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## Knowledge Creation vs Knowledge Co-Production: Knowledge Intensive Business Services and Innovative Activity in EU Regions

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# Knowledge Creation vs Knowledge Co-Production: Knowledge Intensive Business Services and Innovative Activity in EU Regions

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## Abstract

Regional economies are continuously evolving toward a tertiarization of the production systems. Despite the increasing relevance of services, however, the analysis of innovation at the regional aggregate level has mainly focused on manufacturing, gathering the attention on the role of R&D expenditure as input in the production process and, in some cases, accounting for research-based knowledge externalities.

In this paper the role of Knowledge Intensive Business Services is studied and their contribution to the regional aggregate innovation is evaluated. The aim is twofold. First is to provide insights on the role covered by KIBS as a second knowledge infrastructure. Second is to examine the extent to which KIBS operate as bridges between the general purpose analytical knowledge produced by scientific universities and more specific requirement of innovative firms.

A role commonly acknowledged to KIBS is in fact that of knowledge transferors. If on the one side it is however clear to whom they transfer knowledge, their client firms, on the other it is not as clear from whom the knowledge is originally transferred. For this reason a major attention in this work is dedicated to scientific universities considered as a primary source of knowledge. Being this knowledge analytical and highly codified, it probably can be more easily accessed by nearby located firms having higher opportunities of research collaboration and less easily by firms located in different regions. It is argued that KIBS, in transferring knowledge from universities to firms, are therefore specially important in the latter case.

The empirical analysis is based on a sample of 200 EU NUTS II regions and the evidence suggests that the contribution of KIBS to regional innovation is considerable.

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Furthermore it is found that this contribution is more sizeable in regions in which there are not scientific universities.

## 1 Introduction

The Jaffe's formulation of the Knowledge Production Function (KPF) (Griliches [12], Jaffe [13]) is a widely adopted approach to study the determinants of innovation at the regional aggregate level. To put it shortly, innovative output is determined by the amount of research made by private firms and by universities, allowing the output elasticity to research to be larger in correspondence of the geographical coincidence between private firms and university research. This gain in input productivity is attributed to the presence of localized knowledge spillovers between universities and industries. The attribute of localized knowledge spillovers, described as involuntary transfer of knowledge between firms and/or institutions, is explained by the sticky character of knowledge (Von Hippel [27]). Accordingly some knowledge is difficult to be codified and can be transmitted only through face-to-face contacts and frequent interactions.

At the empirical level the model has been estimated by using patent applications as a measure of aggregate innovative output and several studies have reported evidence of a positive effect of knowledge spillovers usually attributed to university-industry collaborations (see Anselin et al. [4], Fischer and Varga [11] and Ponds et al. [22] among the most significant studies.). In their survey of the Geography of Innovation literature Audretsch and Feldman [6] report that the use of other measures of input and output (for instance R&D personnel as alternative input and literature-based measures as alternative output) have usually yielded to very close empirical results.

Despite the general agreement about the robustness of the evidence provided by the use of Jaffe's approach in empirical studies, few attention needs to be deserved to some critical issues. The first worth-considering issue is the extent to which the benefits of co-location of universities and industries could be actually ascribed to the presence of knowledge spillovers. At the micro level Mansfield [17] has documented that the relations between universities and firms are mostly market relations which take place in the form of consulting services. Similarly Zucker et al. [29] find evidence that *"the positive impact of research universities on nearby firms relates to identifiable market exchange between particular university star scientists and firms and not to generalized knowledge spillovers"*. Consequently the use of Jaffe's formulation might determine empirical evidence which, failing to account for market externalities, overestimate the effect of knowledge spillovers.

A second important issue relates to the role played by physical distance in the dissemination of knowledge. In both the cases of market mediated knowledge exchange and pure knowledge spillovers, there is no doubt that distance matters. It is claimed that physical distance, per se, is neither a necessary nor a sufficient condition for learning (Boschma [7]) but, admittedly, learning and interacting is easier if the distance is short. Therefore the probability of undertaking collaborations is expected to decrease with the distance separating universities and firms<sup>1</sup> and, in addition, if

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<sup>1</sup>Ponds et al. [23] provide robust empirical evidence supporting this theoretical hypothesis.

firms and universities are located in two different regions it is expected to be less easier for firms to generally access the knowledge produced by universities.

