the Netherlands, Spain, Portugal and the United Kingdom. Its conclusions, although tentative because of the scarce availability of statistics, emphasised the increasing relevance of KIS at the regional level as facilitators, carriers and sources of innovation, as well as the growing demand for these services (Wood, 2001). The existence of a certain “north-south” location pattern was also stressed: whereas in northern countries the distribution of KIS was strong, varied and flexible, in southern countries there was a high concentration of these services, as a result of the dominant influence of multinational investors, transnational companies and the government. This supports the existence of a potential relationship between poor innovation regional performance and scarce presence of KIS, which would call for the

action of the public sector. In this sense Cooke (2001) takes a step further and highlight the need for public policies aimed at solving this “gap” or “market failure” in the provision of KIS in order to contribute to the maturation of the regional innovation system.

Along with the work carried out by this network, we can cite some empirical studies on the role of those KIS provided to business (KIBS) in regional innovation. These can be classified into three groups, depending of their main interest.

In the first group we find those works aimed at relating regional innovation performance and use of KIBS. This is the case of the works by Makun and MacPherson (1997) for electrical equipment industry in the three main regions of New York, Muller and Zenker (2001) for five regions in France and Germany or Aslesen and Isaksen for Oslo (2007). The paper by Makun and MacPherson (1997) shows how innovation rates are significantly higher in those regions with a high supply of advanced production services. They affirm that despite technological advances like the Internet help to cut off deficiencies in peripheral regions, in most of the cases interregional trade of advanced services is impossible to develop because of the need for face to face contact to adequately transmit knowledge. In this line, Muller and Zenker (2001) conclude that knowledge intensive services are not only innovators but also contribute to innovation in other firms. In particular, those SMSEs that use KIS tend to spend more on R&D and have closer relationships with universities and research centres. In other words, KIS create a “virtuous circle” in which they learn from their clients, codify this knowledge and act as bridges between the generic knowledge and the specific needs of the firms. The analysis of the sectors of software and consultancy in Oslo carried out by Aslesen and Isaksen (2007) reveals that they act as a “motor of competence” and stimulate innovation.

A second group of works centre on the analysis of the cooperation patterns of KIBS firms, underlying the importance of location. Examples are the papers by Koschatzky (1999) for thirteen German regions, Drejer and Vinding (2005) for five Danish urban areas, and Doloreux and Mattson (2008) for the Ottawa region. Koschatzky (1999), after applying probit models to data from a German regional innovation survey, concluded that horizontal networks of service firms located in central regions are characterised by interregional cooperation, which could help to improve interregional innovation. Drejer and Vinding (2005) defend the hypothesis that geographical proximity influences on collaboration. By controlling for size, industrial affiliation and collaboration patterns, they found that those firms located in great urban areas have almost the double probability of collaborating with KIBS firms than those firms located in peripheral areas. As for the Ottawa region, Doloreux and Mattson (2008) point out the need for local proximity given the greater propensity to collaborate with local partners shown by KIBS.

Finally, Koch and Stahlecker (2006) and Andersson and Hellerstedt (2009) adopt a different perspective: instead of analysing how KIBS affect regional innovation they study how regional characteristics affect the foundation of KIBS firms. In their study of Bremen, Munich and Stuttgart, Koch and Stahlecker (2006) find that in early stages, geographical proximity to suppliers and clients play a key role in KIBS development. Andersson and Hellerstedt (2009), using data from Swedish municipalities, show that the qualification of the workforce and the size of the regional market have a positive influence on the development of KIBS firms.

4. KIS and regional innovation performance: a spatial approach.

In the latter section we have shown how there are strong theoretical arguments that support a positive contribution of KIS to regional innovation performance. Nevertheless, what seems to be “clear” from a theoretical viewpoint is more difficult to empirically evaluate because of the absence of statistics with an adequate level of detail. As an example we can mention the wide definition of knowledge intensive services employed by Eurostat (Table 1), which comprises the NACE codes 61, 62, 64-67, 70-74, 80, 85, 92, that is, water transport; air transport; post and telecommunications; financial intermediation; real estate, renting and business activities; education; health and social work and recreational, cultural and sporting activities. We prefer to adopt a narrower definition of KIS in our analysis and take those services called by Eurostat “market KIS”, which excludes traditionally publicly-provided services, namely, education; health and social work and recreational, cultural and sporting activities.

We analyse 194 European regions: 3 from Austria, 3 from Belgium, 2 from Bulgaria, 8 from Czech Republic, 4 from Finland, 8 from France, 38 from Germany, 5 from Greece, 7 from Hungary, 2 from Ireland, 18 from Italy, 12 from the Netherlands, 7 from Norway, 16 from Poland, 5 from Portugal, 8 from Romania, 4 from Slovakia, 16 from Spain, 8 from Sweden and 12 from the United Kingdom. Cyprus, Denmark, Estonia, Latvia, Lithuania, Luxembourg, Malta and Slovenia are included as individual regions (see Annex I for a detailed classification of the regions).

