Innovation and External knowledge sources in Knowledge Intensive Business Services (KIBS): Evidence from de-industrialised UK Regions

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This paper explores the effect of external knowledge sources and the uneven geography on innovation activity in small Knowledge Intensive Business Services (KIBS). It draws on results from a survey of 342 small and medium (SME) KIBS located in the UK's North East and West Midlands, both de-industrialised regions. It is shown that innovation is supported by knowledge gained from frequent interaction with customers both regional and UK based as well as international. More frequent interaction with local business networks, informal contacts and national licensing arrangements also enhances innovativeness. Various industry-specific business networks and regional government agencies act as important sources of knowledge and networking and these are more important for KIBS located in the North East. The results indicate that more frequent collaboration with regional universities and regional public sector organisations does not benefit KIBS from either region. Also, while we acknowledge a positive effect of R&D on KIBS innovativeness we argue that its effect is less important compared to regional and extra regional knowledge sources.

Keywords: KIBS; innovation; external knowledge; knowledge networks; de-industrialised regions; R&D; policy

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1 Introduction

Knowledge Intensive Business Services (KIBS)[1] have been found to demonstrate some of the highest levels of innovation in most developed economies (Miles et al. 2017). As contributors to innovation in other firms, they have been described as key innovation

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[1]Most KIBS markets are dominated by national and international KIBS which offer and often combine expertise in management consulting, accountancy, finance, marketing and advertising, digital, ICT and software and technical and engineering applications. In the UK, their national head offices are usually located in London and the South East. Their presence in other regions is that of corporate branch offices and an array of KIBS SMEs.

intermediaries or "brokers" that excel at connecting innovative ideas as well as translating and transmitting new knowledge into commercial outputs (Tether and Tajar 2008, Doloreux and Shearmur 2010, Doloreux and Shearmur 2012, Asikainen 2015). KIBS are strongly related to innovation processes, which are a key catalyst for growth and economic development, as they facilitate innovation by interfacing between the generic knowledge available in the economy and tacit knowledge located within firms (Braga et al. 2017) and in so doing improving their own innovative performance. This bridging function places KIBS on a par with universities and other research and technology organisations (den Hertog 2002, Rodriguez, Doloreux and Shearmur 2017).

Knowledge is the key competitive resource for all KIBS but, like other service firms (Snyder et al. 2016), KIBS are varied in what they do and they follow heterogeneous innovation patterns (Zieba et al. 2017). KIBS are often broadly categorised in two groups, namely professional services (P-KIBs) and technological services (T-KIBS). P-KIBs are intensive users of technology including consulting, market research and advertising services, while T-KIBS focus on information and communication technologies (ICT) and other technical services such as engineering, technical testing and support (Miles 2008, Doloreux and Shearmur 2012). Another distinction is that P-KIBS rely more on external sources of knowledge, while T-KIBS rely more on internal resources such as in-house R&D (Zieba et al. 2017) but also on interaction with universities. Based on this, KIBS do not have to be technologically intensive but they are always knowledge intensive (Braga et al. 2017).

It is well known that KIBS are mostly concentrated in major metropolitan areas (Shearmur and Doloreux 2015). However, in this paper the focus is on KIBS located in de-industrialised regions. Underlying our interest in KIBS located in de-industrialised regions is an ongoing debate in the territorial innovation literature. Two principal positions dominate this debate. On the one hand, many researchers emphasise the importance of localised innovation systems. Large body of literature shows that closer geographical interaction between firms and customers as well as other sources such as suppliers, informal networks, regional business and industry specific networks as well as universities enhances innovativeness. In practice Pinto et al. (2015) find that absorptive capacity (i.e. the ability of firms to absorb and make commercial use of knowledge located elsewhere) is a central dimension in interactions with universities for KIBS. It follows that firms in more peripheral and de-industrialised regions may be at a disadvantage due to lack of variety of knowledge sources and associated networks (Asheim and Coenen 2005).

On the other hand, network theory[2] considers geographic proximity as, at best, a support for the social and cognitive proximities that drive innovation (Boschma, 2005; Boschma and Frenken, 2010). In particular, it is argued that firms in metropolitan areas *do not* have a distinct advantage (in terms of innovation) over firms located elsewhere (Shearmur and Doloreux, 2015). Following the latter argument, even firms located in the periphery can access knowledge located elsewhere, especially given that a significant amount of information and contact with and within business can take place online (MacPherson 2008). Another important theme which cuts across both strands of this literature is again related to the role of absorptive capacity.

What has emerged from the previous KIBS literature is the two-way relationship between KIBS as innovators and the process of innovation by which they become more innovative as they interact with clients and other organisations. What is not consistently argued in previous studies is the relative importance of external knowledge acquisition versus internal resources such as investment in R&D (Zieba et al. 2017), the geographical scope of the former and the role of context (Uyarra 2010). Hence, we explore two inter-related themes in our analysis. First, we investigate the role of geographies of knowledge networks and the role of R&D in KIBS' innovation. Second, we pay attention to the context within which KIBS function by investigating whether being located in de-industrialised regions makes a difference to KIBS' innovation success and knowledge sourcing strategies.

To contribute to this debate, therefore, the paper aims to answer the following research question: What specific innovation strategies prove effective for KIBS located in de-industrialised regions? We consider whether such KIBS collaborate more with certain types of regional and non-regional partners and/or build internal capacities such as R&D to compensate for their distinct position. KIBS were initially identified according to Standard Industrial Classification (SIC) and they were further distinguished between T-KIBS and P-KIBS in line with Miles (2008).

[2] See Ter Wal and Boschma (2009), for a more comprehensive literature review on networks.

Apart from providing novel theoretical and empirical insights about KIBS' territorial innovation processes, we also aim to contribute to the current policy debate related to UK regional productivity puzzle. The West Midlands and the North East are two English regions that systematically underperform compared to OECD and EU productivity benchmarks, which act as productivity drag for the overall economy (McCann, 2018; Bournakis et al. 2019). One possible explanation for the persistent productivity disparities in the UK is the limited knowledge diffusion and lack of innovation spillovers from London and wider South to other productivity laggard regions such as the West Midlands and North East (McCann 2018, Haldane 2018, OECD, 2013).

