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Innovation, Knowledge Spillovers and High-Tech Services in European Regions

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Regions rely not only on their own efforts and characteristics but also on their capacity to attract and assimilate knowledge produced elsewhere to innovate. In other words, interactions among individuals, firms and institutions produce the transmission of knowledge in the form of knowledge spillovers. In the case of knowledge-intensive business services (KIBS), one of their main features is their capacity to adapt and disseminate tacit knowledge. Despite a variety of recent studies have contributed to improve one´s understanding of the tacit knowledge diffuser role of KIBS, there has been little investigation on the spatial effects related to the presence of KIBS. This article represents an attempt to combine in one model knowledge spillovers and availability of a group of KIBS, those called high-tech services (HTS). The objective is to shed some light on the role of both geographical and technological distance in the knowledge diffusion process and to show how HTS account for a significant part of the regional innovation process using an extended knowledge production function (KPF) framework applied to 240 European regions from 23 countries. Two major findings of this analysis are following. For one part, inter-regional knowledge flows are key elements for explaining regional innovation performance, although technological proximity is far less important than geographical proximity. For the other part, regions with a higher specialization in HTS, or proximate to regions with a higher presence of HTS, tend to innovate more, mainly because HTS can improve their capacity to transform knowledge into innovation.

Keywords: *knowledge production function, spillovers, high-tech services, spatial analysis, the European Union, regions.*

Introduction

The knowledge production function (KPF) approach was introduced by Griliches in 1979 and developed by Pakes & Griliches (1984). As in most theories on innovation the firm was the focus of attention: the process by which firms transform knowledge into innovation was modeled as a "simple" function where the main input was R&D. In essence, this "linear" vision of the innovation process assumed that the higher the investment in R&D, the higher the innovation activity.

In the nineties the "New Economic Geography" implied a radical change in the relationship between knowledge and space, underlying that innovation is a territorially embedded process. The result was that the capacity of R&D to act as a catalyst for innovation depended on the existence of externalities. Starting from Marshall's work (Marshall 1890; 1919), Krugman described the existence of three types of externalities (Krugman, 1991). Firstly, economies of specialization: the presence of a high number of firms was reflected in the outsourcing of complementary activities and into closer cooperation. Firms obtained benefits by sharing resources and competences. These benefits were particularly noticeable when innovation costs were shared. Secondly, economies of labor pooling, where the availability of high qualified labor force not only attracted more specialized labor and more firms but also encouraged higher mobility of labor depending on demand fluctuations and higher investment in training. Finally there were technological externalities or knowledge spillovers: concentration of firms facilitated the emergence of knowledge spillovers because knowledge flows more easily locally than over long distances, especially tacit knowledge[1]. These three types of externalities can help to explain heterogeneity between regions and countries, although most of theoretical works center on the latter type of externalities (knowledge spillovers) which have traditionally been divided in two main groups: location or Marshall-Arrow-Romer (MAR) spillovers, characterized by taking place within a specific industry (Marshall, 1890; Arrow, 1962; Romer, 1986) and Jacobs spillovers which occur among industries (Jacobs, 1970). In the case of MAR spillovers, individuals in the same industries interact when trying to solve similar problems thereby facilitating the diffusion of knowledge. The main argument for the occurrence of this type of spillover is that transaction costs in communication among individuals are low. As for Jacobs spillovers, there is a diversity of knowledge employed in different industries, which permits a fruitful diffusion favored by the fact that firms in different industries are not direct competitors.

Pioneering work on innovation diffusion from a spatial perspective can be attributed to Hägerstrand (1953) who underlined the importance of knowledge diffusion by means of human interaction. Jaffe (1989) was the first in revising the KPF to include the spatial dimension, or, in

[1] *In their seminal work Nonaka & Takeuchi (1995) established a distinction between explicit and tacit knowledge. Explicit knowledge is easily codifiable (for instance it can be written down) and transmits costlessly over long distances, and tacit knowledge often arises out of experience, requires face to face interaction and exhibits distance decay effects.*

other words, to shift the interest from firms to geographical units (states). Originally, Jaffe analyzed the externalities produced by universities. Later on, some works have tried to examine the process of creation and diffusion of knowledge at the regional level using econometric models and assuming that, as Fritsch (2002) states, the KPF is a useful instrument to compare the quality of the regional innovation systems. As many aspects referred to the fact that characteristics of the regions cannot be measured (for example the innovation culture), they have to be incorporated using proxy variables. In the KPF one of the most common output indicators are patents, and more concretely patents applications or citations (Henderson *et al.*, 2005; Jaffe *et al.*, 1993). Among the main advantages attributed to patents there are that they guarantee a minimum level of originality and are intimately linked to invention.

