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Knowledge-intensive Services in Europe: Does Location Matter?

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Abstract
Knowledge-intensive services (KIS) are assuming an increasing importance in innovation, to such an extent that they have even classified as “key agents” within innovation systems (Fischer, 2001). As one of the major features of KIS is coproduction, location is expected to play a significant role on the effects of KIS on regional innovation systems. The objective of this paper is to examine the relationship between the location of KIS and the innovation performance of the European regions. Starting from the results reached by previous studies: Makun and McPherson (1997) for three New York regions, Muller and Zenker (1998) for five German and French regions, Drejer and Vinding (2003) for Danish urban areas or Simmie and Strambach (2006) for large cities of England and Germany, our aim is to widen the traditional scope of the analysis and evaluate the relationship between location of KIS and innovation performance on an European basis. More concretely we try to show that the spatial concentration of KIS in some regions (and particular in capital cities) contributes to foster innovation. To do so we carry out an exploratory spatial analysis for more than 100 European regions. We take as a proxy for the location of KIS the share of employment in KIS in every region. The results obtained support the hypothesis that KIS exert a positive impact on regional innovation performance, an impact that could spill over into the neighbouring regions.

Keywords: KIS, exploratory spatial analysis, regions, innovation

Introduction

Nowadays, it is widely accepted that geography and space play a key role in regional economics, but mainstream economics and economic geography followed different paths until recent dates. The origins of the interest on the location of productive activities is found in Von Thünen’s (1826) pioneering work on the location of food producers around markets. In the twentieth century, the first works on location appeared, retaking the arguments concerning the importance of proximity to market and customers or stressing the role played by transport costs. Among the different contributions, Marshall (1919) elaborated the pillars of the main theories on the concentration of innovation like the industrial districts (Becattini 1979), the cluster approach of Porter (1990) or the new economic geography of Krugman (1991). Krugman, with his novel integration of the new international trade theory and the economic geography, gave place to an increasing participation of geography in economic literature. The most visible consequence of this trend has been the development of new theories, many of them related to innovation. For example, the ‘new industrial spaces’ (Storper 1995) combine, in accordance with Moulaert and Sekia

(2003), ideas from different theories: the industrial districts, the flexible production systems, the social regulation or the transaction costs. 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.

In the particular case of regional innovation, three main approaches can be highlighted: 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 doing so, patents and R&D data are used. The regional innovation systems[1] and the learning regions are very similar to Porter's approach. Recently, the emphasis has been placed on learning processes and regional institutional dynamics, fostering the development of 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.

Concerning innovation studies, services have traditionally been described as 'supplier-dominated industries' since Pavitt (1984) included them within this category in his widely-known taxonomy. The existence of important 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) has contributed to reinforcing the belief that services do not innovate. Nonetheless, a high degree of heterogeneity exists among service industries and a group of highly innovative services (in a technological or 'hard' sense) can be identified: those called knowledge-intensive.

Table 1: Eurostat Classification of Knowledge-intensive Services (KIS)

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
High-tech KIS	64 Post and telecommunications 72 Computer and related activities 73 Research and development
Market KIS (excl. financial intermediation and high-tech services)	61 Water transport 62 Air transport 70 Real estate activities 71 Renting of machinery and equipment without operator and of personal and household goods 74 Other business activities

Source: Eurostat

Taking the classification elaborated by Eurostat, three main groups of these 'knowledge-intensive services' (KIS) can be distinguished (Table 1). In line with the

[1] For an exhaustive review of regional innovation systems literature see Asheim and Gertler (2003).

definitions of Miles et al. (1995) and Muller and Zenker (2001), in our analysis, out of these three groups, we will centre on those services called by Eurostat 'high-tech KIS'.

The objective of this paper is to carry out a spatial analysis of high-tech KIS in 130 European regions. In particular, we try to evaluate two main hypotheses: firstly, that the share of high-tech 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 main functions that KIS can carry out in fostering regional innovation. We also comment on the results obtained by previous empirical studies about the impact of KIS on regional innovation performance. The third section is devoted to the empirical analysis: a descriptive analysis of the spatial distribution of KIS and a correlation analysis between the share of KIS in employment and several innovation indicators are developed. In addition, two statistics are calculated in order to evaluate the presence of global spatial autocorrelation: the Moran-I and the Geary-C. Finally, the existence of local clusters is examined. The main conclusions reached are summarized in the last section.