Innovation spillovers can be mediated via a variety of possible channels including market mechanisms, trade relationships, inter-personal networks and inter-firm linkages. It has been argued that patterns of these linkages and spillovers within the UK tend to be concentrated and centralised in and around the London economy in a manner, which is profoundly different compared to many other advanced countries (OECD, 2013). Despite this long-standing evidence in productivity narratives, the role of knowledge-diffusion in innovation has largely been ignored in the past and it has only recently become increasingly central to government policy thinking (McCann, 2018). Hence, our analysis contributes toward the current policy debate on regional productivity puzzle by investigating what types of networks and their geographies can benefit firms in more laggard regions.

The paper is organised as follows: section 2 provides a review of previous theoretical and empirical research related to KIBS and geographies of innovation and external knowledge sources in KIBS and the role of R&D. Section 3 presents data analysis techniques. Section 4 discusses the results and section 5 concludes the paper.

2 KIBS in Innovation

2.1. KIBS and geographies of knowledge networks

The main innovation challenges of non-metropolitan regions are often attributed to lack of factors that lead to innovation in metropolitan areas because of the scarcity of the means by which external knowledge is acquired (Doloreux and Shearmur 2012, Eder and

Trippl 2019). These include social capital, markets, necessary infrastructure and lack of partners for innovation (Todtling and Trippl 2005, Doloreux and Dionne 2008). If we maintain the proposition that external knowledge is important for innovation, the crucial question for firms in non-metropolitan regions is whether they compensate for lacking local knowledge spillovers by collaborating with more distant partners (Grillitsch and Nilsson 2015, Eder 2019, Eder and Trippl 2019).

The role of proximity in external knowledge sourcing and innovation is subject to debate, especially for KIBS in non-core regions. A complex picture emerges with some studies emphasising the importance of geographic proximity. Early evidence showed that proximity is important in KIBS' interactive learning processes, both with their local customers and with other organizations (Strambach 1998; den Hertog 2000; Koschatzky 1999; Muller and Zenker 2001; Keeble and Nachum 2002; Koch and Stahlecker 2006). It has been suggested that firms are more likely to source knowledge from universities and professional networks within their region (Huggins and Johnston 2010). However, D'Este et al. (2012) and Johnston and Huggins (2015) argue that successful collaboration with universities is essentially a matter of technological complementarity between partners rather than being an outcome of co-location, also of absorptive capacity (Pinto et al. 2015). Moreover, the internet has altered the need for proximity between KIBs and their clients as noted by MacPherson (2008). In addition, KIBS may prefer a more isolated location with little local interaction so that in-house development is their primary mode of innovation (Eder 2019).

The geography of KIBS' external cooperative ties may also differ by the extent of their formality. When firms share the same geographical location, face-to-face interaction is easier, which in turn enables trust building. It is also more likely that business relationships, because of more frequent face-to-face interaction, become personal relationships (Braga et al 2017). Regional and industry specific business networks provide not only consultancy and financial assistance but also promote relationship building. In contrast to informal or personal arrangements, formal transactions are often protected by contracts and written agreements such as those with consultants.

Indeed, there is some evidence which suggests that a lack of access to local knowledge spillovers can be overcome through more distant collaboration, e.g. central cities (see MacPherson 2008, Doloreux and Shearmur 2012 for evidence from the US and Canada). Other studies which draw evidence from a European and Scandinavian countries showed similar findings. Huggins and Johnston (2009), Todtling et al. (2012), Grillistch and Nilsson (2015), Fitjar and Rodrigues-Pose (2011) investigate whether innovative firms located in knowledge periphery collaborate more on different geographical scales than firms located in non-peripheral regions. Grillitsch and Nilsson (2015) use a sample of Swedish firms demonstrating that firms in peripheral locations collaborate more than similar firms in regions with high access to local knowledge to compensate for a lack of opportunities. In a similar line of argument, Todtling et al. (2012) find that ICT KIBS firms in peripheral regions in Austria use more international knowledge sources compared to their metropolitan counterparts. In contrast, a number of studies from metropolitan regions show that both local and global ties enhance competitiveness (see for example Simmie 1997, Keeble et al. 1998, Romijn and Albaladejo 2002).

2.2 The role of R&D and external knowledge sources in KIBS Innovativeness

Investment in R&D has long been acknowledged as the main source of new knowledge as well as an important mediator for absorbing external knowledge (Cohen and Levinthal 1990, Keller 2004, Hall et al. 2010, Diaz-Diaz and de Saa-Perez 2014, Zieba et al 2017, Bournakis et al. 2018). Although evidence suggests that R&D is a key determinant of innovation, it has been argued that R&D does not necessarily result in innovation at the firm level (at least in the short to medium term) but instead contributes to building firms' absorptive capacity i.e. ability to recognize the value of new information, assimilate it and apply it to commercial purposes (Rodrigues et al. 2017). However, Diaz-Diaz and de Saa-Perez (2014) point to the dangers of an excess of internal sources of knowledge because this can lead to inertia. Firms therefore need external knowledge in order to innovate. While this applies equally to KIBS as well as manufacturing firms, there are differences in how they innovate – the strategies they adopt per se and the geographies of external knowledge acquisition.

Evidence from Community Innovation Survey (CIS) data shows that overall R&D is less important in services (Evangelista 2000, Tether 2003), although some studies emphasise that the degree of similarity between services and manufacturing increases with the level of knowledge intensity so that KIBS will display innovation behaviour similar to those of high technology manufacturing firms (Hollenstein 2003). Pina and Tether (2016), following from Asheim and Coenen (2005) point to a direct relationship between KIBS' primary knowledge base and the major drivers of innovation. They argue that while investment in R&D is related to product and process innovation, in KIBS whose knowledge base is primarily analytical or synthetic, such a distinction has no effect. Rodriguez and Ballesta (2010) in examining innovation activity of Spanish KIBS firms concluded that although internal R&D seems to be an essential activity, other forms of knowledge acquisition such as universities were used.

However, evidence on the importance of more formal collaboration for example with universities, public research institutes and trade organisations for KIBS innovativeness is somewhat controversial. On the one hand, Djellal and Gallouj (2001) did not recognise universities and other public organisations as important sources of innovation for KIBS. On the other hand, Mina et al. (2014) claim that access to scientific knowledge is an important complement to keeping up to date with new technological and research developments, which can also benefit actual and potential customers. Similarly, D'Este et al. (2012) argue that KIBS actively collaborate with universities and point out that 22.7% of collaborative business grants - by the UK's Engineering and Physical Science Research Council between 1999 and 2003 - were awarded to KIBS. In addition, Mina et al. (2014) highlight that, unlike with clients - where cooperation is necessary - mere access to information provided by universities and research institutions has a positive influence on the development of radical innovations in KIBS firms.