Some empirical studies have tried to measure the spatial range of knowledge spillovers (Acs, 2002; Anselin *et al.*, 1997; Botazzi & Peri, 2003; Moreno *et al.*, 2005; Varga, 2000). In their seminal study on the effects of universities on regional innovation in the US, Anselin *et al.* (1997) found a positive impact of university research up to 50 miles, later on corroborated by Acs (2002). Varga (2000) established a limit of 75 miles for knowledge spillovers. Botazzi & Peri (2003), using data for European regions, estimate the impact of R&D expenditure carried out in neighboring regions, obtaining a threshold distance of 300 kilometers. A similar figure of 250 kilometers was obtained by Moreno *et al.* (2005). But not only geographical proximity but also technological proximity have been examined in recent studies (Autant-Bernard, 2001; Autant-Bernard & LeSage, 2011; Botazzi & Peri, 2003; Greunz, 2003; LeSage *et al.*, 2007; Moreno *et al.*, 2005; Parent & LeSage, 2008). Majority of works come to the same conclusion: technological proximity between regions have an important impact on knowledge and innovation. The reason is quite simple: in many cases the incorporation of new knowledge requires the existence of certain technological similarities so, given all the firms operating in the same region, it can be expected spillovers to be higher between those regions with similar technological profiles.

Within services, traditionally absent in innovation studies because of their assumed "non-innovative nature", knowledge-intensive business services (KIBS) have been classified as a "differentiated group" characterized by acting as sources, facilitators and carriers of innovation (Bessant & Rush, 1995; Czarnitzki, & Spielkamp, 2000; Den Hertog & Bilderbeek, 1998; Den Hertog, 2000; Muller & Doloreux, 2009). From a regional perspective, the pioneering work by Strambach (1998) employed the learning regions theory to describe the two major types of effects (direct and indirect) that KIBS carry out in innovation. The direct effects refer to the development of own innovations (product, process or organizational). Nevertheless, the effects specific to KIBS are the indirect ones, which were classified into four types: knowledge transfer, integration of different stock of knowledge and competences, adaptation of existing knowledge to the specific needs of their clients and production of new knowledge (Strambach, 1998; Simmie & Strambach, 2006). Moreover KIBS are not only involved in knowledge creation and provision for other firms but also in bridging the gap between the knowledge residing in the scientific community and the application of this knowledge (Bishop, 2008).

Among the empirical studies on the role of KIBS in regional innovation performance, because of its pioneering nature, we can highlight the one developed by the KISINN network (Knowledge-Intensive Services and Innovation) (Wood, 2001). More recent analyses can be classified into three groups depending on their main objective.

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 & MacPherson (1997) for electrical equipment industry in three main regions of New York, Muller & Zenker (2001) for five regions in France and Germany, Aslesen & Isaksen for Oslo (2007) or Rodriguez *et al.*, (2012) for 194 European regions. The paper by Makun & 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 transmit knowledge adequately. In this line, Muller & Zenker (2001) conclude that KIBS are not only innovators but also contribute to innovation in other firms. In particular, those small and medium size enterprises (SMSEs) that use KIBS tend to spend more on R&D and have closer relationships with universities and research centres. In other words, KIBS 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 & Isaksen (2007) reveals that they can act as a "motor of competence" and stimulate innovation. In this line Rodriguez *et al.*, (2012) find the existence of spatial clusters of KIBS in the European regions which are closely related to regional innovation performance.

Second group of works focuses on the analysis of cooperation patterns of KIBS firms, underlying the importance of location. Examples are the papers by Koschatzky (1999) for thirteen German regions, Drejer & Vinding (2005) for five Danish urban areas and Doloreux & Mattson (2008) for 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 characterized by interregional cooperation, which could help to improve interregional innovation. Drejer & 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 Ottawa region, Doloreux & Mattson (2008) point out the need for local proximity given the greater propensity to collaborate with local partners shown by KIBS.

Finally, Koch & Stahlecker (2006), Andersson & Hellerstedt (2009), Shearmur & Doloreux (2009) and Doloreux & Shearmur (2011) adopt a different perspective: instead of analyzing 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 & Stahlecker (2006) find that in early stages, geographical proximity to suppliers and clients play a key role in KIBS development. Andersson & Hellerstedt (2009), using data from Swedish municipalities, show that qualification of the workforce and size of the regional market have a positive influence on the development of KIBS firms. Shearmur & Doloreux (2009) highlight the existence of geographical patterns in the innovation activity of KIBS in Québec regions, being a distance from metropolitan area a key element. In a wider analysis, Doloreux & Shearmur (2011) demonstrate that for certain types of innovation it is the access to resources that locations provide and not the local context that seems to be important.