The Role of Knowledge-Intensive Services in Regional Innovation: Some Insights

If we accept the arguments exposed in recent theories on regional innovation (regional innovation systems and learning regions), knowledge, and in particular tacit knowledge, transmits adequately at short distances. Moreover, user-provider interactions in services are carried at the local level (Wood 2001). This supports the choice of the region as the main scenario for the analysis of the impact of knowledge-intensive services on innovation. In this sense, 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 organizational). Nevertheless, the specific effects of KIS are the indirect ones, which are divided into four types: knowledge transfer, integration of different stocks of knowledge and competence, adaptation of existing knowledge to the specific needs of their clients and production of new knowledge. Taking arguments from evolutionary and institutional theories, Simmie and Strambach (2006) describe how KIS 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 generation of knowledge spillovers.

In spite of the considerable importance of these functions, there are 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). 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 emphasized 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 pointed out: 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. These findings support the hypothesis 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 underlines 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.

In addition to the work carried out by this network, we can cite some empirical studies on the role of KIS in regional innovation: Makun and MacPherson (1997) for electrical equipment industry in the three main regions of New York, Muller and Zenker (1998) for five regions in France and Germany, Koschatzky (1999) for thirteen German regions, Drejer and Vinding (2005) for five Danish urban areas and Koch and Stahlecker (2006) for three German regions.

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. In this line, Muller and Zenker (1998) conclude that knowledge intensive services are not only innovators but also contribute to innovation in other firms. Koschatzky (1999), after applying probit models to data from a German regional innovation survey, concludes that horizontal networks of service firms located in central regions are characterized by interregional cooperation, which could help to improve interregional innovation. Drejer and Vinding (2005) support the hypothesis that geographical proximity influences on collaboration. By controlling for size, industrial affiliation and collaboration patterns, they find that those firms located in great urban areas have almost the double probability of collaborating with KIS firms than those firms located in peripheral areas. Finally, Koch and Stahlecker (2006) adopt a different perspective: instead of analyzing how KIS affect regional innovation they study how regional characteristics affect the development of KIS. In their study of Bremen, Munich and Stuttgart, they find that in early stages, geographical proximity to suppliers and clients play a key role in KIS development.

High-tech KIS and Regional Innovation Performance: a Spatial Approach

The results of the studies carried out to date, described in the latter section, point out 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:

1. Is there a positive link between the location of high-tech KIS and the regional innovation performance?
2. Can the differences in the concentration of high-tech KIS be explained by spatial dependence?
3. Are there spatial clusters of high-tech KIS?

To answer the first question, we carry out a descriptive analysis of the regional distribution of high-tech KIS and of the rest of indicators employed to construct the regional composite innovation indicator (RCII) included in the Regional Innovation Scoreboard elaborated by the European Commission. Global spatial analysis is used to evaluate the existence of location patterns in high-tech KIS. Finally, local exploratory analysis goes deeper in the characterization of spatial concentration and aims or identifies clusters of regions.

Descriptive Analysis

Our indicator of the presence of high-tech KIS is their participation in regional employment. In addition to this one, six other innovation variables are used to construct the RCII: human resources in science and technology core, participation in life-long learning, public R&D expenditures, business R&D expenditures, employment in medium-high and high-tech manufacturing and European Patent Office (EPO) patents per million population[2]. We identify the ten regions with the highest participation of high-tech KIS as well as their ranking in terms of the other innovation indicators mentioned above. The first fact to point out is the existence of a high correspondence between the presence of high-tech KIS and regional innovation performance. Thus, the four highest ranking regions in terms of innovation performance (Stockholm, Västsverige, Sydsverige and Île de France) are at the same time the regions with the highest presence of high-tech KIS.

A close relationship is also observed between the location of high-tech KIS and the indicators of knowledge workers and business R&D. Thus, six out of the ten regions with highest participation of high-tech KIS are among the ten regions with the highest share of knowledge workers. The same coincidence is observed for R&D expenditures in the business sector.

To go deeper into these relationships, we calculate the correlation matrix for the six innovation indicators plus the regional composite innovation indicator (RCII) (Table 2).