Long distances do not however imply that academic knowledge is inaccessible. As far as it concerns the mechanisms of knowledge dissemination other than direct interaction, a recent literature has acknowledged the role played by so-called Knowledge Intensive Business Services (KIBS) as producers, providers and, more important, transferors of knowledge (Den Hertog [10]). In particular, according to Den Hertog, KIBS might represent a *"point of fusion"* between more generic global knowledge, as it is that produced by scientific universities, and specific needs of local firms.

The investigation of the role played by KIBS in supporting firms innovation has recently began to receive attention in firm-level empirical studies (see Cainelli et al. [8] [9] as an example of micro-econometric analysis). Meantime less has been already studied about the contribution of KIBS at the regional aggregate level. In this a spatial econometric analysis of the innovative performance relative to a sample of 200 EU regions is presented and two primary hypothesis are tested. The first hypothesis relates to the participation of KIBS in the production of innovation at the regional level. In more detail it is examined the extent to which the regional concentration of KIBS represents a considerable factor in explaining the regional variation in the level of innovative activity. The second hypothesis more specifically relates to the exact role played by KIBS. As an intermediate level knowledge infrastructure, the activity of KIBS is expected to be more influential for firms in those regions in which scientific and academic knowledge is locally absent and, consequently, not directly accessible.

In an attempt to measure the scientific and academic knowledge in the region a new variable is constructed which, contrarily to R&D investments made by universities, is expected to be not biased by the existence of market transactions between universities and firms. The variable is first included in the KPF framework and further used to differentiate the sample of regions endowed with scientific knowledge from the remaining of regions which are not. The empirical models are specified accounting for the presence of spatial relations and spatial interactions between neighbouring regions and are eventually estimated by using heteroschedasticity-consistent estimator for spatial models developed by Arraiz et al. [5] and Kelejian and Prucha [14].

The evidence suggest that KIBS do actually contribute to the regional production of knowledge, mainly as co-producers of innovations assisting their client firms and providing them with the necessary soft skills. Furthermore there is evidence that KIBS working in high-tech sectors can be qualified as scientific knowledge transferors, but only in regions where the scientific and academic knowledge is absent. Oppositely in presence of scientific and academic knowledge in the region R&D investments by private firms continue to be the most productive way to internalize scientific knowledge. Overall the results in this paper indicate KIBS as a second infrastructure which, together with research spillovers, contribute to the dissemination of scientific knowledge. The remaining of the paper is organized as follows. The next section is aimed at defining what KIBS are and what is, at least according to the existing theoretical literature, their contribution to the regional innovation. In the third section the dataset is illustrated, paying special attention the the issue of measuring scientific and academic knowledge. Empirical results are summarized and discussed in section four. Conclusion follow.

## 2 KIBS and Innovation

The attention to business services has increased over time together with the progressive shift of national and regional economies from manufacturing-based production systems to more service-oriented development paths. According to Shearmur and Doloreux [24] such an increase in attention has been channelled differently from geographers and innovation economists. For the sooner group of scholars the emphasis was on the urban location of High Order Producer Services<sup>2</sup> (HOBS) and, thus, on the role of cities in a dualistic picture of the regional production separated in manufacturing activities and service firms. From the viewpoint of innovation economists, oppositely, the focus has been more on the role of service firms in the production of knowledge and only to a lower extent on the distinction between manufacture and services. Admittedly, the two different conceptualisations actually identify, at the empirical level, the same sectors (Wood [28]).

In a recent survey of the KIBS literature Muller and Doloreux [18] highlight three most important characteristics of KIBS, at least based on the existing definitions. A first characterizing feature is the explicit orientation of the provided services to business enterprises and not to private consumers. Secondly there is the implicit transfer of knowledge between the service firm and the clients (i.e. the business enterprises). Finally the provision of the services is realized with the predominant activity of human capital. Accordingly, the role of KIBS is intermediate in nature but, nonetheless, it still appears to be difficult to disentangle what their exact contribution to innovation is made up of.