In brief, interactions among individuals, firms and institutions produce the transmission of knowledge in the form of knowledge spillovers. In the case of KIBS, one of their main features is their capacity to adapt and disseminate tacit knowledge. This article represents an attempt to combine in one model knowledge spillovers and availability of a group of KIBS, those called high-tech services (HTS)[2]. The objective is to shed some light on the role of both geographical and technological distance in the knowledge diffusion process and to show how HTS account for a significant part of regional innovation. The existence of knowledge spillovers and effect of HTS on innovation are modelled using an extended knowledge production function (KPF) framework applied to 240 European regions from 23 countries.

The article is organized into four further sections. The second section presents the methodology. In the third section the data are described. Then in the fourth section the empirical results are discussed. The final section concludes the main findings.

Methodology

As a previous step before estimating our modified knowledge production function (KPF), we carry out an exploratory spatial analysis of our key variables of interest: innovation and HTS. Therefore a statistic of spatial dependence, the Moran's I (Moran, 1948), is employed. The existence of spatial dependence means that the presence of high innovation levels (or HTS) in one region is not only explained by other variables, but also by the innovation activity (or the presence of HTS) in neighboring 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:

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

[2] The statistical office of the European Union (Eurostat) classifies knowledge-intensive services into four groups: knowledge-intensive high-tech services, knowledge-intensive market services, knowledge-intensive financial services and other knowledge-intensive services. The group of high tech services comprises three sectors: post and telecommunications, computer and related activities and research and development.

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

From this definition the Moran´s I statistic is constructed as follows:

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

To test the significance of the statistic we compare theoretical distribution and empirical distribution. If the standardized value is positive and significant this indicates existence of positive spatial dependence.

In our analysis we will use two types of matrices: geographical and technological contiguity matrices. In geographical contiguity matrix $w_{ij}=1$ if regions i and j share a border and 0 otherwise. The first-order geographical contiguity matrix includes the immediate neighbors of the considered region and the second order geographical contiguity matrix takes into consideration the neighbors of the neighbors.

To compute technological contiguity matrices we follow the proposal of Jaffe (1986). For each region the average patent applications over the period of 2004–2006 disaggregated into the 118 classes of the International Patent Classification (IPC) are employed to construct the following coefficient:

$$p_{ij}=\frac{\sum_{k=1}^{118} f_{ik}f_{jk}}{\sqrt{\sum_{k=1}^{118} f_{ik}^2\sum_{k=1}^{118} f_{jk}^2}} \quad (3)$$

where f_{ik} is the share of the patent class k in the total of patents of the region i. If the technological profiles of regions i and j are similar, p_{ij} is close to 1. On the contrary, if they are different, it is close to 0. The first-order technological contiguity matrix includes, for each region, three regions with the highest values of p_{ij}. The second-order technological contiguity matrix includes three regions with second highest values of p_{ij}.

In its basic form, the KPF relates an output measure for knowledge to the research and development performed (Griliches, 1979; Jaffe, 1986). In our approach we also take into account other factors:

$$I_i=RD_i^{\delta_1}Z_{1i}^{\delta_2}e_i \quad (4)$$

where I is a proxy for knowledge output (commonly patents), RD represents the research and development expenditures, Z_1 is a vector of exogenous economic and institutional characteristics and e is the stochastic error term. The KPF is commonly modelled using a Cobb-Douglas production function. We do not impose any restriction on the type of returns to scale. By taking logarithms in (4) the following equation is obtained:

$$\ln I_{i,t}=\beta_1\ln RD_{i,t-1}+\beta_2\ln HTS_{i,t-1}+\beta_3\ln MAN_{i,t-1}+\sum_{i=1}^{22}\delta_c NAT_{ic}+\varepsilon_{i,t} \quad (5)$$

Under this formulation, innovation activity as measured by patent applications (I) is related to R&D expenditures (RD), the presence of high-tech services (HTS) and the presence of manufacturing (MAN). A set of national dummy variables accounting for "national fixed effects" (NAT) is also included so as to take into account the influence of national factors such as social and institutional conditions. In models based on the KPF, spillovers are evaluated in terms of their contribution to the creation of new knowledge. In our case, robust Lagrange multiplier tests for spatial lag (LM-LAG) and spatial error (LM-ERR) are computed to identify the type of spatial dependence: substantive (spatial lag model) or nuisance process (spatial error model) and formulate the spatial model. Using the substantive model for the case of our KPF, we can incorporate the presence of knowledge spillovers by assuming that innovation in neighboring regions has a positive impact on regional innovation (Z_2):

$$I_i = RD_i^{\delta_1} Z_{1i}^{\delta_2} Z_{2i}^{\delta_3} e_i \qquad (6)$$

Taking of logarithms in (6) leads to:

$$\begin{aligned} \ln I_{i,t} &= \beta_1 \ln RD_{i,t-1} + \beta_2 \ln HTS_{i,t-1} + \beta_3 \ln MAN_{i,t-1} \\ &+ \beta_4 W\ln I_{i,t} + \sum_{i=1}^{22} \delta_c NAT_{ic} + \varepsilon_{i,t} \end{aligned} \qquad (7)$$

where WlnI is the spatial lag for innovation, that is, a weighted measure of innovation in neighboring regions, which tries to capture interregional knowledge spillovers. Neighborhood is measured by means of matrix W, which, as noted before, is computed both from a geographical and technological point of view.

We can also expect that innovation in a region depends on the presence of HTS in neighboring regions. Formally, this is expressed in the following equation:

$$\begin{aligned} \ln I_{i,t} &= \beta_1 \ln RD_{i,t-1} + \beta_2 \ln HTS_{i,t-1} + \beta_3 \ln MAN_{i,t-1} \\ &+ \beta_4 W\ln I_{i,t} + \beta_5 W\ln HTS_{i,t-1} + \sum_{i=1}^{22} \delta_c NAT_{ic} + \varepsilon_{i,t} \end{aligned} \qquad (8)$$

In this case WlnHTS is the spatial lag for HTS. The significance of this parameter suggests that accessibility to HTS permits inter-regional transfer of knowledge.

Maximum Likelihood (ML) procedures have to be employed to estimate equations (7) and (8) as Ordinary Least Squares (OLS) estimations are biased and inconsistent in the spatial lag model.

Data

In this article we examine 240 European regions from 23 countries: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. Most of the regions are included at the NUTS II level (232), although five countries are analyzed at the NUTS 0 level: Denmark, Estonia, Latvia, Lithuania and Slovenia. Belgian regions are covered at the NUTS I level.

Innovation at the regional level is measured by the average of the number of patents applied by firms at the European Patent Office between 2004 and 2006. In addition to HTS, two other variables were taken into consideration: R&D expenditures and the share of manufacturing activities. R&D expenditures stand for total R&D expenditures with respect to regional Gross Domestic Product (GDP). Presence of HTS and manufacturing are approached by employment in HTS and employment in manufacturing, respectively, over total regional employment. As we work with cross-section data, each variable is computed as the average of three years so as to approximate medium/long term values. We also assume that it takes time for research and development to turn into patents so we assume a lag structure of two years. So the dependent variable is referred to the period of 2004–2006 whereas all the independent variables are computed for the period of 2002–2004. All data were drawn from the statistical office of the European Union (Eurostat).

Results

First of all, we examine the existence of spatial dependence in the distribution of patents and HTS. Table 1 reports the standardized values for the Moran´s I statistic.

Table 1

Moran´s I for patents and HTS

	Patents		**HTS**	
	Z-value	*Prob.*	*Z-value*	*Prob.*
Wg1	18,104	0,000	8,276	0,000
Wg2	19,664	0,000	11,779	0,000
Wt1	6,660	0,000	7,866	0,000
Wt2	3,130	0,002	4,460	0,000

Wg1 and Wg2 are the first order and second order geographical contiguity matrices and

Wt1 and Wt2 are the first order and second order technological contiguity matrices.

The standardized values are positive and significant in all cases which indicate the existence of positive spatial dependence in the distribution of both patents and HTS[3].

R&D expenditures have been generally seen as a key factor influencing regional differences in innovation due to the presence of knowledge spillovers, which are supposed to be geographically localized. Empirical studies have included variables to measure the presence of agriculture or manufacturing activities but, as far as our knowledge, the role played by HTS has not been examined. The goal of this article is twofold: to corroborate empirically the existence of knowledge spillovers and to analyze the role of HTS in regional innovation. Therefore the estimations of equations (5), (7) and (8) are reported in Tables 2 and 3. The structure of the tables is the same: the first part shows the OLS estimations and the results of the spatial dependence tests. Next, the estimations of equations (7) and (8), using first and second order contiguity matrices, are reported. First, we test for spillovers generated by the geographical neighborhood. Table 2 summarizes the results.