The main variable employed is the participation of KIS in regional workforce in manufacturing and services in 2006. The results of the studies carried out to date highlight the existence of substantial differences in the spatial location patterns of KIS, which are more concentrated in those regions or areas with better innovation performance. As was mentioned, this can be explained by the fact that they do not only generate innovations (direct effects) but also have a positive effect on the innovation processes of their client industries, by facilitating the absorption and diffusion of knowledge (indirect effects). Starting from the conclusions of these studies, we put forward three questions:

Q1: Is there a positive link between the location of KIS and the regional innovation performance?

Q2: Can the differences in the concentration of KIS be explained by spatial dependence?

Q3: Are there spatial clusters of high-tech KIS?, and, if so, how important are innovation indicators for explaining the concentration of KIS?

To answer the first question we carry out a descriptive analysis of the regional distribution of KIS and of the some other indicators included in the Regional Innovation Scoreboard 2009. Global spatial analysis is used to evaluate the existence of location patterns in KIS. Local exploratory analysis goes deeper in the characterisation of spatial concentration and aims at identifying clusters of regions. Finally, a spatial econometric model is estimated in order to evaluate the relationship between the regional innovation efforts and the concentration of KIS.

4.1. Descriptive analysis.

As was mentioned, our indicator of the presence of KIS is their participation regional workforce. This is one of the indicators employed included in the last edition of the Regional Innovation Scoreboard (RIS 2009). In addition to this one, six other innovation indicators are examined: tertiary education, participation in life-long

learning, public R&D expenditures, business R&D expenditures, employment in medium-high and high-tech manufacturing and EPO patents per million population⁴.

To try to answer our first question, in Table 2 we report the regions with a participation of KIS in workforce higher than 75%, as well as their ranking in terms of the other innovation indicators mentioned below. The first fact to point out is the existence of a high correspondence between the presence of KIS and regional innovation indicators, especially in terms of “human capital” variables. Thus, nine out of the fifteen highest ranking regions in terms of KIS are at the same time regions with the highest levels of human capital.

Table 2. Leading regions in KIS and innovation indicators, 2006.

Region	Country	TEDU	LEAR	PUBRD	BURD	PAT	HTMAF
Stockholm	Sweden	10	24	20	7	13	153
London	United Kingdom	4	1	45	136	95	179
Île de France	France	6	89	24	18	18	115
Darmstadt	Germany	51	75	116	12	10	35
Bruxelles-Capitale	Belgium	1	58	70	91	57	168
Luxembourg	Luxembourg	85	80	145	37	21	187
Oslo og Akershus	Norway	2	17	25	51	24	177
Hamburg	Germany	60	60	49	45	29	89
Berlin	Germany	9	55	1	21	38	73
Noord-Holland	Netherlands	12	25	53	86	59	184
Praha	Czech Republic	74	65	15	50	124	135
Utrecht	Netherlands	5	33	13	95	47	183
Madrid	Spain	11	52	46	49	113	155
Oberbayern	Germany	37	84	23	4	3	13
South East	United Kingdom	26	3	12	25	49	88

TEDU: Population with tertiary education; LEAR: Participation in life-long learning, PUBRD: Public R&D expenditures; BURD: Business R&D expenditures; PAT: Patents applied; HTMAF: Employment in medium and high-tech Manufacturing; Source: Own elaboration from RIS 2009 database.

A close relationship is also observed between the location of KIS and business R&D. To go deeper into this relationship, in Table 3 the correlation matrix for the six innovation indicators and KIS is shown.

Table 3. Correlation matrix for KIS and innovation indicators, 2006.

	TEDU	LEAR	PUBRD	BURD	PAT	HTMAF	KIS
TEDU	1	0.63	0.53	0.43	0.38	-0.18	0.62
LEAR		1	0.48	0.53	0.49	-0.04	0.61
PUBRD			1	0.48	0.38	-0.04	0.58
BURD				1	0.81	0.44	0.56
PAT					1	0.43	0.60
HTMAF						1	-0.02
KIS							1

TEDU: Population with tertiary education; LEAR: Participation in life-long learning, PUBRD: Public R&D expenditures; BURD: Business R&D expenditures; PAT: Patents applied; HTMAF: Employment in medium and high-tech Manufacturing; KIS: Employment in knowledge-intensive services Source: Own elaboration from RIS 2009 database.

⁴ See Annex II for a brief description of the innovation indicators included in the RIS 2009.