Table 2: Correlation Matrix for High-tech KIS and Innovation Indicators

	RCII	KNOW	LIFLEAR	TECHMAF	KIS	PUBR&D	BUR&D	PAT
RIS	1.00	0.86	0.83	0.73	0.86	0.34	0.85	0.89
KNOW		1.00	0.77	0.49	0.80	0.17	0.67	0.70
LIFLEAR			1.00	0.54	0.68	0.04	0.67	0.72
TECHMAF				1.00	0.47	0.12	0.62	0.72
KIS					1.00	0.29	0.69	0.71
PUBR&D						1.00	0.13	0.13
BUR&D							1.00	0.79
PAT								1.00

RCII: Regional composite Innovation Indicator, KNOW: Knowledge workers,
LIFLEAR: Life-long learning, TECHMAF: Medium and High Tech Manufacturing,
KIS: High Tech KIS, PUBR&D: Public R&D, BUR&D: Business R&D, PAT: Patents
Source: Own elaboration from RIS (2006) database

In comparison with the rest of indicators, the employment in high-tech KIS is the second in terms of correlation with the RCII and with business R&D. This supports the idea that the location of high-tech KIS contributes to improving regional innovation performance and fosters innovation efforts of firms.

Therefore, innovation and high-tech KIS seems to be closely intertwined at the regional level. But, how homogeneous are the participations of high-tech KIS in the different European regions?

[2] Detailed tables of the descriptive analysis are available on request.

An Examination into the Spatial Distribution of High-tech KIS

Our objective in this subsection is to analyze the spatial distribution of high-tech KIS using global exploratory spatial analysis. As Koschatzky (1999: 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".

If we classify the 130 regions into natural breaks, significant disparities appear among regions (Figure 1). In particular, we can detect a pattern which could be labelled as 'Scandinavian-Mediterranean' or 'North-South': a great number of the regions with high participations are located in Scandinavian countries whereas the regions with lowest participations are mainly located in Mediterranean countries. Thus, 24 out of the 26 regions included within the first group are located in southern countries: Greece (11), Portugal (4) and Spain (9). The exceptions within this 'Mediterranean/South group' are two regions: Bourgogne and Sachsen-Anhalt.

At the opposite end of the scale, we find those regions included in the fifth group, with values for the high-tech KIS indicator ranging from 0.12 to 0.17. The five regions included within this group are capital regions: Stockholm, Île de France, Bruxelles, Madrid and Lazio.

The same trend is found in the case of the second group with highest participation of high-tech KIS: London or Berlin is included within this second group. So, the trend of high-tech 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 Jakobsen (2007) for Norway. The main explanation for this concentration pattern is that agglomeration of high-tech KIS in city regions results in more active learning and greater competitiveness, and in sum, in positive externalities.

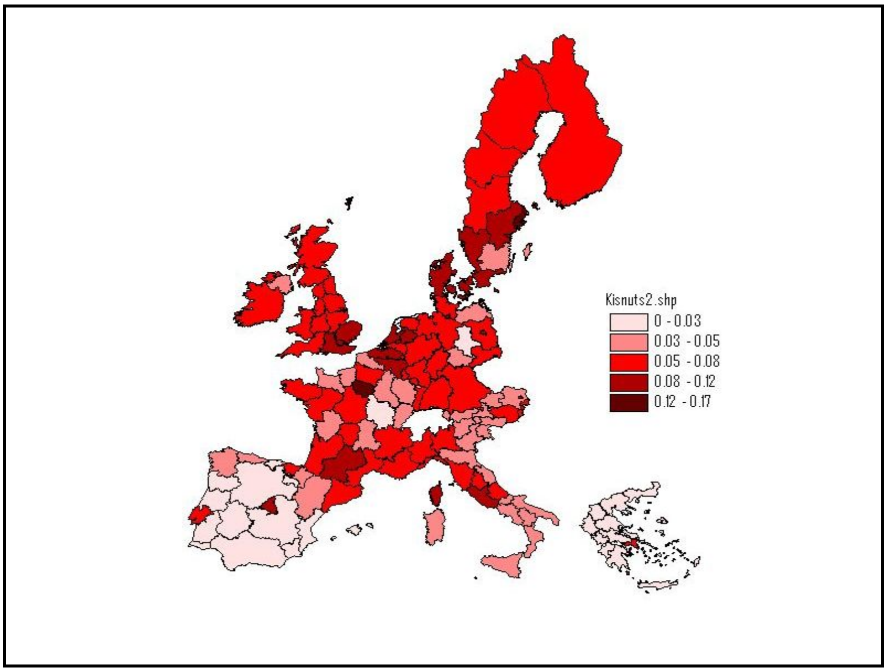

Figure 1: Spatial Distribution of High-tech KIS in Europe, 2004. *Source*: Own elaboration.