[3] *Maps were also employed to analyze the spatial distribution patterns of patents and HTS but they have not been included due to space reasons. They are available on request.*

Table 2

Estimations of KPF using geographical contiguity matrices

	OLS estimation		ML estimation			
	Wg1	*Wg2*	*Wg1*	*Wg2*	*Wg1*	*Wg2*
LnRD	0,328		0,306	0,306	0,336	0,340
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)
LnHTS	0,504		0,481	0,482	0,515	0,498
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)
LnMAN	1,348		1,010	1,018	0,906	0,845
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)
W1lnI			0,211	0,222	0,129	0,121
			(0,000)	(0,000)	(0,003)	(0,005)
W2lnI				-0,016		
				(0,789)		
W1lnHTS					0,501	0,436
					(0,000)	(0,000)
W2lnHTS						0,239
						(0,012)
Dummies	Yes		Yes	Yes	Yes	Yes
R^2-adj	0,954		0,958	0,958	0,950	0,945
AIC	431,05		410,43	412,38	383,54	379,37
LM-ERR	1,260	0,222				
	(0,262)	(0,637)				
LM-LAG	11,683	7,100				
	(0,001)	(0,008)				
LR test			22,611	11,494	8,505	7,616
			(0,000)	(0,001)	(0,004)	(0,006)

P-values are shown in parentheses. Wg1 and Wg2 are the first order and second order geographical contiguity matrices.

As far as the OLS estimation, a positive impact of R&D expenditures on the number of patents is noticed, in line with previous works (Botazzi & Peri, 2003; Greunz, 2003; Moreno *et al.*, 2005). Moreover, the presence of HTS plays an important and significant role, with an elasticity of 0,504. As was expected, higher concentration of manufacturing activities also favors the patenting activity (1,348). Most of dummy variables are significant with the exception of Belgium, Denmark, Greece, Ireland and Sweden. Negative fixed effects are obtained for southern countries (Spain, Italy and Portugal) and new member countries (Slovenia, Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, the Czech Republic and Romania). This seems to reflect a poorer innovation capacity once we control for the R&D expenditures carried out and the presence of HTS and manufacturing and to confirm that capacity of every region or country to transform R&D into innovation is not exclusively linked to the amount of R&D but there are multiple reasons behind the unequal passage from R&D to innovation such as the existence of institutional and cultural settings more conducive to innovation (Asheim & Gertler, 2005). Multicollinearity is not a problem (with a condition number of 6,606) and the Jarque-Bera test confirms the normality of the distribution of the error term. This is very important because the spatial tests are based on the hypothesis of normality. In addition to the OLS estimates, the first part of Table 2 reports the spatial tests. The LM-LAG test clearly rejects the null hypothesis whereas the LM-ERR is non-significant. In other words, the tests point to the estimation of the spatial lag models described in the equations (7) and (8) by ML.

In relation to knowledge spillovers (second and third columns), we can note a positive and significant effect of the first order geographical neighborhood whereas second order geographical neighborhood turns out to be no longer significant for the patenting activity. This corroborates the existence of physical limit in knowledge spillovers (Acs, 2002; Anselin *et al.*, 1997; Botazzi & Peri, 2003; Moreno *et al.*, 2005; Varga, 2000). In contrast, we observe a strong impact of the first and second order geographical neighborhoods for the presence of HTS (fourth and fifth columns) although a distance decay effect is obtained. Thus, if we look at the last column, the estimated elasticity for the presence of HTS in the home region is 0,498. For the presence of HTS in the first-order neighboring regions the elasticity is slightly lower (0,436) whereas for the second-order neighboring regions the elasticity diminishes considerably (0,239). Overall, the fit of the model improves with the introduction of the spatial lags of both patents and HTS, as the AIC descends to 379,37.

We now turn the attention to technologically-mediated spillovers. Table 3 reports the estimates of the equations (7) and (8) using technological contiguity matrices. Regarding the OLS model (first part) the difference with Table 2 is the value of the spatial tests. In this case the results are different depending on whether we take the first order or the second order technological matrix. In the first case both the LM-LAG and the LM-ERR tests are significant, although the value for the LM-LAG is higher. This indicates that the spatial lag model is the best-fitting model. On the contrary neither the LM-LAG nor the LM-ERR are significant when using the second-order technological matrix.

The results confirm that technological neighborhood matters for patenting activity. In line with the spatial tests, the first-order technological proximity influences patenting activity but second-order technological neighborhood has no significant impact anymore. Compared to the estimates for knowledge spillovers in geographical space, when taking technological distance into consideration, the estimate for the first-order neighborhood is significant but far less important than for geographical proximity. As for HTS (fourth and fifth columns) technological neighborhood no longer influence patenting activity. In other words, for HTS, spillovers are very important in the case of geographical neighbors but do not seem to be significant in the case of technological neighbors.