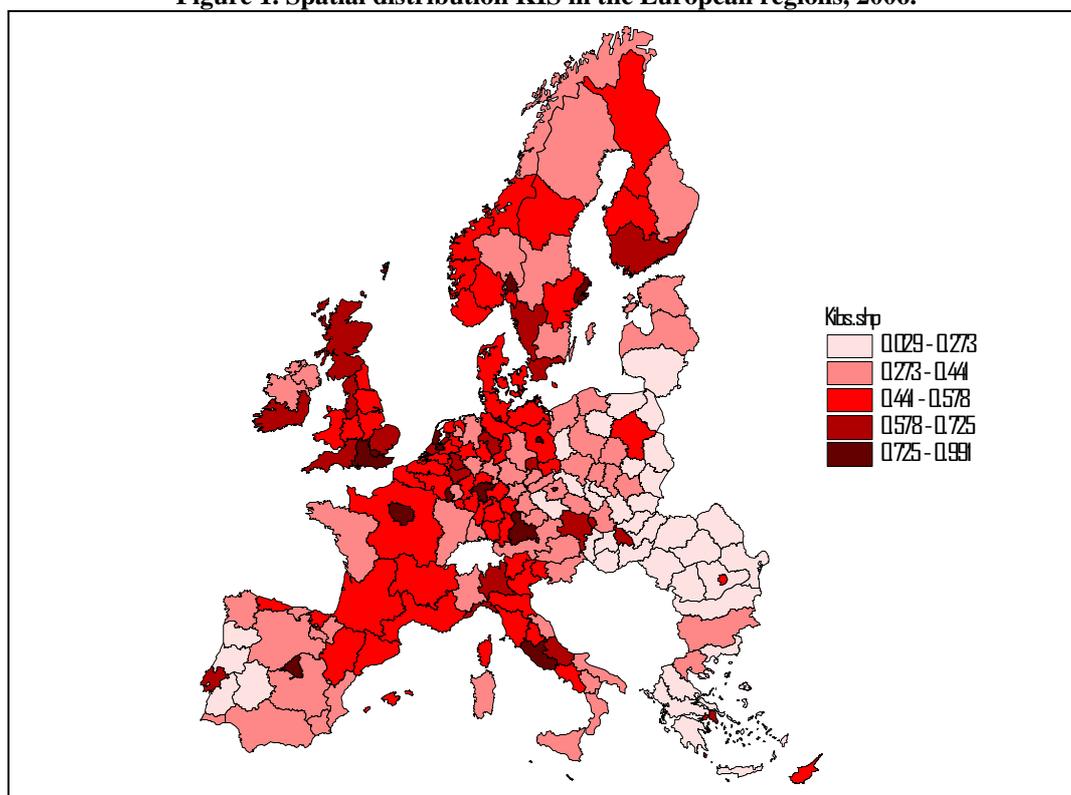
As can be observed, KIS are strongly correlated with rest of innovation indicators: it is the second in terms of correlation with all variables excepting the share of medium and high-tech manufacturing (where no clear relationship is appreciated) and public expenditures on R&D. In this latter case, the presence of KIS is the variable that shows the highest correlation with public R&D. Concerning patents, which is the most commonly used indicator for measuring innovation output, the share of KIS is, after business expenditures on R&D, the variable with a higher correlation. This supports the idea that the location of high-tech KIS contributes to improving regional innovation performance and fosters innovation efforts of firms, or, taking a different perspective, that the regional innovation performance of regions conditions the location of KIS. Therefore, innovation and KIS seems to be closely intertwined at the regional level. But, how homogeneous is the participation of KIS in the different European regions?

4.2. Global spatial analysis.

Our objective in this subsection is to analyse the spatial distribution of KIS using global exploratory spatial analysis. As Koschatzky (1999, p. 739) notes, evolutionary economics highlights the importance of spatial aspects in innovation: “since the propensity for knowledge spillovers and for finding network partners is higher in central, metropolitan regions, innovative firms are not equally distributed geographically, but expected to be located mostly in urban regions”.

In Figure 1, we show a map of the spatial distribution of KIS in our 194 European regions under analysis. The groups of regions are constructed using natural breaks⁵.

Figure 1. Spatial distribution KIS in the European regions, 2006.



Source: Own elaboration.

⁵ To construct the natural breaks the Jenk optimization method is employed. The Jenks optimisation method is also known as the goodness of variance fit (GVF). It is used to minimise the squared deviations of the class means. Optimisation is achieved when the quantity GVF is maximised.