Even so other evidence suggests that, in comparison with manufacturing, the scale of R&D activity in KIBS is smaller (Tether 2004), although Freel (2006) argues that there is still a positive effect of R&D on KIBS innovativeness. Tether (2005) found that while manufacturing firms are more likely to innovate using in-house R&D as well as collaborations with universities and research institutes, service firms are more likely to collaborate with customers and suppliers. In a survey of Finnish KIBS firms, Leiponen (2005) found that external knowledge sources, especially customers and competitors, positively affects innovation while in-house R&D has no significant effect.

Mansury and Love (2008), in their study of US business service firms, show that external linkages have a positive effect on various measures of innovation performance. Similar results are found for a sample of KIBS in Northern Ireland (Love et al. 2010). Tether and Metcalfe (2004) argue that cooperation with customers and suppliers represents the main source of knowledge and technology for services. Studies of service innovation and service management acknowledge the role of customers in co-creation of innovation (Leiponen 2005; Tether 2005; Love et al. 2011, Bryson et al. 2012, Zieba et al. 2017). Clients are the main beneficiaries of innovation and contribute towards the formation of the tacit knowledge that is often developed as a result of face-to-face interaction between KIBS firms and their clients. One result of this interaction is also that feedback from clients can shape innovation in service firms, just as much as service firms can influence their customers' innovation processes (Braga et al. 2017). The involvement of suppliers is also beneficial for new service innovation as they provide information for technology adoption (Tether 2001; Leiponen 2005) and technical problems solving (Tsai and Hsieh 2009).

Cooperation with competitors is often seen as another potential external source of innovation for KIBS (Tether 2001; Bryson and Monnoyer 2004; Leiponen 2005) but the relationship is not straightforward. Cooperation with rivals is subject to serious appropriability issues associated with weaknesses with respect to intellectual property rights (IPR) (Freel 2006). However, while Leiponen (2005) found positive innovation effects in KIBS from both customers and competitors, Czarnitzki and Spielkamp (2003) pointed to the relevance German business services assign to competitors. Overall, vertical co-operative linkages (with customers and suppliers) appear to be more significant than horizontal linkages (with competitors) (Tomlinson 2010).

Consultants and commercial labs are often perceived as sources of more complex knowledge, where interaction with professional associations and consultants may help to relieve the necessity in relation to firms possessing their own skills in marketing and launching new service models (Love et al. 2011). Other sources of information are attendance at scientific events such as conferences, trade fairs and exhibitions. Access to scientific/specialised journals is also a potential source of external knowledge (Zahra and George 2002). Foreign direct investment is the most common way for KIBS to penetrate international markets (Roberts 1998, Glucker 2004). However, the risks associated with foreign market entry, technology sharing and product/service development, as well as the barriers posed by foreign regulation, may be overcome by forming joint ventures and strategic alliances. These in turn may impact KIBS innovativeness positively.

Accordingly, these ‘soft’ sources define KIBS innovation strategy more clearly than traditional ‘hard’ sources, such as R&D. Leiponen (2012) states that service innovation depends primarily on employee skills and professional knowledge, rather than on a narrow (and relatively rarely encountered) set of activities that fall under formalized R&D. Moreover, there is a variation between types of KIBS: T-KIBS seem more prone to carry out R&D than P-KIBS. It should be noted that Doloreux et al. (2016) suggest that KIBS firms do not recognize social-science type research (i.e. research carried out by legal or marketing firms) as investment in R&D thus the apparent predominance of R&D in T-KIBS may be simply a reporting issue. In summary, the current literature suggests that the role of internal knowledge, external openness and linkages are of particular importance in service sector innovation, whereas the role of R&D is ambiguous, due to the nature of R&D in KIBS being unclear and R&D activity under-reported (Doloreux et al. 2016).

2.4 Hypotheses Formulation

In line with the literature on regional innovation systems and clustering, we expect that, despite the apparent growing influence of non-local knowledge networks, alliances developed within the same region such as clients, competitors, informal and business networks and regional universities will be positively related to innovation performance. In line with UK evidence from the South East and peripheral UK regions, we also acknowledge the importance of wider national and international networking for innovation (Keeble et al. 1998, Simmie 1997, Romijn and Albaladejo 2002, Huggins and Johnston 2009). Based on these considerations, we propose that the inflow of knowledge transferred via intra-regional, inter-regional and international sources is more important in facilitating innovation in KIBS than is internal R&D.

Following from the previous discussion, in order to answer the research question, the paper formulates four hypotheses:

H1: Knowledge from regional customers and regional informal and business networks and professional associations enhances KIBS innovativeness.

H2: Knowledge from regional public institutions (i.e. universities, regional and national public sector organisations) and regional competitors enhances KIBS innovativeness.

H3: Knowledge from international customers, informal contacts and formal strategic alliances and joint ventures and other international untraded networks enhances KIBS innovativeness.

H4: R&D activity is not among the most important determinants of KIBS innovation.

3 The Empirical Specification

3.1 Regional context

The two regions studied in this paper exhibit some notable similarities. These are mainly related to economic history of early industrialisation which started in the 18th century UK and the resulting legacy. As a result, both regions share similar industrial profiles (i.e. a heavy reliance on manufacturing of cars, machinery, metals and electrical equipment). Second, both regions have suffered rapid de-industrialization from the mid-20th century and more recent job losses in the automotive (in the West Midlands) and steel (in the North East) industries. There are some notable differences in the industrial composition of the two regions as the North East is more specialized in chemicals, pharmaceuticals and mining, whereas the West Midlands specializes in the production of rubber and plastics and technical testing and analysis (Savic, 2016).

Other important differences between the two regions are related to their geographical position. For example, the North East region is more distant from substantial urban demand (i.e. that can be found in the London and South East areas), which is a geographical disadvantage (Savic, 2016). In contrast, some areas in the West Midlands are much better connected to large urban areas and their hinterlands, so KIBS benefit from proximity to a larger market (Savic 2016). In such context, it is pertinent to identify types of knowledge network as well as most important sources of demand and their associated geographies, which are common to both regions and are conducive to KIBS innovativeness.