Table 3

Estimations of KPF using technological contiguity matrices

	OLS estimation		ML estimation			
	Wt1	*Wt2*	*Wt1*	*Wt2*	*Wt1*	*Wt2*
LnRD	0,328		0,304	0,301	0,301	0,291
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)
LnHTS	0,504		0,462	0,450	0,449	0,443
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)
LnMAN	1,348		1,290	1,271	1,292	1,284
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)
W1lnRD			0,077	0,073	0,067	0,064
			(0,001)	(0,002)	(0,010)	(0,014)
W2lnRD				0,026		
				(0,282)		
W1lnHTS					0,059	0,045
					(0,323)	(0,459)
W2lnHTS						0,084
						(0,195)
Dummies	Yes		Yes	Yes	Yes	Yes
R2-adj	0,954		0,955	0,955	0,954	0,954
AIC	431,05		421,99	422,82	422,99	423,32

	OLS estimation		ML estimation			
	Wt1	*Wt2*	*Wt1*	*Wt2*	*Wt1*	*Wt2*
LM-ERR	4,608	0,117				
	(0,032)	(0,732)				
LM-LAG	7,407	2,622				
	(0,006)	(0,105)				
LR test			11,055	9,736	7,052	6,467
			(0,001)	(0,002)	(0,008)	(0,011)

P-values are shown in parentheses. Wt1 and Wt2 are the first order and second order technological contiguity matrices.

Conclusions

The aim of this article was to shed some light on the role of both geographical and technological distance in the knowledge diffusion process and to show how a group of KIBS, those called high-tech services (HTS), accounts for a significant part of the regional innovation process. As in previous works on knowledge spillovers, innovation was measured by the average of the number of patents applied by firms at the European Patent Office. As for HTS, their share in total regional employment was employed.

The exploratory analysis carried out by means of the Moran´s I test shown positive and significant standardized values thereby confirm the need for introducing spatial dependence both for patents and HTS. Our starting point was the KPF introduced by Griliches (1979) and Pakes & Griliches (1984) and pioneering modified by Jaffe so as to take into account knowledge spillovers in 1989 (Jaffe, 1989). In its basic form, the KPF relates an output measure for knowledge to the research and development performed. In our approach we also take into account other factors: the presence of HTS and manufacturing activities and social and institutional differences among nations. The benefits associated to the presence of HTS were pointed out in the introduction: they act as sources, facilitators and carriers of innovation (Den Hertog & Bilderbeek, 1998; Den Hertog, 2000; Muller & Doloreux, 2009) and even contribute to bridge the gap between the knowledge residing in the scientific community and the application of this knowledge (Bishop, 2008). As for the presence of manufacturing, it is clear that a strong industrial structure generates benefits not only in terms of greater cooperation possibilities among firms but also affecting the propensity to innovate. Other factors such as social and institutional conditions can determine the rhythm of innovation, as they make some nations more prone to innovate and adopt and transform knowledge than others (Asheim & Gertler, 2005). But the explanatory capacity of these factors is constrained by the fact that regions rely not only on their own efforts and characteristics but also on their capacity to attract and assimilate knowledge produced elsewhere. In other words, interactions among individuals, firms and institutions produce the transmission of knowledge in the form of knowledge spillovers. So our extended model examines two major aspects: the existence of knowledge spillovers (by introducing spatial lags of the innovation variable) and the impact of the availability of HTS (by incorporating both the presence of HTS in the same region and the presence of HTS in neighboring regions, namely, the spatial lags of the HTS variable).

The results obtained confirmed those of previous works: the elasticities for R&D expenditures and manufacturing were positive and significant as well as most of the dummy variables. Negative fixed effects were obtained for southern countries and new member countries, pointing out a poorer innovation capacity in comparison with central and northern European countries.

As for knowledge spillovers, first-order geographical and technological proximity influences patenting activity, although the latter is far less important. This shows that, despite the opportunities to codify knowledge and transmit it over long distance have increased due to new technologies; proximity makes access to knowledge easier, and, as a result, fosters innovation.

In the case of HTS, the elasticity for the share of HTS in regional employment was positive and a geographical distance decay effect was obtained, being the parameters for both the first and second order geographical neighborhood positive and significant. In other words, HTS significantly contribute to regional innovation because they do not only exert a positive impact on innovation in the regions where they are located but also in neighboring regions. On the contrary, technological neighborhood did not affect HTS

In essence, the two major findings of this analysis are following. For one part, inter-regional knowledge flows are key elements for explaining regional innovation performance, and, for the other part, regions with a higher specialization in HTS, or proximate to regions with a higher presence of HTS, tend to innovate more, mainly because HTS can improve their capacity to transform knowledge into innovation.