After examining the spatial distribution using a map, we shall take a step further and evaluate whether there are clusters in the location of high-tech 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. Both indices are derived from the notion of spatial autocorrelation. The main difference between the two indices is in the definition of similarity. Secondly, we employ local indicators to identify clusters of regions.
The Moran's I 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:

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

where x_i is the value of a variable for region i and $\overline{x}$ the mean of the values of the variable under study.
The Moran's I is constructed as:

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

The Geary's C defines the similarity as the difference between individual values squared:

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

and is constructed as:

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

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

In our case, we use two types of matrices: contiguity and inverse distance matrices. In a binary contiguity matrix wij=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 3 reports the values of the two indices for the share of employment in high-tech KIS in 2004.

Table 3: Moran's I and Geary's C for High-tech KIS, 2004

Weight	*Moran's I*			*Geary's C*		
Matrix	I	Z-value	Prob.	C	Z-Value	Prob.
Cont	0.324	4.842	0.000	0.542	-5.568	0.000
Invdis	0.127	12.237	0.000	0.839	-9.927	0.000
Invdis2	0.288	8.155	0.000	0.716	-7.023	0.000

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

The Spatial Distribution of High-tech KIS in more Detail: Identification of Clusters

With the two indices calculated in the second subsection we analyzed 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: 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:

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

Where z_i is the value of the normalised variable for region I and Ji is the group of neighbouring regions of region i.

The significant local Moran statistics can be represented on a map known as a Moran Significance map (Figure 2).

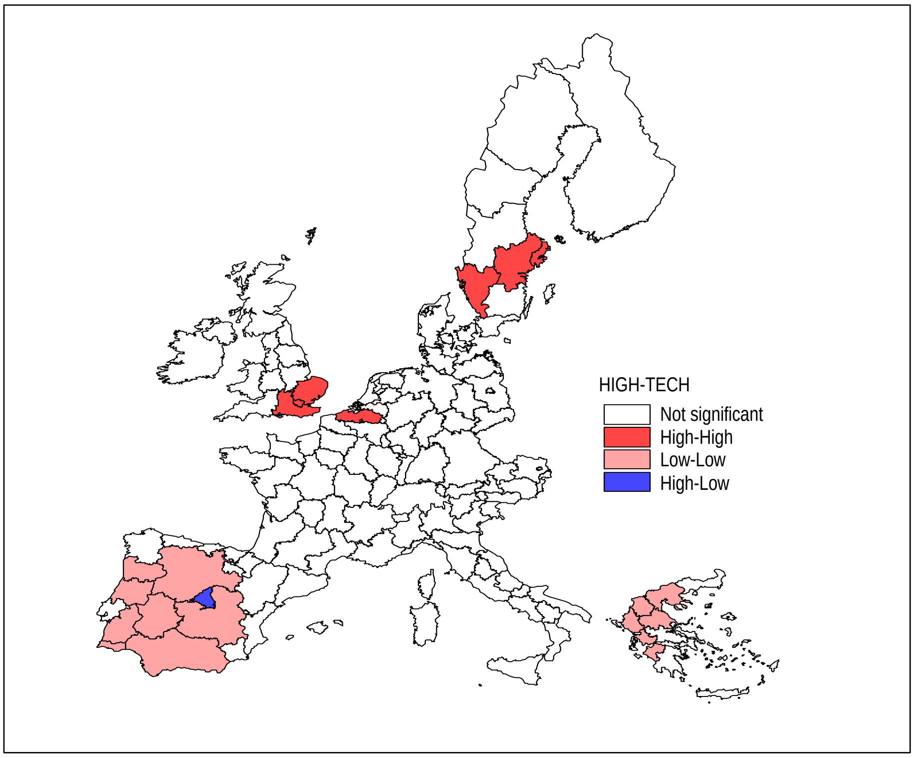

Figure 2: Moran significance map for high-tech KIS, 2004. *Source*: Own elaboration.