As can be noticed, if we classify the 194 regions into natural breaks, significant disparities appear among regions. In particular we can detect a pattern which could be labelled as “north/western” versus “south/eastern”: a great number of the regions with high participations are located in northern and central European countries whereas the regions with lowest participations are mainly located in eastern countries, and, to a lesser extent, in southern countries. Thus, all the Romanian and Hungarian regions (excepting the two capital regions, Bucuresti–Ilfo and Közép-Magyarország) are included in the first group. Other countries with a high number of regions in this first group are Slovakia, the Czech Republic, Poland, Bulgaria and Lithuania. In the case of Southern countries, two cases deserve attention: Portugal and Greece.

At the opposite end of the scale we find those regions included in the fifth group, with values for the KIS indicator above 0.725. The trend of KIS to concentrate in capital regions is confirmed by the map, in line with previous findings like the study of Wood et al. (1993) for the United Kingdom or the most recent analysis of Aslesen and Isaksen (2007) for Norway. In fact that 11 out of the 16 regions of this group are capital regions: Stockholm, London, Île de France, Bruxelles, Luxembourg, Oslo, Berlin, Noord-Holland, Praha, Madrid and Lazio. The main explanation for this concentration pattern is that the agglomeration of KIS in capital regions results in more active learning and greater competitiveness, and in sum, in positive externalities.

After examining the spatial distribution using a map, we shall take a step further and evaluate whether there are clusters in the location of KIS in the European regions, which will involve two processes. First, we evaluate the existence of spatial autocorrelation by means of two global statistics; the Moran’s I and the Geary’s C. The presence of spatial autocorrelation means that the location of KIS in one region is not only explained by other variables, but also by the location of KIS in the neighbouring regions. Once having verified the existence of positive spatial autocorrelation, we can try to identify “clusters” of regions with high and low participations of KIS by using a local indicator of spatial autocorrelation (LISA).

Starting with the global analysis, the two most commonly used measures of spatial autocorrelation are the Moran’s I and the Geary’s C statistics. Both indices are derived from the notion of spatial autocorrelation. The main difference between the two indices is in the definition of similarity.

The Moran’s I (Moran, 1948) defines the similarity as the cross-product of the differences between individual values and the mean of the values under study that is to say:

$$c_{ij} = (x_i - \bar{x})(x_j - \bar{x}) \quad [1]$$

where x_i is the value of a variable for region i and \bar{x} is the mean of the values of the variable under study.

The Moran’s I is constructed as:

$$I = \frac{N}{S_0} \frac{\sum_{ij} w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{ij} (x_i - \bar{x})^2} \quad \text{where } S_0 = \sum_i \sum_j w_{ij} \quad [2]$$

The Geary’s C (Geary, 1954) defines the similarity as the difference between individual values squared:

$$c_{ij} = (x_i - x_j)^2 \quad [3]$$

and is constructed as:

$$C = \frac{N-1}{2S_0} \frac{\sum_{ij} w_{ij} (x_i - x_j)}{\sum_{ij} (x_i - \bar{x})^2} \quad [4]$$

To test the significance of the statistics we compare the theoretical distribution and the empirical distribution.

In the case of the Moran's I, if the standardised value is positive and significant, this indicates the existence of positive autocorrelation. In the case of the Geary's C, if the standardised value is negative and significant, this indicates the existence of positive spatial autocorrelation.

In our analysis we will use two types of matrices: contiguity and inverse distance matrices. In a binary contiguity matrix $w_{ij}=1$ if regions i and j share a border and 0 otherwise. In the inverse distance matrices, weights are defined as the inverse distance and the inverse squared distance between the centroids of regions i and j . Table 4 reports the values of the two indices for the share of KIS in workforce in 2006.

Table 4. Moran's I and Geary's C for KIS, 2006.

Weight Matrix	Moran's I			Geary's C		
	I	Z-value	Prob.	C	Z-Value	Prob.
Cont	0.418	8.071	0.000	0.492	-8.385	0.000
Invd	0.130	17.252	0.000	0.865	-3.659	0.001
Invd ²	0.299	7.676	0.000	0.743	-2.821	0.005

Source: Own elaboration.

As can be seen, in all cases the values for the indices are significant and the standardised values confirm existence of positive spatial autocorrelation. Again, the externality argument reappears: the location of KIS in some regions could generate positive effects on neighbouring regions.