3.2 The Survey

This paper draws evidence from the independent survey of KIBS SMEs located in the North East and the West Midlands conducted in August 2010. Firms' decisions about innovation and knowledge accumulation, which are not primarily driven by short term developments in the business environment, represent a long term strategy with a degree of persistence. Therefore, we expect that responses gathered from the survey will be relevant for the years ahead. Implications and lessons that are drawn from our study will thus be applicable for future policy recommendations.

The OneSource database was used to draw a stratified sample of KIBS SMEs in two regions. Two individual samples for the North East and the West Midlands were identified according to standard industrial classification definition of KIBS (as explained in the introductory chapter) and size (small and medium firms with 1-249 employees). The sampling frame was originally planned to be stratified using two criteria in order to meet the survey requirement of a diverse sample with analysable sub-groups. The stratifying criteria were intended to be applied to both the North East and the West Midlands individually and were to include: - Employment size class, divided into two groups: Industrial sector, divided into nine groups: computer and related, R&D, engineering, technical testing and analysis, architecture and urban planning, marketing research, management consultancy, advertising and publishing.

The sampling frame would have been divided into 18 strata (9 industrial sectors * 2 size). However, the stratification model for the North East was abandoned since the contacts in the North East were exhausted. In other words, even if the attempt had been made to obtain a stratified sample in North East, it would almost certainly be comprised of the same respondents. The West Midlands contacts were stratified into three geographical regions and random samples were drawn from these.

The number of cases selected for the North East was 888 and for the West Midlands it was 2900. It is only plausible to calculate the response rate for the North East since the West Midlands responses were targeted at 175 and all 175 responses were obtained. 167 usable responses were received for the North East representing a response rate of 19%. This is somewhat higher when compared to other survey response rate of the general SME population in the UK which is between 12%-15% (see for example Brooksbank et al., 2001).

A total of 342 usable responses were collected in both regions using Computer Aided Telephone Interviews (CATI). The number of responses from a population of 31,495 firms gives a confidence interval of ±6.09% for a binary answer. If the mean answer is 0.5 (50%), e.g. if 50% of firms report innovation, one can claim within a 95% confidence interval that the actual population that innovates can be as low as 44% (50-6.09) and as high as 56% (50+6.09). For proportions larger or smaller than 50% (which is to say, in most cases), the CI will be smaller[3]. The respondents in this survey were owners or managers of KIBS SMEs[4].

3.3 The Analytical Model and Variables

The analytical model represents the innovation capability of firms arising from internal inputs, such as their absorptive capacity, and various external inputs. The innovation variable is initially defined as a combined measure of innovation (i.e. either product or process innovation), using a simple binary variable indicating whether or not a firm had introduced at least one innovation during the three years preceding the survey. It should be noted that this measure does not account for the significance or the impact of any particular innovation[5]. The decision to consider as a baseline measure a variable that combines both product/service and process innovation relies on the previous literature which recognises that a distinction between product/service and process innovation is less meaningful in services (Love, et al. 2010).

The internal capability or absorptive capacity is measured through investment in in house R&D. Following Doran and O'Leary (2011), R&D is defined, and this was communicated to respondents to the survey, as expenditure by the firm on creative work to increase its stock of knowledge for innovation. The following probit model is formulated to estimate the probability a firm to be an innovator:

[3] According to the Interdepartmental Business Register database (IDBR), total KIBS population in 2010 is 31,495 firms for both regions.
[4] Firms with 1-250 employees.
[5] Qualitative information from the survey points to a wide variation in the nature of innovation in firms, some being more radical than others. This information is not captured in a binary variable on innovation.

$$\Pr(y_i=1)=X_i\boldsymbol{\beta}+u \quad (1)$$

Where y is a binary variable taking value 1 if the firm has produced an innovation as per the above definition and 0 otherwise. Vector X includes a set of other control variables that matter for innovation and $\boldsymbol{\beta}$ is a vector of coefficients to be estimated. R&D investment is a dummy variable taking the value 1 if the firm invests in R&D and 0 otherwise. To capture different levels of R&D intensity, we also measure R&D as a categorical variable: a) investment in R&D as a proportion of total turnover greater than 10%; b) investment between 6%-10% and c) investment in the range of 1%-5%. The external capability of firms is measured by the frequency with which knowledge is sourced from various external sources. These ranged from 1-10 on a Likert scale, representing managers' and business owners' assessments.

External sources of knowledge are classified into following: Customers; Suppliers; Rival firms; Employment, Licences; Consultants; Formal strategic alliances/joint ventures; Public sector organisations; Private sector organisations, such as private training or research providers and consultants; Literature/patents; Conferences, trade fairs, exhibitions; Professional and trade associations; Universities or other higher education institutes; Contract research; Research cooperation; Business networks and Informal contacts. These variables were classified into regional, national and international sources of knowledge and grouped into thirteen significant factors using principal component analysis. Other control variables in X include: size and age of the firm; a regional dummy, with 1 for the North East and 0 for the West Midlands and also a technology dummy, with 1 for P- KIBS and 0 for T- KIBS.

3.4 Descriptive Statistics

The average firm size in the sample is 12 employees while the largest firm employed 249 employees. None of the firms are majority owned by another entity. Firms have been operating for an average of 17 years and had an average profit to sales ratio of 4.84%. From 240 companies who reported information on profits, 47.4% claimed profits above 10% of the turnover and 6% reported zero profits in 2008. From 340 companies who answered the question, 150 (44%) had introduced at least one product/service innovation in the previous three years. From a sample of 339 KIBS who answered the question, 110 (32%) had introduced at least one process innovation.

The survey questionnaire asked business owners and managers to identify how often they source knowledge from various networks located within their region[6], UK and abroad; whether their firms have introduced innovative products, services, processes and marketing methods in the past three years, and how much they invest in R&D. The links between performance indices (innovation) and determining factors (investment in R&D, frequency of sourcing knowledge from various traded and untraded networks) are analysed statistically. Although the emphasis is not on analysing differences or similarities between the two regions per se, as a robustness test we do replicate our benchmark econometric specification using interaction terms between a regional dummy and key significant knowledge sources to test whether the estimated effects are stable between West Midlands and the North East (Table 6).

Turning to the descriptive statistics related to frequency of sourcing external knowledge (Table 1), it should be noted that the mean scores for co-operation with clients, informal networks and professional and trade organisations are higher than those recorded for co-operation with competitors (horizontal co-operation). This is not surprising as empirical evidence from other studies shows that KIBS are more likely to co-operate with customers and other trading partners along the vertical production chain rather than with competitors. Table 1 also shows that customers and informal contacts are the most frequently utilised sources of external knowledge.