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Mercedes Rodriguez

Inovacijų, žinių sklaida ir moderniųjų technologijų paslaugos Europos regionuose

Santrauka

Šiuo metu regioniniai skirtumai yra pagrindinė daugelio sričių, tokių kaip ekonomika, politika ar geografija tema, nes jos laikomos vienu svarbiausių elementų nustatant regioninio augimo skirtumus. Tokie veiksniai kaip investicijos į tiriamąją ir plėtros veiklą arba socialinės ir institucinės sąlygos, sudaro regioninės inovacijos esmę. Tačiau regionų plėtra priklauso ne tik nuo savo pačių pastangų bei savybių, bet ir nuo gebėjimo pritraukti ir įsisavinti kitur sukurtas ir sukauptas žinias/informaciją. Kitaip tariant, bendraudami tarpusavy individai, įmonės ar institucijos gautas žinias/ informaciją vienaip ar kitaip paskleidžia aplinkai. Jos gali būti klasifikuojamos į *aiškias* ir *numanomas*: aiškias žinias galima lengvai koduoti ir perduoti tolimais atstumais nemokamai. *Numanomoms žinioms* perduoti reikia asmeninio bendravimo, kur atstumas neigiamai veikia tokį bendravimą. *Žinioms imlių verslo paslaugų* (ŽIVP) atveju, viena iš svarbiausių savybių yra ta, kad jos sugeba pritaikyti ir paskleisti *numanomas žinias*. Nors naujausi tyrimai leido geriau suprasti ir įvertinti ŽIVP *numanomų žinių* skleidėjo vaidmenį, tačiau pats ŽIVP egzistavimo erdvinis poveikis yra mažai tirtas. Žvelgiant iš regioninės perspektyvos, paminėtinas novatoriškas Strambach (1998) darbas, kuriame taikoma *besimokančių regionų teorija,* norint apibūdinti du svarbiausius poveikio tipus: *tiesioginį ir netiesioginį*, kuriuos inovacijoje vykdo ŽIVP. Tiesioginis poveikis nurodo pačių naujovių plėtrą (gaminio, proceso arba organizacinę). Jis yra klasifikuojamas į keturis tipus: žinių perdavimas, skirtingų žinių ir kompetencijų išteklių integracija, esamų žinių pritaikymas specifiniams klientų poreikiams ir naujų žinių kūrimas (Strambach, 1998; Simmie ir Strambach, 2006). Be to, ŽIVP yra susijęs ne tik su žinių kūrimu ir perdavimu kitoms įmonėms/ įstaigoms, bet taip pat turi įtakos papildant ir pritaikant šias mokslinės bendruomenės žinias (Bishop, 2008). Šiame straipsnyje į vieną modelį bandoma sujungti žinių pasklidimą ir ŽIVP grupės, kuri vadinama *modernių technologijų paslaugomis* (MTP) egzistavimą. *Straipsnio tikslas atskleisti geografinio, technologinio atstumo svarbą skleidžiant žinias/ informaciją, taip pat parodyti, kaip MTP paaiškina svarbią regioninio inovacijų proceso dalį.*

Žinių/ informacijos paskleidimas ir MTP poveikis inovacijoms yra sumodeliuoti panaudojant išplėstinės *žinių kūrimo funkcijos* (ŽKF) struktūrą, kuri buvo pritaikyta 240 Europos regionų 23-ose šalyse: Austrijoje, Belgijoje, Čekijos respublikoje, Danijoje, Estijoje, Suomijoje, Prancūzijoje, Vokietijoje, Graikijoje, Vengrijoje, Airijoje, Italijoje, Latvijoje, Lietuvoje, Olandijoje, Lenkijoje, Portugalijoje, Rumunijoje, Slovakijoje, Slovėnijoje, Ispanijoje, Švedijoje ir Jungtinėje Karalystėje. Dauguma regionų yra priskiriami NUTS II lygiui (232), nors penkios šalys buvo analizuotos lygiu NUTS 0. Danijos, Estijos, Latvijos, Lietuvos ir Slovėnijos bei Belgijos regionai apima NUTS I lygį.

Straipsnyje analizuojama išplėstinė- erdvinė, svarbiausia mus dominančių kintamųjų analizė: inovacijos ir MTP. Tam panaudojama erdvinės priklausomybės statistika: Moran-o I (Moran, 1948). Erdvinės priklausomybės egzistavimas reiškia, kad modernių inovacijų lygių (arba MTP) buvimą viename regione paaiškina ne tik kiti kintamieji, bet ir inovacinė veikla (arba MTP buvimas) kaimyniniuose regionuose. Panaudoti du matricų tipai: geografinio ir technologinio artumo matricos. Geografinio artumo matricoje w_{ij}=1, jei regionai i ir j turi bendrą sieną ir 0 kitu atveju. Pirmos eilės geografinio artumo matrica apima artimiausius nagrinėjamo regiono kaimynus, o antros eilės geografinio artumo matrica atsižvelgia į kaimynų kaimynus. Norėdami apskaičiuoti technologinio artumo matricas, mes pasinaudojome Jaffe (1986) pasiūlymu ir sukūrėme koeficientus p_{ij}. Jei regionų i ir j technologiniai profiliai yra panašūs, p_{ij} yra artinas 1. Priešingu atveju, jei jie yra skirtingi, koeficientas bus artimas 0. Pirmos eilės technologinio artumo matrica apima (kiekvieno regiono), tris regionus, turinčius aukščiausias p_{ij} vertes. Antros eilės technologinio artumo matrica apima tris regionus turinčias, antras pagal dydį aukščiausias p_{ij} vertes.