The contribution of Den Hertog [10] has represented the point of departure in the analysis of the role played by KIBS in the process of innovation. In his work the *"symbiotic nature"* of the relation between KIBS and their clients is emphasized and it is accordingly argued that KIBS act as co-producers of innovation together with their client firms. This in turn indicates that KIBS do not innovate themselves but nonetheless play a fundamental role in assisting manufacturing firms in the innovation process. The idea of co-production is further categorized in the work of Den Hertog in three main dimensions, attributing to KIBS the role of facilitators, carriers and sources of innovation. As facilitators of innovation the role of KIBS is that of bare support to the client manufacturing firm, from which the innovation anyhow originates. As carriers of innovation KIBS act as transferors of existing knowledge to the client firm. The KIBS mediation is motivated by the fact that the knowledge source is generally not directly accessible to the client firm. Also in this latter case the innovation process originates within the client firm but now the contribution of KIBS is more remarkable. Finally as sources of innovation KIBS do initiate the innovation process in place of the client firms and further develop the innovation in close collaboration with them.

All these elements qualify KIBS as a second knowledge infrastructure which, alongside universities and public research institutes (which are considered the first knowledge infrastructure) contribute to the diffusion of knowledge. Remarkable dif-

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<sup>2</sup>As it is noted by Shearmur and Doloreux [24], the term has been in use to identify business firms providing their clients with management and consulting services and so to distinguish them from providers of more general business services.

ferences however exist between the two knowledge infrastructures especially regarding their relative contribution to the creation and dissemination of knowledge and, consequently to innovation in firms. Research is carried out by universities and public research institutes (hereinafter UPRI) systematically, with structured projects and usually long term horizons. Moreover UPRI projects are designed and developed by specific departments in which the process of knowledge creation is highly formalized and extensively based on R&D investments. On the contrary research is approached by KIBS in a less systematic and structured manner which better accommodates their problem-solving objective. Innovation is not realized through R&D investments but instead via frequent interactions with clients, during which knowledge is mutually exchanged in the attempt to apply general purpose technologies to solve firm-specific problems. (Simmie and Strambach [25]). Due to that university-industry cooperation is more likely to take place with firms in R&D intensive industries, having these firms the know how and the organizational structure which is necessary to engage in cooperation projects with UPRI. Likewise collaboration between KIBS and firms is more likely in the case of SMEs which are surely willing to engage in innovative projects but, at the same time, lack the specific know how to do that<sup>3</sup>. Muller and Zenker [19] describe the innovation taking place with the interaction between KIBS and firms as a process of re-engineering of existing knowledge which, accordingly does not require that any or both invest in R&D.

In spite of the fact that the knowledge creation process largely differs between KIBS and UPRI, to some extent their relative contribution to innovation can be considered as overlapping. Based on the Pavitt definition of industries (Pavitt [20]) Strambach [26] distinguishes two types of knowledge. Analytical knowledge is generated on the base of formal models of research and development and within structured research programs. This knowledge is mainly explicit (as in the case of publishing or patenting) but is highly codified and hence difficult to access. Synthetic knowledge is on the contrary generated by applying generic knowledge to specific problems and, consequently is usually considered as tacit. The knowledge developed within UPRI undoubtedly belongs to the first category but, conversely, not necessarily knowledge developed by KIBS in collaboration with their clients belongs to the second. In fact Strambach defines, according to the type of knowledge used, two categories of KIBS, distinguishing R&D consulting oriented KIBS, which use analytical knowledge, from technical and economic oriented KIBS, which use synthetical knowledge<sup>4</sup>.

To sum up KIBS are service firms which not only contribute to innovation by transferring knowledge from various sources to manufacturing firms. KIBS actively participate in the creation of new knowledge by interacting with their client firms with the aim of adapting to specific needs some general purpose technologies (Muller and Doloreux [18]). In doing these they act as bridges between generic knowledge and more specific problems of firms. In the specific case of R&D consulting firms KIBS represent a bridge between analytical knowledge developed by UPRI and firms to which such a knowledge is inaccessible.

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<sup>3</sup>Kleinknecht [15] observes that the lack of adequate know how is likely to be among the most important obstacles to innovation in small and medium size firms. For these firms R&D investments might be insufficient for innovation.

<sup>4</sup>Actually Strambach defines a third category of KIBS, oriented to marketing and advertising, which makes use of what he calls *symbolic* knowledge, particularly relevant in the culture and creativity industries.

The present paper aims at contributing to the existing empirical literature, mainly grounded on either case studies or micro-level analysis, by providing insights from the regional aggregate level analysis. Accordingly, the contribution of KIBS to aggregate regional innovation is examined pinpointing two specific hypothesis.