4.3. Local spatial analysis.

With the two indices calculated in the second subsection we analysed all the regions globally. The problem is that these global tests are not sensitive to situations of instability in the spatial distribution of the variable, in other words, if the spatial process is non-stationary. For example, they are not able to detect the existence of a cluster in a specific location if randomness dominates in the rest of the regions. Consequently, it is necessary to calculate a local indicator of spatial association (LISA) in order to correctly identify spatial clusters. Following Anselin (1995, p. 95) local spatial clusters "may be identified as those locations or sets of contiguous locations for which the LISA is significant". In our case we compute the local Moran's I statistic, which is defined as follows:

$$I_i = \frac{z_i}{\sum_i z_i^2 / N} \sum_{j \in J_i} w_{ij} z_j \quad [5]$$

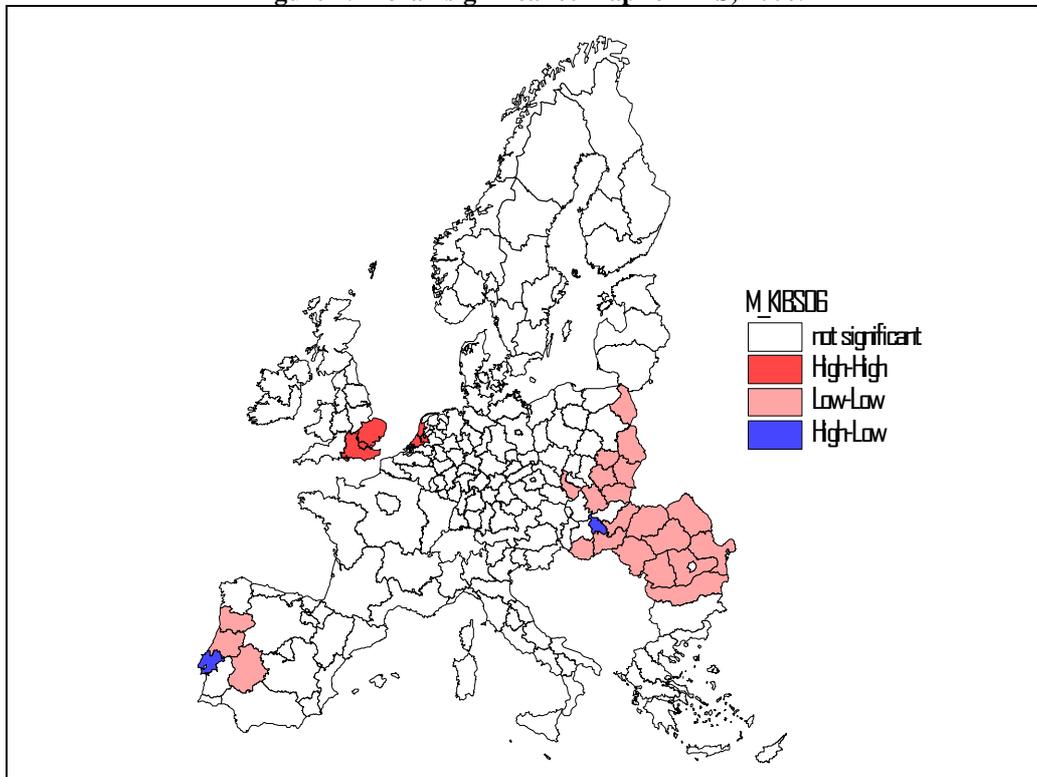
where z_i is the value of the normalised variable for region i and J_i is the group of neighbouring regions of region i .

If the standardised value of the local Moran's I is positive and significant, this indicates the existence of a cluster of similar values around the region. On the contrary, a negative and significant value points out the existence of a cluster of dissimilar values around the region.

A cluster appears when the value of the participation of KIS in a region is more similar to its neighbouring regions (taking as an indicator the spatial weighted average of the participations in the neighbouring regions) than it would be in the case of spatial randomness. Nonetheless, we have to bear in mind that the spatial clusters shown on the LISA map refer to the core of the cluster.

The significant local Moran statistics can be represented on a map known as a Moran significance map (Figure 2). In the Moran Significance map the significant locations are colour coded by type of spatial autocorrelation. In our case we can find clusters of similar values, with the exceptions of the capital regions of Portugal and Hungary: Lisbon and Közép-Magyarország, which appear as high-low clusters, that is, regions with a high presence of KIS surrounded by regions with low presence of KIS. The dark red shows the high-high clusters (clusters of similar regions with high participations of KIS) and the pink shows the low-low clusters (clusters of similar regions with low participations of KIS).

Figure 2. Moran significance map for KIS, 2006.



Source: Own elaboration.

The picture described by the Moran significance map is very similar to those shown in the natural breaks map: again, strong differences between the northern/central and southern/eastern regions appear. In particular there are two high-high clusters and two low-low clusters.

The two high-high clusters are composed of regions located in countries where the KIS sector plays a key role: the United Kingdom and the Netherlands. Thus, the first cluster comprises three British regions: London, South East and Eastern. The second high-high cluster is composed of three Dutch regions: Noord-Holland, Utrecht and Zuid-Holland.