Tyrimo metu buvo atsižvelgta ir į kitus veiksnius: MTP gamybinės veiklos egzistavimą bei socialinius ir institucinius skirtumus tarp šalių. Regioninio lygio inovacijos yra vertinamos pagal vidutinį skaičių patentų, kuriuos įmonės/įstaigos pateikė *Europos patentų biurui* nuo 2004 iki 2006 metų. Mokslinio tyrimo ir projektavimo konstravimo darbų išlaidos reiškia bendras išlaidas mokslinio tyrimo ir projektavimo konstravimo darbams, atsižvelgiant į regioninį bendrąjį vidaus produktą (BVP). MTP gamybos egzistavimas buvo nagrinėjamas atitinkamai įvertinant įdarbinimą MTP ir įdarbinimą gamyboje, taip pat visame regione. Kadangi šiame darbe yra naudojamasi atrankiniais duomenimis, kiekvienas kintamasis yra apskaičiuojamas kaip trijų metų vidurkis taip, kad būtų galima palyginti vidutinio/ilgo laikotarpio vertes. Taip pat mes manome, kad reikia kažkiek laiko, kad tyrimo ir plėtros rezultatas taptų patentu. Dėl šios priežasties manoma, kad struktūra vėluoja du metus. Tokiu būdu, nagrinėjamas *priklausomas* kintamasis yra paimtas iš 2004-2006 metų laikotarpio, o *nepriklausomi* kintamieji yra skaičiuojami 2002-2004 metų laikotarpiui. Visi duomenys buvo paimti iš *Europos Sąjungos statistikos biuro* (Eurostat).

ŽKF dažniausiai yra modeliuojamas naudojant Cobb-Douglas kūrimo funkciją. Nagrinėjamu atveju yra apskaičiuojami stiprūs Lagrange koeficieto testai erdvinio vėlavimo (LM-LAG) ir erdvinės klaidos (LM-ERR), norint nustatyti erdvinės priklausomybės tipą: *savarankiškas* (erdvinis vėlavimo modelis) ar *trukdantis procesas* (erdvinės klaidos modelis), taip pat suformuoti *erdvinį modelį*. Panaudodami *savarankišką* modelį ŽKF atvejui, galime įtraukti žinių paskleidimo egzistavimą, manydami, kad inovacijos kaimyniniuose regionuose daro teigiamą įtaką regioninei inovacijai. Taip pat nagrinėjama galimybė, kad inovacija regione priklauso nuo MTP egzistavimo kaimyniniuose regionuose.

Standartinės Moran-o I statistikos vertės yra teigiamos ir svarbios visais atvejais. Jos parodo teigiamos erdvinės priklausomybės egzistavimą. Kalbant apie vertinamus modelius, reikia pasakyti, kad remiantis ankstesniais darbais, pastebėta teigiama mokslinio tyrimo ir konstravimo projektavimo darbų išlaidų įtaka patentų skaičiui. Be to, MTP egzistavimas atlieka svarbų ir žymų vaidmenį, esant lankstumui 0.504. Kaip buvo tikėtasi, didesnė gamybinės veiklos koncentracija taip pat prisideda prie patentinės veiklos. Dauguma dirbtinių kintamųjų yra svarbūs, išskyrus Belgiją, Daniją, Graikiją, Airiją ir Švediją. Užfiksuotas neigiamas poveikis buvo gautas pietinėms šalims (Ispanijai, Italijai ir Portugalijai) ir naujoms šalims narėms (Slovėnijai, Slovakijai, Estijai, Vengrijai, Latvijai, Lietuvai, Lenkijai, Čekijos respublikai ir Rumunijai). Tai parodo šių šalių blogesnius inovacinius gebėjimus, kurie pasireiškia atlikus mūsų mokslinių tyrimų ir projektavimo konstravimo darbų išlaidų kontrolę ir esant MTP ir gamybai.

Raktažodžiai: *žinių kūrimo funkcija, sklaida, moderniųjų technologijų paslaugos, erdvinė analizė, Europos Sąjunga, regionai.*

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