**Hypothesis 1** New knowledge is produced not only through internal R&D investments and some firms might prefer to rely on external sources of knowledge to innovate. Alongside the more traditional first knowledge infrastructure, represented by universities and public institutes, also the localized concentration of KIBS, corresponding to a second knowledge infrastructure, is expected to be positively related with the level of regional innovative performance.

**Hypothesis 2** University knowledge, being analytical and highly codified, can be more easily accessed by firms located nearby universities, having these firms higher probabilities to engage in research collaborations with universities. At the regional aggregate level the relative contribution of R&D investments is thus expected to be more sizeable in regions where firms and universities are co-located and, contrarily, external knowledge sources like KIBS are expected to contribute more in regions where university knowledge is less accessible for firms. Especially R&D consulting firms are expected to contribute more in the latter case provided that they act as bridges between academic and scientific knowledge and the demand of knowledge by local firms.

### 3 Empirical Approach and Data

Regional innovation is studied by adopting the standard Griliches-Jaffe's framework. The regional innovative activity, as measured by patent applications per millions of inhabitants, is related to the amount of expenditure in research made by both firms and universities, measured as shares of Gross Domestic Product (variables in log). This empirical framework is applied to a sample of 200 European NUTS II regions for which the necessary data were available. The dependent variable  $pa_i$  is measured as the average for the years 2006-2007 while the covariates are taken in a previous period (average 2003-2005) in order to avoid the estimation bias due to simultaneity between input and output.

As discussed in the introduction of this work, the use of research expenditure in universities might reveal not a good measure for the identification of spillovers related to university-industry collaborations and thus a second additional measure is used. This measure (*rank*) is obtained by counting the number of regional universities ranking in the top 500 positions of the ARWU ranking<sup>5</sup> (Shanghai Ranking) and weighting their relative position. More in the detail the ranking has been constructed based on the classification of only European Universities and the final measure is the sum of the regional universities present in the ranking multiplied by a factor which was set increasing with the relative score of the university. In such a manner it is guaranteed that the presence of an university scoring in the top 100 of the ranking is valued more respect to the presence of an university scoring between 400 and

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<sup>5</sup>Rankings are available at the website <http://www.arwu.org/>.

500<sup>6</sup>. The advantage of such a measure is that ranking is constructed on the base of publications and citations and hence represents a piece of knowledge completely accessible. Differently from university knowledge accessed through R&D, any market transaction between universities and firms is not necessary. Moreover while R&D expenditure might be registered by universities operating also in non scientific fields of research the ranking is based on publications and citations in only top scientific journals, making the measure a better proxy of the amount of scientific knowledge which can be accessed by within the region.

For the goal of hypothesis testing the empirical specification of the model proceeds in two steps. In the first it is tested the hypothesis that KIBS do contribute to aggregate regional innovation (*Hypothesis 1* in the previous section). The basic model specification is extended by including the share of regional employees in KIBS (*kibs*) on the regional employed population (equation 1). The empirical model is further re-specified by using only the share of workers in high tech KIBS (*kibsh*) and market KIBS (*kibsmkt*)<sup>7</sup>. In the second it is tested that the contribution of both R&D expenditures and KIBS concentration to regional innovation varies across regions based on the presence, within the region, of a top-quality universities, as indicated by the *rank* variable (*Hypothesis 2* in the previous section). Therefore the general model is estimated separately for *university regions* and *non-university regions* (equation 2).

More in the detail, the first hypothesis is tested through inference on the  $b_5$  parameter in equation 1. The parameter is expected to be greater than zero. Likewise the coefficients  $b_1$  and  $b_2$ , respectively related to the amount of private firms R&D and university R&D are also expected to be positively sloped. Finally, the  $b_4$  coefficient, which is related to the market potential of the region<sup>8</sup>, is also expected to be positive.

$$pa_i = a + b_1berd_i + b_2urd_i + b_3rank_i + b_4mp_i + b_5kibs_i + e_i \quad (1)$$

The expected value of the  $b_5$  coefficient continues to be greater than zero when *kibs* is substituted in the model with either *kibsh* or *kibsmkt*. Especially the expectation on the coefficient related to *kibsh* is positive because of the peculiar role attributed to KIBS in using analytical knowledge to bridge the availability of technological innovation and the successful application of it to solve the problem of firms. The coefficient related to *kibsmkt* is also expected greater than zero but, in this case, because the availability of specialized providers of market services can stimulate the part of innovation based on the so-called *soft skills*.