Six eastern countries appear as core of the first low-low cluster: Romania, Hungary, Bulgaria, Slovakia, Poland and the Czech Republic. We find seven out of the eight Romanian regions: Nord-Est, Sud-Est, Sud-Muntenia, Sud-Vest Oltenia, Vest, Nord-Vest, Centru; three Hungarian regions: Dél-Dunántúl, Észak-Alföld and Dél-Alföld; one out of the two Bulgarian regions: Severna i iztochna Bulgaria; two Slovakian regions: Stredné Slovensko and Východné Slovensko; five Polish regions: Malopolskie, Lubelskie, Podkarpackie, Swietokrzyskie and Podlaskie, and one Czech region: Strední Morava. The second low-low cluster comprises two Portuguese regions, Norte and Centro, and one Spanish region, Extremadura.

So, the local exploratory analysis concludes that there are local spatial clusters of KIS in the European regions, with clear differences between northern/central and southern/eastern regions, as the pioneering project KISSIN pointed out a decade ago. Despite the common trend of KIS to concentrate in capital regions, in the centre and north of Europe this concentration helps to rise employment in KIS in neighbouring regions, giving place to what we called high-high clusters. On the contrary, in eastern and southern (less innovative) regions the presence in KIS uses to be lower leading to the emergence of low-low clusters. In order to go deeper into this relationship, in the next sub-section we estimate a spatial econometric model.

4.4. Spatial econometric model.

In the first sub-section we noted how there is a strong relationship between traditional innovation indicators like human capital variables or R&D expenditures and the share of KIS in workforce. Later, we have obtained empirical evidence about the existence of positive spatial autocorrelation in the spatial distribution of KIS. The aim of this sub-section is to take a step further and integrate in one model these two results. In particular, we estimate a spatial model which explains the location of KIS by the presence of KIS in neighbouring regions and the regional innovation efforts⁶:

$$\ln KIS_i = c + \beta_1 \ln TEDU_i + \beta_2 \ln LEAR_i + \beta_3 \ln PUBRD_i + \beta_4 \ln BURD_i + \beta_5 W \ln KIS_i + \varepsilon_i \quad [6]$$

The dependent variable KIS_i is the share of KIS in workforce in one region. As for the independent variables, we include two indicators related to human capital ($TEDU_i$ and $LEAR_i$) and two others related to R&D expenditures ($PUBRD_i$ and $BURD_i$). The term $W \ln KIS_i$ is the spatial lag for the presence of KIS, that is to say, a weighted measure of the share of KIS in the regions with which region i has contacts.

⁶ Patents are not included for theoretical and empirical reasons. In relation to theory, we only include innovation variables related to efforts not to results. In empirical terms, it is excluded because of their high correlation with Business R&D which gives place to multicollinearity problems. In the case of medium and high-tech manufacturing, it is excluded because of its weak relationship the rest of innovation efforts (including KIS).

Table 5 reports the main econometric results. In the first column the OLS estimation results are shown, whereas the second column reports the spatial lag model described in equation (6). The elasticity of the location of KIS with respect to all variables is significant, both in the OLS and the ML estimations, in line with the results obtained in the descriptive analysis. The LM-LAG test rejects the null hypothesis, so the location of KIS in neighbouring regions influences the presence of KIS. When estimated by Maximum Likelihood (ML), the spatial lag of the KIS variable is significant and the LR test, along with the improvement in the AIC, confirms the statistical adequacy of the spatial lag model. This corroborates the hypothesis defended in previous sub-sections: the importance of the role played by the presence of KIS in neighbouring regions. Entering into the elasticity of the independent variables, the highest value is found in the case of business R&D (0.22), followed by the availability of a qualified labour force (0.22).

Table 5. Spatial estimation of the location of KIS, 2006.

	OLS estimation	ML estimation
c	0.008 (0.894)	0.147 (0.007)
Ln(TEDU)	0.231 (0.000)	0.224 (0.000)
Ln(TEAR)	0.331 (0.000)	0.160 (0.001)
Ln(PUBRD)	0.224 (0.001)	0.204 (0.001)
Ln(BURD)	0.222 (0.003)	0.223 (0.001)
WLn(KIS)		0.356 (0.000)
R ²	0.648	0.707
AIC	115.507	86.793
LM-LAG	27.962 (0.000)	
LR Test		30.715 (0.000)

Notes: 190 observations. P-values in parentheses.

Source: Own elaboration.

Thus, we can confirm that the location of KIS is influenced not only by regional innovation efforts, but also by the presence of KIS in neighbouring regions. Moreover, regional innovation efforts seem to influence the presence of KIS.

5. Conclusions.

The aim of this paper has been to contribute to the study of the spatial distribution of KIS in the European regions. It is widely accepted that KIS are as innovative as manufacturing industries, but their main virtue is their capacity to diffuse knowledge, especially of a tacit type, and, more concretely, their ability to foster regional innovation.