Table 1 about here

3.5 Analytical Technique

Because the data are self-reported and collected via cross-sectional research design, systematic measurement bias might be present in our data. To mitigate this problem as well as to address potential co-linearity between variables of external knowledge, we use Principal Component Analysis (PCA) (Abdi and Williams, 2010). PCA aggregates and normalises the external knowledge variables and uses orthogonal transformation to convert these variables into a set of linear uncorrelated variables that can be used in the econometric estimation. It first normalises the raw data by expressing them as differences from the mean and then they are weighted by standard deviation.

Subsequently, the covariance matrix is calculated to show the correlation between each pair of variables. From the covariance matrix, we obtain eigenvectors that capture the direction of the variance of the principal component. Then, eigenvalues produced contain the amount of the variance carried in the principal component. We have in total thirteen eigenvalues that we used in the Probit regressions. All raw components derived from survey questions are directly related to the hypotheses outlined above, therefore we keep all thirteen components to ensure that we do not overlook any information available. Table 2 presents the results from the PCA. The description of the external knowledge factors is provided below. PCA revealed 13 distinct factors among the external knowledge variables that account together for 71% of the variance with the first largest factor to account for 21% of the variance. Given that PCA puts maximum possible information in the first component, our external sources are all meaningful thus our results are robust.

Table 2 about here

Description of Factors:

1) *International Formal Knowledge Sources* These include overseas public sector organisations, consultants, former employment, research cooperation, private sector organisations such as training or research providers, licences, contract research, universities or other higher education institutes, rival firms, professional and trade associations, formal strategic alliances/joint ventures and suppliers.
2) *National Public and Professional Knowledge Infrastructure elsewhere in the UK:* Universities or other higher education institutes, professional and trade associations, business networks.
3) *Regional and National Commercial Networks:* Consultants, both within the local region and elsewhere in the UK; private sector training or research providers and consultants within the region; formal strategic alliances/joint ventures, both elsewhere in the UK and within the region.

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[6] Region is defined as former UK Government Office Region (GOR).

4) *International Customer and Informal Networks:* Overseas business networks, conferences, trade fairs exhibitions, customers, informal contacts and formal strategic alliances and joint ventures.
5) *Regional Informal and Business Networks:* Regional business networks, informal contacts, conferences, trade fairs and exhibitions within the region.
6) *Regional and National Research Cooperation:* Contract research and research cooperation.
7) *Regional Public Knowledge Infrastructure* Regional public sector organisations and, Higher education institutes.
8) *Regional and National Patents and Literature.*
9) *Regional and National Customers.*
10) *Regional and National Employees.*
11) *Regional and National Rivals.*
12) *Regional and National Suppliers.*
13) *Regional and National Licences.*

In the Probit estimations, the dependent variable is defined as innovation (i.e. including both product-service and process innovation) and regressed on the following independent variables: (a) the thirteen types of external sources of knowledge identified by the Principal component analysis, (b) investment in R&D, and (c) standard control variables usually included in an innovation function (age, size, region and type). Table 3 shows pairwise correlation between firms' specific characteristics.

Table 3 about here

Tables 4 and 5 show Probit estimates. The main issue to be considered in the estimation of our probit model is that R&D might not be an exogenous treatment. Doing R&D is likely to depend on unobserved factors that also affect a firm's decision to innovate, leading to correlation between R&D and the error term in equation (1). These issues point out towards endogeneity and omitted variables bias that might yield spurious estimated coefficients $\boldsymbol{\beta}$[7]. To ensure that our estimates are robust to unobserved endogeneity bias, we

[7] The issue of endogeneity is also related to underlying simultaneity bias or also known as reverse causality, this is to say, that it is equally plausible the scenario that a more innovative firm is also a more successful

also performed a two stage estimation that enables us to project at the first stage the determinants of R&D and estimate the probability of innovation at the second stage.

First, Table 4 presents results from the benchmark one stage estimation in which R&D and innovation are treated as strictly exogenous variables. Column one shows estimates from a dummy R&D variable, while column two shows estimates from categorical R&D measures. Table 5 presents results from the two stage estimation that controls for endogeneity bias between innovation and R&D as previously discussed. The present empirical context does not provide strictly exogenous instruments for R&D[8] (i.e. determinants that are correlated with the R&D decision but remain exogenous to the innovation decision), thus a slightly modified two-stage estimation was applied (Angrist and Pischke, 2009; Leon-Ledesma and Christopoulos, 2016). We implemented the two stage estimation as follows: first, a Probit model was estimated that projects the determinants of an R&D active firm. In the first stage estimation, the dependent variable is a binary R&D indicator that takes value 1 if the firm invests in R&D and 0, otherwise. First stage results are shown in column 1 of Table 5. The control variables used at the first stage are: region, age, type (P-KIBS vs. T-KIBS) and size. Additionally, different degrees of profitability[9] have been included in order to capture whether or not firms' financial strength affects the decision to invest in R&D. Once the R&D Probit model is estimated, predicted values were used as regressors in the second stage which is the innovation Probit model. Second stage estimates do not include the trichotomous R&D variable anymore but only the predicted values from the R&D Probit estimation obtained in the first stage. This way a two stage approach reduces bias from unobserved endogeneity providing a sense of robustness in the relationship between R&D and innovation.

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one, which in turn increases the funds that can be spent on R&D. We do not claim that we address causality within the current context (that might be present) but rather we ensure that endogeneity bias derived from unobserved correlation between the error term and R&D does not drive our estimates.

8 The current data are collected from a telephone survey. Although this method has certain advantages for investigating the importance of external knowledge sources for KIBS innovativeness; two main constraints were encountered with regards to implementation of IV estimation. First, none of the variables can be considered as exogenous instruments for R&D and second most of the variables are not continuous which renders them as not suitable for use in IV estimation.

9 KIBS SMEs leaders were asked to state whether their annual profits were: a. less than or equal to 0% of turnover (i.e. a loss or break even), b. above 0% and up to 1% of turnover, c. above 1% and up to 5% of turnover, d. above 5% and up to 10% of turnover, e. above 10% of turnover.