The second hypothesis is tested by comparing the coefficient estimates in the two groups (regimes) of regions. One regime is characterized by the presence of at least one top-ranked university (which corresponds to the condition  $rank > 0$ ).

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<sup>6</sup>More information on the procedure are available to the authors upon request

<sup>7</sup>The choice to identify only two additional sub-categories is made based on the general definition of KIBS used in this paper and in the majority of the literature, according to which KIBS are predominantly business-oriented. The Eurostat definition includes in fact also non-business services in the general definition of KIBS (like financial services which are not-exclusively business oriented), while actually only business services are considered in the definition of high-tech KIBS and market KIBS. For a more detailed description of the European classification see the appendix.

<sup>8</sup>Such a measure is included as control variable in the model specification in an attempt to control for the size of the regional market. It refers to the year 2006 and is available at the ESPON project website [www.espon.eu](http://www.espon.eu).

By the opposite, the second regime groups regions without top-ranked universities. Accordingly, a dummy variable  $R$  is created taking non-zero value if at least one of the top-ranked universities is located in the region. The structural formulation is summarized in the equation 2;  $X = (berd, urd, mp, kibs)$  is a matrix of covariates and  $d' = (a, b_1, b_2, b_4, b_5)$  is a vector of related coefficients. The formulation allows the expected value of each coefficient to vary across the two regimes (the values in the  $d_1$  vector represent the differences between the two). In particular the coefficient related to *berd* is expected to be larger in regions in the university regime and the one related to *kibs* in regions belonging to the non-university regime.

$$\begin{aligned} pa_i &= X_i' d + ui \\ d &= d_0 + d_1 R \end{aligned} \tag{2}$$

Spatial autocorrelation in the data is accounted for by using a suitable spatial econometric model indicated by a battery of specification tests and, if necessary, using heteroskedasticity consistent estimation methods for spatial data which are described in the next section.

## 4 Results

The empirical analysis of the innovative activity in the sample of EU regions starts with the estimation of the model described in the equation 1 with OLS methods. The estimation output is summarized in the table 4. In the first column (model (a)) the variation in regional innovative activity is explained by the only private and university expenditure in research and, additionally, by the size of the regional market. Both coefficients related to research are positive and significant. Moreover the estimate relative to the private research is more than double of the one relative to university research. As expected also the coefficient related to the market potential is positive and significant. In the second column (model (b)) the *rank* variable is added. Its coefficient is positive and significant and the inclusion of this variable does not alter the main results described above. The variable *kibs* is further introduced in model (c) and enters into the model with a positive and significant coefficient. It is now noticeable a significant decrease in the coefficient estimates for private and university research, especially in the latter case.

Based on the OLS estimates a series of diagnostic statistics are further computed, first to detect residual spatial autocorrelation in the data and, secondly, to choose the correct spatial model. Spatial autocorrelation in OLS residuals is detected through the *Moran's I* statistic, the value of which is always larger than its expected value under the hypothesis of spatial randomness<sup>9</sup>. The choice of the spatial model is based on two groups of tests. On the one side the usual Robust Lagrange Multipliers (RLM) diagnostics (Anselin et al. [3]) based on OLS residuals compare the most simple non

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<sup>9</sup>Under spatial randomness the statistic should show a value of  $E(I) = \frac{-1}{N-1}$ , where  $N$  indicates the number of observations. The p-values associated to the test in which the alternative hypothesis is non-randomness (two-sided test) are obtained under randomization (Anselin [2]).

Table 1: Linear Model - OLS Estimates

	(a)	(b)	(c)
<i>Intercept</i>	-4.931*** (1.119)	-4.519*** (1.121)	-7.847*** (1.300)
<i>berd</i>	0.698*** (0.073)	0.677*** (0.074)	0.590*** (0.072)
<i>urd</i>	0.319*** (0.078)	0.269*** (0.080)	0.189*** (0.079)
<i>rank</i>		0.109** (0.047)	0.092*** (0.045)
<i>mp</i>	1.634*** (0.236)	1.502*** (0.241)	1.092*** (0.247)
<i>kis</i>			1.470*** (0.326)
<i>Diagnostics on Linear Model Residuals</i>			
<i>Moran's I</i>	0.135 [0.000]	0.137 [0.000]	0.125 [0.000]
<i>RLM<sub>ERR</sub></i>	40.807 [0.000]	40.627 [0.000]	45.886 [0.000]
<i>LR<sub>ERR</sub></i>	5.460 [0.150]	5.870 [0.210]	7.860 [0.160]
<i>RLM<sub>LAG</sub></i>	3.758 [0.050]	4.969 [0.020]	0.070 [0.790]
<i>LR<sub>LAG</sub></i>	15.100 [0.000]	14.490 [0.000]	25.569 [0.000]