As was mentioned in the second section, the co-development of economics and geography has given place to new theoretical contributions, like the learning regions, which help to explain how KIS behave at the regional level, and more importantly, how they contribute to regional innovation. Although empirical analyses carried out to date

are scarce, all of them come to the same conclusion: the existence of a positive relationship between the location of KIS and the regional innovation performance. Our descriptive analysis carried out using information coming from the last edition of the Regional Innovation Scoreboard (RIS 2009) has also shown that KIS are a determinant variable in terms of regional innovation performance. The level of employment in KIS was strongly correlated with all the innovation indicators analysed except the employment in medium and high-tech manufacturing.

The analysis of the spatial distribution of KIS has confirmed our initial hypotheses: first, that there is spatial dependence in the regional distribution of KIS, second, that there are spatial clusters, and, finally, that regional innovation efforts are determinant in explaining the location of KIS. The global exploratory analysis has corroborated the so-called trend of KIS to locate in capital regions as well as the existence of positive spatial autocorrelation in the distribution of KIS. In other words, the location of KIS in one region is not only explained by other variables, but also by the location of KIS in the neighbouring regions. In order to better characterise this spatial pattern, a local exploratory analysis was carried out. The differences in KIS distribution between northern/central regions and southern/eastern regions were corroborated by the location of the local clusters identified. For one part, we found high-high clusters composed of British and Dutch regions, respectively. For the other part, a great number of eastern regions were included in the two low-low clusters obtained. The isolation of Lisbon and Közép-Magyarország, surrounded by regions of the low-low clusters, points out to potential deficiencies of those regions in eastern and southern countries when reaping the benefits associated to the knowledge diffusion carried out by KIS. Whereas in countries like Norway (Aslesen and Isaksen, 2007) or the United Kingdom (Wood et al., 1993) regions closely located in space are specialised in different types of KIS and constitute clusters that mutually benefit from knowledge exchange and competition, in most of eastern and southern countries all types of KIS tend to concentrate in the capital region. This pattern of extreme concentration could limit the emergence of regional knowledge spillovers, and, in sum, the improvement of regional innovation performance, even in high-innovative regions (Wood, 2006). Moreover, our spatial econometric model has confirmed the existence of a close relationship between regional innovation efforts and presence of KIS thereby supporting those works that defend the importance of regional innovation performance when explaining the concentration of knowledge-intensive activities.

To conclude, we can affirm that a deeper analysis of the spatial location of KIS, using more detailed information on regions, could shed more light on the explanatory factors for the location of KIS. The results of these analyses could be very useful in order to improve the design of regional innovation policies which have to be today, more than ever, service-oriented.

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Annex I. European regions included in the analysis.