The specification with the trichotomous R&D variable is better at predicting the probability of innovation compared to the use of a binary R&D variable in Table 4 as indicated from the log likelihood (LR) test, 6.32 (pvalue=0.04). The overall fit of the model as implied from R-squared values is low in both Tables 4 and 5. This is expected given that it is a cross-sectional analysis without any time variation in the data. To ensure that our model is still well-specified we provide at the bottom of all Tables a Wald test for the hypothesis that the estimated coefficients in the model are jointly zero. The test indicates rejection of the null hypothesis in conventional levels of statistical significance in all econometric specifications of the paper implying that the current variables considered carry significant information for the probability of a firm to be an innovator.

4 Main Findings

4.1 Hypothesis testing

This section shows the results from testing hypotheses H1-H4. We also show results from a two stage estimation in Table 5 that controls for unobserved endogeneity of internal R&D. Table 6 provides results from interaction terms of a regional dummy and the external knowledge sources that were found to play an important role in Table 4. We have kept eight out of the thirteen external sources used in the benchmark specification in Table 4. We then define a dummy variable *Region* (North East=1 and West Midlands=0), which is interacted with the statistically significant sources of Table 4. This serves as a robustness test indicating whether crucial knowledge factors are equally important for KIBS in both regions.

In answering the research question, what specific innovation strategies prove effective for KIBS located in de-industrialised regions?, the survey firstly takes into account the geography of various knowledge sources. The results show that the relationship between ‘soft’ knowledge sources such as interaction and learning from customers, suppliers and other networking partners, on the one hand, and ‘hard’ knowledge sources such as R&D, on the other, differ once frequency of interaction and its effect on innovativeness have been taken into account. The descriptive analysis of the survey shows that the most frequently utilised sources of external knowledge are indeed clients, informal contacts, business networks and suppliers (Table 1). However, higher frequency of networking with regional and UK clients confers innovation advantages while this does not seem to apply to interaction with suppliers

(Tables 4 and 5). In fact, more frequent interaction with local and UK suppliers seem to have negative effect on innovation (Tables 4 and 5). Orientation towards local or national client/market exchange is therefore associated with higher innovation performance. This is in line with the majority of KIBS studies which emphasise the importance of KIBS-client co-production for innovation.

Another important result is related to the influence of regional informal and business networks on firms' innovativeness (Tables 4 and 5). KIBS engagement with various support networks within the region (through informal contacts and business networks), as well as *ad hoc* networking (through conferences, trade fairs and exhibitions) seem to have profoundly positive effect on firms' innovativeness[10]. Hence, the findings support H1.

Overall, the frequency of interaction with firms in a similar line of business (Tables 4 and 5) does not seem to enhance KIBS' innovativeness, as also found in Tomlinson (2010). In Table 6, six out of the eight interaction variables considered are statistically insignificant. This indicates that the factors which matter for the probability to innovate do not vary across regions with two exceptions. These are the Regional and National Commercial Sources and Regional Informal and Business Sources. The probability to innovate increases for KIBS in the North East that interact with regional and national commercial networks (i.e. consultants and commercial training providers) as compared to KIBS in West Midlands. Similarly, interaction with regional informal and business sources increase the probability of innovation proportionally more for North East KIBS.

More intensive collaboration with national and regional universities and public sector organisations decreases the probability of innovation in the first model (Table 4). Keeble et al. (1998) and Huggins and Johnston (2009) report similar results stating that the negative association is likely to be driven by competitive pressure between KIBS SMEs and other universities and public sector organisations. However, once we cater for the possible effect of reverse causality between innovation and R&D, there is no significant effect from regional universities and public networks on innovation. Given the inconclusive effect of regional

[10] A caveat should be placed here concerning the causality bias that may exist in relation to the link between external knowledge sources and innovation. The results suggest that the more innovative firms are more likely to take up learning from external sources. Nevertheless, in the current empirical context it is difficult to provide further evidence about the validity of such a hypothesis.

public knowledge infrastructure on innovation, we conclude that the present study does not provide any support for H2. This finding is in line with D'Este and Iammarino (2010) who noted that firms seek collaboration with suitable university partners not necessarily those located in the same region. Similarly, Johnston and Huggins (2015) find that university-industry collaboration is not positively influenced by geographical proximity.

Table 1 with descriptive data indicates that for KIBS, international networks are much less common than regional and UK networks. However, the more KIBS engage in networking with international informal contacts, the probability of introducing product/service/process innovation increases (Tables 4 and 5). The positive effect of engaging with international clients suggests that, as KIBS establish exporting activities they tend to benefit from the more sophisticated international demand. A similar finding is documented in Romijn and Albaladejo (2002) for high tech firms located in the South East. It can be concluded that learning through exporting improves innovation capability (Tables 4 and 5). Accordingly our findings provide support for H3.

The survey results also indicate the relative importance of internal R&D: only a small proportion (14.6%) of the North East and the West Midlands KIBS SMEs invested in R&D. Without controlling for unobserved endogeneity, the role of R&D in supporting KIBS innovation appears to be positive and significant using both the binary and the trichotomous R&D measure (Table 4). After controlling for endogeneity bias in Table 5, R&D becomes insignificant (Column 2, Table 5). Given the increased likelihood that there are unobserved variables which simultaneously affect the decision to invest in R&D and to innovate, we should assign higher importance to the results reported in Table 5.

Having said this, we do not suggest that internal R&D is of minor importance for KIBS; quite the opposite, as KIBS' investment in internal R&D seems to improve absorptive capacity and firm's ability to learn from the technological advancements of others. The present study does not directly test for these scenarios but the interplay between in-house R&D and external knowledge factors is definitely important as more aggregate evidence has shown (Bournakis et al, 2018). Our findings regarding the role of internal R&D in the innovation performance of KIBS are in line with Freel (2003) and Tomlinson (2010), while they contrast those from (Love and Mansury 2007; Love et al 2010). Overall, our results provide support for H4.

Turning to results regarding the other controls used in the innovation equation in Table 4, firm size is not a significant determinant. Also, the probability of being an innovator in Table 4 increases for KIBS in the West Midlands, while T-KIBS are also more likely to innovate. In the two stage estimation, Table 5, we find that different profitability variables are all significant determinants of the R&D equation in stage 1, while KIBS that are large in size and located in North East are more likely to invest in R&D. There is no statistical difference in the probability to invest in internal R&D between T-KIBS and P-KIBS. To avoid multicollinearity, we did not include size, age, region and type in stage two estimation (Table 5, column 2), as these are already captured in the predicted values of R&D.