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 sole exception of Madrid. The high-high clusters are clusters of similar regions with high participations of employment in high-tech KIS and the low-low clusters are clusters of similar regions with low participations of employment in high-tech KIS. The picture described by the Moran significance map is very similar to the natural breaks analysis: again, strong differences between the northern and southern regions appear. In particular, there are three high-high clusters and two low-low clusters.

The three high-high clusters are composed of regions located in countries where the high-tech KIS sector plays a key role: Sweden, Belgium and the United Kingdom. Thus, the first cluster comprises three Swedish regions: Stockholm, Västsverig and Östra Mellansverig. The second one includes three British regions: London, South East and Eastern. The third high-high cluster is composed of two Belgian regions: Vlaams Gewest and Brussels.

Three southern countries appear as cores of low-low clusters: Greece, Portugal and Spain. We find five Greek regions: Kentriki Makedonia, Dytiki Makedonia, Ipeiros, Thessaly and Dytiki Ellada in the first low-low cluster. The second low-low cluster includes most of the Portuguese and Spanish regions: the regions of Norte, Centro, Alentejo and Algarve in Portugal and Castilla León, Castilla la Mancha, Extremadura and Andalucía in Spain.

The most striking case is Madrid: the concentration is so high (it is the fourth highest ranking region in terms of employment in high-tech KIS in our group of 130 regions) that it emerges as an ‘island’ surrounded by regions with low levels of employment in high-tech KIS. This pattern of extreme concentration could limit the emergence of regional knowledge spillovers, and, in sum, the improvement of regional innovation performance. In other words, location matters in terms of the innovation driving role exerted by high-tech KIS.

So, the local exploratory analysis concludes that there are local spatial clusters of high-tech KIS in the European regions, with clear differences between northern/central and southern regions as the pioneer project KISSIN pointed out a decade ago. Despite the common trend of high-tech KIS to concentrate in capital regions, in the centre and north of Europe this concentration helps to rise employment in high-tech KIS in neighbouring regions, giving place to what we called high-high clusters. On the contrary, in southern (less innovative) countries the level of employment in high-tech KIS uses to be quite low, leading to the emergence of low-low clusters.

Conclusions

The aim of this paper has been to contribute to the knowledge of the spatial distribution of KIS in Europe. Our descriptive analysis carried out using information coming from the 2006 edition of the Regional Innovation Scoreboard (RIS 2006) has shown that high-tech KIS are a determinant variable in terms of regional innovation performance. The level of employment in high-tech KIS is not only strongly correlated with the composite index of regional innovation, but also with four other innovation indicators: knowledge workers, patents, life-long learning and business R&D.

The analysis of the spatial distribution has confirmed that there are spatial patterns in the regional distribution of high-tech KIS and that there are spatial clusters. The global exploratory analysis 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 high-tech KIS. In other words, the location of high-tech KIS in one region is not only explained by other variables, but also by the location of high-tech KIS in the neighbouring regions. This supports the arguments of Muller and Zenker (2001) or Koschatzky (1999) about the potential role of KIS in fostering interregional innovation.

In order to better characterize this spatial pattern, a local exploratory analysis was carried out. The differences in high-tech KIS distribution between northern/central regions and southern regions were confirmed by the location of the local clusters identified. For one part, we found high-high clusters composed of Swedish, British and Belgian regions, respectively. For the other part, most of southern regions were included in the two low-low clusters obtained. The isolation of Madrid, surrounded by regions of the low-low clusters, points out to potential deficiencies of regions in southern countries when reaping the benefits associated to the knowledge diffusion carried out by high-tech KIS. Whereas in countries like Norway (Aslesen and Jakobsen 2007) or the United Kingdom (Wood et al. 1993) regions closely located in space are specialized in different types of KIS and constitute clusters that mutually benefit from knowledge exchange and competition, in most of southern countries all types of KIS tend to concentrate in the capital region.

To conclude, we can affirm that an in depth analysis of these spatial clusters, combined with detailed information on regions, could shed more light on the advantages and disadvantages linked to the different spatial distributions of high-tech KIS. The results of these analyses could be very useful in order to improve the effectiveness of regional innovation policies.

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