Country	NUTS level (number)	Regions
Austria	NUTS 1 (3)	Ostösterreich; Südösterreich; Westösterreich
Belgium	NUTS 1 (3)	Région de Bruxelles-Capitale; Vlaams Gewest; Région Wallonne
Bulgaria	NUTS 1 (2)	Severna i iztočna Bulgaria; Yugozapadna i yuzhna centralna Bulgaria
Cyprus	NUTS 0 (1)	Cyprus
Czech Republic	NUTS 2 (8)	Praha; Střední Čechy; Jihozápad; Severozápad; Severovýchod; Jihovýchod; Střední Morava; Moravskoslezsko
Denmark	NUTS 0 (1)	Denmark
Estonia	NUTS 0 (1)	Estonia
Finland	NUTS 2 (4)	Itä-Suomi; Etelä-Suomi; Länsi-Suomi; Pohjois-Suomi
France	NUTS 1 (8)	Île de France; Bassin Parisien; Nord - Pas-de-Calais; Est; Ouest; Sud-Ouest; Centre-Est; Méditerranée
Germany	NUTS 2 (38)	Stuttgart; Karlsruhe; Freiburg; Tübingen; Oberbayern; Niederbayern; Oberpfalz; Oberfranken; Mittelfranken; Unterfranken; Schwaben; Berlin; Brandenburg; Bremen; Hamburg; Darmstadt; Gießen; Kassel; Mecklenburg-Vorpommern; Braunschweig; Hannover; Lüneburg; Weser-Ems; Düsseldorf; Köln; Münster; Detmold; Arnsberg; Koblenz; Trier; Rheinhessen-Pfalz; Saarland; Chemnitz; Dresden; Leipzig; Sachsen-Anhalt; Schleswig-Holstein; Thüringen
Greece	NUTS 2 (5)	1 merged region (Anatoliki Makedonia Thraki + Dytiki Makedonia+Thessalia); Kentriki Makedonia; Kentriki Ellada; Attiki; Nisia Aigaiou Kriti
Hungary	NUTS 2 (7)	Közép-Magyarország; Közép-Dunántúl; Nyugat-Dunántúl; Dél-Dunántúl; Észak; Magyarország; Észak-Alföld; Dél-Alföld
Ireland	NUTS 1 (2)	Border, Midlands and Western; Southern and Eastern
Italy	NUTS 2 (18)	3 merged regions (Valle d'Aosta+Piemonte; Molise+Abruzzo, Bolzano+Trento); Liguria; Lombardia; Provincia; Veneto; Friuli-Venezia; Giulia; Emilia-Romagna; Toscana; Umbria; Marche; Lazio; Campania; Puglia; Basilicata; Calabria; Sicilia; Sardegna)
Latvia	NUTS 0 (1)	Latvia
Lithuania	NUTS 0 (1)	Lithuania
Luxembourg	NUTS 0 (1)	Luxembourg
Malta	NUTS 0 (1)	Malta
Netherlands	NUTS 2 (12)	Groningen; Friesland; Drenthe; Overijssel; Gelderland; Flevoland; Utrecht; Noord-Holland; Zuid-Holland; Zeeland; Noord-Brabant; Limburg
Norway	NUTS 2 (7)	Oslo og Akershus; Hedmark og Oppland; Sør-Østlandet; Agder og Rogaland; Vestlandet; Trøndelag; Nord-Norge
Poland	NUTS 2 (16)	Lódzkie; Mazowieckie; Malopolskie; Slaskie; Lubelskie; Podkarpackie; Swietokrzyskie;; Podlaskie; Wielkopolskie; Zachodniopomorskie; Lubuskie; Dolnoslaskie; Opolskie; Kujawsko-Pomorskie; Warminsko-Mazurskie; Pomorskie
Portugal	NUTS 2 (5)	Norte; Algarve; Centro; Lisboa; Alentejo
Romania	NUTS 2 (8)	Nord-Vest; Centru; Nord-Est; Sud-Est; Sud – Muntenia; Bucuresti – Ilfov; Sud-Vest Oltenia; Vest
Slovenia	NUTS 0 (1)	Slovenia
Slovakia	NUTS 2 (4)	Bratislavský kraj; Západné Slovensko; Stredné Slovensko; Východné Slovensko
Spain	NUTS 2 (16)	Galicia; Principado de Asturias; Cantabria; País Vasco; Navarra; La Rioja; Aragón; Madrid; Castilla y León; Castilla-la Mancha; Extremadura; Cataluña; Comunidad Valenciana; Andalucía; Murcia; Islas Baleares
Sweden	NUTS 2 (8)	Stockholm; Östra Mellansverige; Småland med öarna; Sydsverige; Västsverige; Norra Mellansverige; Mellersta Norrland; Övre Norrland
United Kingdom	NUTS 1 (12)	North East ; North West; Yorkshire and The Humber; East Midlands; West Midlands; Eastern; London; South East; South West; Wales; Scotland; Northern Ireland

Source: Own elaboration.

Annex II. Regional innovation indicators.

Indicator	Description
Tertiary education	Population with tertiary education (ISCED 5-6) per 100 population aged 25-64. This is a general indicator of the supply of advanced skills (it is not limited to science and technical fields).
Life-long learning	Participation in life-long learning per 100 population aged 25-64. Life-long learning is defined as participation in any type of education or training course during the four weeks prior to the survey.
Public R&D expenditures	R&D expenditures in the government sector (GOVERD) and the higher education sector (HERD), defined according to the Frascati Manual, as a percentage of GDP.
Business R&D expenditures	Business R&D expenditures (BERD), according to the Frascati Manual, as a percentage of GDP.
Medium-high and high-tech manufacturing	Number of employed persons in the medium-high and high tech manufacturing sectors as a percentage of workforce in manufacturing and services. These include chemicals (NACE24), machinery (NACE29), office equipment (NACE30), electrical equipment (NACE31), telecommunications and related equipment (NACE32), precision instruments (NACE33), automobiles (NACE34) and aerospace and other transport (NACE35)
Knowledge-intensive services	Number of employed persons in the knowledge-intensive services sectors as percentage of workforce in manufacturing and services. These include water transport (NACE 61), air transport (NACE 62), post and telecommunications (NACE64), financial intermediation (NACE 65), insurance and pension funding (NACE 66), activities auxiliary to financial intermediation (NACE 67), real estate activities (NACE 70), renting of machinery and equipment (NACE 71), computer and related activities (NACE72), research and development (NACE73) and other business activities (NACE 74).
EPO patents	Number of patents applied for at the European Patent Office (EPO), by year of filling, per million population. The national distribution of the patent applications is assigned according to the address of the inventor

Source: Own elaboration.