4.2. Limitations

From a methodological viewpoint, our analysis provides novel and original evidence about the characteristics of external knowledge sourcing for KIBS SMEs located in two de-industrialised UK regions. Nonetheless some limitations merit further discussion. First, in relation to the utilisation of a binary response regarding investment in R&D in the second stage (Table 5), it has been argued that his definition might be potentially problematic as it tends to overstate the importance of external knowledge interactions (Roper et al 2008, Doran and O'Leary 2011).

Second, cross-sectional analysis does not allow us to identify the aspect of time variation in the behaviour of innovation and how knowledge sourcing varies with time. Third, the direction of causality always remains an issue. In the current framework we effectively address endogeneity using a two-stage estimation approach with the decision of investing in R&D to be modelled in the first stage. In a panel data set up, there are issues that call for future research especially in relation to identifying how strategies differ across firms and over time within firms. Therefore, the agenda of analysing the interactions between the internal knowledge capability of the firm and the external knowledge sources is by no means complete. To this end, further empirical evidence is required from both de-industrialised and core regions.

5 Discussion and Conclusions

5.1. Discussion of the Results

This study focussed on investigating the effectiveness of specific innovation strategies for KIBS located in two de-industrialised regions in the UK. Evidence was obtained on the role of various external knowledge sources and their geographies on the one hand and the effect of internal R&D on the other. The study presents two sets of findings. First, we establish which external knowledge sources are most frequently utilised by KIBS and the geographies at which these function. The descriptive data indicate that, for KIBS in de-industrialised regions, international and national networks are much less utilised compared to regional networks. This is in contrast with some literature, which suggests that firms in more peripheral regions rely predominantly on knowledge available elsewhere (Eder 2019, Eder and Trippl 2019, Meili and Shearmur 2019).

The survey results show that for KIBS in de-industrialised regions informal networks are most important and that they transcend geographical boundaries, whereas there is a relatively low number of respondents who frequently source research-type knowledge from universities, research contracts or research cooperation (Table 1). Regional customers, suppliers and professional and trade associations are also frequently utilised sources of external knowledge. Compared with other external knowledge sources, informal contacts and customers are being utilised most frequently and this applies to all geographical scales (regional, national and international).

The second set of results focuses upon the impact of knowledge sources on innovativeness, exploring hypotheses derived from the existing literature. The results indicate that both regional and more distant networks are conducive of firms' innovativeness in de-industrialised regions. This corresponds to previous findings from developed regions where both local and global ties enhance competitiveness (see for example Simmie 1997, Keeble et al. 1998, Romijn and Albaladejo 2002). In addition, being an exporter increases the chance of success but so does learning from local and UK customers. The unexpected result with regards to regional and UK suppliers emphasises the need for the role of regional and UK suppliers to be better explored and understood. We have answered the research question, “What innovation strategies prove effective for KIBS located in de-industrialised regions?”. It seems that H1, H3 and H4 are supported but not necessarily H2.

Bearing in mind the positive role of external informal contacts and business networks (both regional and global) the role of firms’ internal R&D and their corresponding absorptive capacity should not be underestimated. A more systematic treatment of endogeneity between R&D and innovation in Table 5 shows that internal R&D itself might not be sufficient to lead to innovation but internal R&D efforts are still crucial in improving the in-house absorptive capacity. This is to say that a firm can more effectively assimilate knowledge from external informal networking and elsewhere as long as there is sufficient internal R&D activity. Our findings call for further research on the interactive role of internal R&D with external knowledge sources so as to better understand the mix of factors that maximize knowledge benefits for KIBS.

The regression analysis indicates that more frequent interaction with universities and public sector organisations which are located in the same region does not have a significant positive impact on KIBS’ innovativeness. These findings challenge some aspects of the economic geography discourse related to clusters and localised learning which postulate that geographic clustering and collaboration with local universities provides a panacea for regional economic development. The results of this study show that in line with Shearmur and Doloreux (2015, 2018) the geography of services innovation is based neither upon co-location nor upon completely a-spatial connections but is dependent on accessibility and ability to cover distance.

We should emphasise that there are spatial boundaries to the KIBS innovation system as the most frequent interactions between KIBS and their knowledge sourcing does happen within the region in question. This applies equally to the vertical and horizontal supply chains, informal contacts and other sources of knowledge. In the survey, a number of organisations, such as the Chambers of Commerce, Business Link, the professional trade organisations, the former Regional Development Agencies and other regional and industry specific business networks were listed as important networking partners, providing consultancy, financial assistance and mediation between firms and other organisations. In this respect they are important sources of knowledge for KIBS SMEs in de-industrialised regions as they ameliorate possible market failures related to insufficient provision of commercial support to SMEs. Their impact should therefore be viewed not only through their direct role in providing business, marketing and financial assistance to firms but also through their role as mediators between KIBS SMEs and local and international business networks and potential distant markets.

5.2. Implications for Policy

The lack of any productivity upturn since the 2008 economic crisis is overwhelmingly dominated by economic geography of non-core regions of the Midlands and the Northern regions of England plus Wales and Northern Ireland, while there have been productivity upturns concentrated in the geographical core of the economy of London and its hinterland (McCann 2018). From a national governance perspective, these enormous interregional productivity disparities are problematic because they limit the efficacy of national policies as well as one size fits all polices. This is because the likelihood of any particular region reflecting a hypothetical representative region on which the policy design is based is very low (McCann 2018).

On example of one-size-fits all UK SME policy has focused on building clusters of related firms. This initiative has mainly involved providing physical infrastructure such as science parks (Huggins et al. 2010). Science parks have been largely created to promote linkages with scientific institutions and universities located close to industry. This policy direction draws its authority mainly from localised learning and cluster literature. Our findings challenge these policy practices showing that for KIBS SMEs, more frequent interaction with firms in a similar line of business does not necessarily enhance innovation. In addition, firms' do not seem to benefit from forming closer relationships with scientific institutions and universities in closer geographic proximity. Hence, in case of KIBS, simply encouraging formation of KIBS clusters located close to universities may not be a sensible policy.

Another type of one size fits all policy which is extensively promoted in the UK is the provision of R&D tax credits. Our results show that policy measures aimed at reducing the cost of innovation expenditure should not solely focus on internal R&D but should also include promotion of other types of support such as formation and strengthening of both local and international networks in de-industrialised regions. These in turn should be industry and context specific.