Notes to table 4:

SE in parenthesis. Probabilities in brackets.

\*\*\*, \*\* and \* denote significance at 1, 5 and 10% confidence levels.

spatial model with the lag (LAG) and error (ERR) alternatives<sup>10</sup>. A significant value of the statistic indicates that the relative spatial model is to be preferred to the linear model and the specification with the higher statistic is chosen. On the other side the Likelihood Ratio (LR) tests compare the most general spatial model, the Spatial Durbin model, with the lag and error alternatives, both nested in the sooner (LeSage and Pace [16]). A significant value of the statistic indicates that the most general, Spatial Durbin, model captures the spatial structure of the data better than the relative alternative and the model with non-significant statistic is chosen.

The RLM statistic is always significant when the basic model is compared to the ERR alternative while it is significant for the only models (a) and (b) when the alternative is the LAG. On the opposite the statistic turns insignificant in model (c), when *kibs* is introduced in the model specification. In any of the observed cases the value of the *RLM<sub>ERR</sub>* statistic is always larger than the *RLM<sub>LAG</sub>* one and, therefore, the preference is for the error specification. In addition the LR test is always significant when LAG is the alternative and it is never when ERR is the alternative. Also in this case the error specification is therefore preferred. Accordingly, for the remaining of the empirical analysis the Spatial Error Model (SEM) specification is used to account for spatial correlation in the data.

Estimates obtained by using the SEM specification applied to the model in equation 1 are presented in the table 4. Coefficients in the first column (model (d)) are directly comparable with those in the model (c) of table 4. Both the coefficients related to research have decreased in magnitude while, on the opposite, the coefficient

<sup>10</sup>LAG refers to the Spatial Lag Model, in which a spatially lagged dependent variable is included as explanatory variable. ERR refers to the Spatial Error Model in which the error structure of the linear model is assumed to follow a conditional autoregressive process.

related to the concentration of KIBS and to the market potential variable have increased. The only noticeable difference is that once the spatial error structure of the residuals is taken into account the coefficient for university research turns insignificant, while the coefficient for the university ranking remains significant and of the same magnitude. Finally the estimated error autoregressive parameter  $\lambda$  is always positive and statistically significant.

Table 2: Spatial Error Model - ML Estimates

	(d)	(e)	(f)
<i>Intercept</i>	-9.038*** (1.412)	-5.075*** (1.184)	-4.652*** (1.220)
<i>berd</i>	0.545*** (0.068)	0.530*** (0.072)	0.583*** (0.070)
<i>urd</i>	0.112 (0.072)	0.170** (0.072)	0.176** (0.072)
<i>rank</i>	0.091** (0.041)	0.085** (0.043)	0.079* (0.043)
<i>mp</i>	1.210*** (0.256)	1.460*** (0.255)	1.218*** (0.302)
<i>kis</i>	1.609*** (0.384)		
<i>kisht</i>		0.477** (0.206)	
<i>kismkt</i>			0.613**
$\lambda$	0.874*** (0.076)	0.878*** (0.074)	0.877*** (0.074)
<i>Diagnostic for Heteroskedasticity</i>			
<i>Spatial BP test</i>	12.229 [0.032]	9.662 [0.085]	13.239 [0.021]

Notes to table 4:

SE in parenthesis. Probabilities in brackets.

\*\*\*, \*\* and \* denote significance at 1, 5 and 10% confidence levels.

Turning the attention to the aim of the research question, it is worth noting that the coefficient relative to the regional concentration of KIBS is strongly significant. Thus the concentration of KIBS in the region positively affects the innovative activity of firms in the same region. The result does not change when the concentration of either the only high-tech KIBS (model (e)) or the only marketing KIBS (model (f)) are considered. The contribution of KIBS continues to be positive and significant and the magnitude of the estimated coefficient is larger in the latter case. When only high-tech and market KIBS are respectively considered the coefficient related to university research gains significant again.

The lowest part of the table 4 reports the result of the Breusch-Pagan test for heteroschedasticity adapted by Anselin [1, pp. 121-122] to spatial models. The null hypothesis of homoschedastic errors is always rejected, although only at a significance level higher than the common 5% in the case of model (e).

In testing the second research hypothesis an heteroschedasticity consistent estimator is applied to the spatial error specification of the model in equation 2<sup>11</sup>. The

<sup>11</sup>Actually the spatial error structure is added to the reduced form of the model in equation 2. This allows to simultaneously estimate the model parameters for the two different group of regions while

model is basically a restricted form of the general Cliff-Ord type of spatial models<sup>12</sup> in which disturbances are considered heteroschedastic. The so called HAC model is formalized by Arraiz et al. [5] and Kelejian and Prucha [14] and implemented in the *sphet* R-package by Piras [21]. It is considered restricted as long as, in order to maintain the SEM structure, the coefficient of the lagged dependent variable is arbitrarily set to zero.

Table 3: Heteroskedastic Spatial Error Model - GS2SLS Estimates

	(g)		(h)		(i)	
	uni	not uni	uni	not uni	uni	not uni
<i>Intercept</i>	-8.215*** (2.505)	-9.489*** (2.247)	-4.917** (2.286)	-5.031*** (1.541)	-4.882*** (2.259)	-4.302*** (1.691)
<i>berd</i>	0.745*** (0.097)	0.396*** (0.103)	0.719*** (0.103)	0.394*** (0.109)	0.753*** (0.096)	0.468*** (0.111)
<i>urd</i>	-0.042 (0.105)	0.121 (0.130)	-0.003 (0.104)	0.178 (0.142)	0.014 (0.102)	0.176 (0.144)
<i>mp</i>	1.354*** (0.441)	1.030*** (0.313)	1.494*** (0.486)	1.387*** (0.328)	1.405*** (0.513)	1.063** (0.481)
<i>kibs</i>	1.228*** (0.480)	1.929*** (0.629)				
<i>kibsh</i>			0.314 (0.264)	0.573* (0.343)		
<i>kibsmkt</i>					0.349	0.704
$\lambda$	(0.324) (0.456)		0.900*** (0.217)		0.900*** (0.187)	

Notes to table 4:

SE in parenthesis. Probabilities in brackets.

\*\*\*, \*\* and \* denote significance at 1, 5 and 10% confidence levels.

The estimates are obtained by using the Generalized Spatial Two Stage Least Square procedure described by Piras [21] and results are summarized in the table 4. As in the more general case the concentration of all KIBS activities is used (model (g)), but also the concentration of only high tech KIBS (model (h)) and of market KIBS as well (model (i)). In all the three cases coefficients seem to vary between the two groups of university and non-university regions<sup>13</sup>. By looking at the model (g) it emerges that the coefficient related to private firms research is positive and significant while, on the contrary, the one related to university research it is not. Also the coefficient for market potential is of the expected sign and significant and turning the attention to KIBS, the related coefficient continues to be positive and significant as well.

As expected, the *berd* coefficient is larger for the group of university regions. Investments in research made by private firms are more productive in terms of innovation in regions where top-ranking universities are localized. By the opposite, the

assuming a spatial structure of the random part of the model which is common to the two groups.

<sup>12</sup>Cliff-Ord type models are spatial models in which both a spatially lagged dependent variable is included in the right hand side of the model equation and a spatial structure is assumed for the disturbances. More details on the classification of spatial models are available in LeSage and Pace [16].

<sup>13</sup>Unfortunately an exact statistic for the significance of the differences in coefficients is not available for HAC models. While in fact a modified version of the Chow test for coefficient stability is available for general spatial models in case of likelihood-based estimation, the same version of the test cannot be used after IV/2SLS estimation.

*kibs* coefficient is larger in the sample of regions where top-ranked universities are absent. The result indicates that in absence of a scientific knowledge base publicly available, firms prefer to rely more on external sources of innovation, as provided by KIBS. Therefore the evidence suggests that actually KIBS do constitute a second knowledge infrastructure. Concerning the hypothesis on the capacity of KIBS to bridge scientific knowledge into practical innovative solutions for firms it is worth looking at the model (*h*) in which only high tech KIBS are considered. Again the estimation output indicates that there are differences between the two groups. More in the detail the *berd* coefficient continues to be larger in university regions while the *kibsht* coefficient is larger in non-university regions. Moreover, limited to the group of university regions, the *kibsht* coefficient turns insignificant. The evidence thus further suggests that in presence of wide physical distances between firms and universities firms rely on external sources of knowledge also to internalize the available academic and scientific knowledge.

## 5 Discussion and Concluding Remarks

Universities, in particular scientific ones, undoubtedly represent a valuable source of knowledge for firms. Nonetheless, the access to such knowledge is limited because of the distance, both geographical and organizational, which separates universities and firms. Low geographical distance facilitates the interaction between firms and universities as research collaboration requires frequent and continuous exchange of knowledge. As far as it concerns the organizational distance, universities, contrarily to firms, do research to get general purpose innovations which eventually find application also in fields other than those they were originally engineered for. Sometimes this field is related, sometimes it is a completely different one. Firms, at the end of the day, have to solve problems. And, for such a purpose, they generally require very specific knowledge.

Building on a theoretical stream of literature which has drawn the attention upon the so-called Knowledge Intensive Business Services as actors of innovation through knowledge transformation, this paper has examined the contribution of KIBS to the regional innovative activities. In building the empirical framework it is argued that expenditure in research and development is not the only driver of innovation at the regional level as firms, especially SMEs might prefer to rely on external sources of knowledge like KIBS are. More in the detail it is argued the KIBS work not only as generic co-producers of innovation, but also contribute in bridging the distance between the general purpose research carried out by universities and specific applications required by firms to solve problems.

The evidence in the paper confirms the research hypothesis. It is found that the regional innovative output is positively related with the amount of research carried out by private firms and by the presence of external public knowledge as well. Alongside with these two main inputs, private external knowledge, as measured by the share of workers in KIBS, also significantly contributes to explain the variance in regional innovative activity. Thus KIBS actually promote innovation at the regional level mainly working as a second knowledge infrastructure. Moreover there is evidence that such a second knowledge infrastructure is more important in the group of regions in

which the first knowledge infrastructure is absent. The analysis further reveals that this greater importance attributed to KIBS in regions where university knowledge is absent is twice motivated. On the one side it is characterized the contribution of KIBS as co-innovators of their client firms, mainly through an interactive learning process in which soft-skills are exchanged. On the other side some KIBS, like R&D consulting firms, act to bridge the analytical research carried out by universities in some regions and more specific needs of firms who are willing to innovate but lack the know-how which is necessary to re-purpose the result of analytical research to their needs.

The interpretation of the role of KIBS proposed in the present paper sheds new light on the academic and policy debate on regional innovation. From the academic perspective it is worth noting that while KIBS have already received attention in micro-level analysis, more work remains to be done at the regional aggregate level. Both in terms of theoretical conceptualization of the contribution of KIBS to the aggregate regional innovation and in the development of empirical tools which enable to understand the functioning of innovation processes in services, not only in the manufacturing. As far as policy is concerned, with the continue tertiarization of regional production systems, more attention should be deserved to monitoring the composition of different regional innovation systems. R&D targeting has represented the traditional instrument for the evaluation of innovative capacity at the regional level. This mainly because R&D based indicators allow to identify the structural nature of technological gaps in some less developed regions. However the evidence in this paper has emphasized the role played by knowledge which is not only developed within firms through formal and formalized research activities but is also produced in collaboration with third parties. The role of these third parties might thus become fundamental in the diffusion of knowledge, with the important consequences of contributing to fill the technological gap of least developed regions and of promoting the technological catch-up at the European level.

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## A Appendix

Eurostat Classification of Knowledge Intensive Services

**Knowledge-intensive high-tech services:** Post and Telecommunications (64); Computer and related activities (72); Research and development (73).

**Knowledge-intensive market services:** Water transport (61); Air transport (62); Real estate activities (70); Renting of machinery and equipment without operator, and of personal and household goods (71); Other business activities (74);

**Knowledge-intensive financial services:** Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66); Activities auxiliary to financial intermediation (67).

**Other knowledge-intensive services:** Education (80); Health and social work (85); Recreational, cultural and sporting activities (92).