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Table 1 Frequency of sourcing external knowledge (answers reported on a 1-10 Likert Scale)

	N	Mean	Std.	Std. Error
Customers within the region	**329**	**4.32**	**3.221**	**.178**
Suppliers within the region	**329**	**3.08**	**2.710**	**.149**
Rival firms within the region	330	2.37	2.081	.115
Employment within the region	312	1.92	1.980	.112
Licences within the region	321	1.70	1.682	.094
Consultants within the region	328	2.73	2.365	.131
Strategic alliances/joint ventures within the region	329	2.86	2.563	.141
Public sector organisations within the region	329	2.89	2.606	.144
Private sector organisations, such as private training or research	**328**	**3.08**	**2.616**	**.144**
Literature/patents within the region	328	2.88	2.662	.147
Conferences, trade fairs, exhibitions within the region	**330**	**3.09**	**2.501**	**.138**
Professional and trade associations within the region	**329**	**3.48**	**2.817**	**.155**
Universities or other higher education institutes within the region	327	2.60	2.372	.131
Contract research within the region	325	1.58	1.523	.084
Research cooperation within the region	325	1.49	1.400	.078
Business networks within the region	330	2.98	2.637	.145
Informal contacts within the region	**330**	**4.88**	**3.012**	**.166**
UK Sources of External Knowledge				
Customers in the UK	**327**	**3.74**	**3.219**	**.178**
Suppliers in the UK	329	2.74	2.674	.147
Rival firms in the UK	330	2.04	1.930	.106
Employment in the UK	317	1.58	1.550	.087
Licences in the UK	323	1.58	1.641	.091
Consultants in the UK	328	2.10	2.079	.115
Formal strategic alliances/joint ventures in the UK	329	2.28	2.378	.131
Public sector organisations in the UK	329	2.32	2.368	.131
Private sector organisations, such as private training or research providers	329	2.45	2.463	.136
Literature/patents in the UK	330	2.41	2.538	.140
Conferences, trade fairs, exhibitions in the UK	330	2.73	2.496	.137
Professional and trade associations in the UK	330	2.84	2.634	.145
Universities or other higher education institutes in the UK	329	1.96	1.964	.108
Contract research in the UK	329	1.43	1.378	.076
Research cooperation in the UK	329	1.40	1.342	.074
Business networks in the UK	330	2.25	2.253	.124
Informal contacts in the UK	**330**	**3.91**	**3.177**	**.175**
Overseas sources of external knowledge				
Customers overseas	**329**	**1.78**	**2.175**	**.120**
Suppliers overseas	332	1.59	1.859	.102
Rival firms overseas	332	1.23	1.116	.061
Employment overseas	328	1.10	.745	.041
Licences overseas	329	1.16	.980	.054
Consultants overseas	331	1.17	.938	.052
Formal strategic alliances/joint ventures overseas	330	1.34	1.469	.081
Public sector organisations overseas	330	1.13	.794	.044
Private sector organisations, such as private training or research providers	329	1.24	1.138	.063

Literature/patents overseas	331	1.44	1.660	.091
Conferences, trade fairs, exhibitions overseas	332	1.54	1.810	.099
Professional and trade associations overseas	332	1.33	1.359	.075
Universities or other higher education institutes overseas	330	1.16	.882	.049
Contract research overseas	331	1.15	.968	.053
Research cooperation overseas	330	1.14	.853	.047
Business networks overseas	332	1.25	1.166	.064
Informal contacts overseas	**331**	**1.68**	**2.061**	**.113**

Table 2 Principal Component Analysis (PCA) Results Rotated Component Matrix[a]

	1	2	3	4	5	6	7	8	9	10	11	12	13
Public sector organisations overseas	.850												
Consultants overseas	.799												
Employment overseas	.797												
Research cooperation overseas	.770												
Private sector organisations, such as private training or research	.696												
Licences overseas	.681												
Contract research overseas	.677												
Universities or other higher education institutes overseas	.677												
Rival firms overseas	.637												
Professional and trade associations overseas	.592												
Formal strategic alliances/joint ventures overseas	.592			.519									
Suppliers overseas	.492												
Universities or other higher education institutes in the UK		.692											
Professional and trade associations in the UK		.626											
Business networks in the UK		.575			.552								
Public sector organisations in the UK		.494											
Consultants elsewhere in the UK			.720										
Private sector organisations, such as private training or research			.692										
Consultants within the region			.642										
Private sector organisations, such as private training or research			.629										
Formal strategic alliances/joint ventures within the region			.530										
Formal strategic alliances/joint ventures elsewhere in the UK			.514										
Business networks overseas				.685									
Conferences, trade fairs, exhibitions overseas				.684									
Customers overseas				.589									
Informal contacts overseas				.547									
Literature/patents overseas				.492									
Conferences, trade fairs, exhibitions in the UK				.485									
Business networks within the region					.680								
Informal contacts within the region					.644								
Conferences, trade fairs, exhibitions within the region					.644								

Informal contacts in the UK	.477								
Professional and trade associations within the region	.461								
Contract research within the region		.848							
Contract research in the UK		.815							
Research cooperation within the region		.587							
Research cooperation in the UK		.521							
Public sector organisations within the region			.684						
Universities or other higher education institutes within the			.581						
Literature/patents within the region				.771					
Literature/patents in the UK				.650					
Customers in the UK					.722				
Customers within the region					.694				
Employment in the UK						.776			
Employment within the region						.768			
Rival firms within the region							.824		
Rival firms in the UK							.805		
Suppliers within the region								.829	
Suppliers in the UK								.715	
Licences in the UK									.752
Licences within the region									.607

Notes: Explained variance= 71.057; Kaiser-Meyer-Olkin (KMO) test= 0.819; Bartlett's test of sphericity: X2=9855.969; p=0.000

Table 3 Correlation Matrix Innovation, R&D and firm specific Characteristics

	Innovation	Region	Age	Size	P-KIBS/ T-KIBS	R&D	RD>10	6<R&D<10	1<R&D<5
Innovation	1								
Region	-0.061	1							
Age	-0.001	0.09	1						
Size	0.161	0.048	0.295	1					
P-KIBS/T-KIBS	0.086	-0.002	-0.056	0.006	1				
R&D	0.221	0.037	0.021	0.242	-0.014	1			
RD>10	0.174	-0.052	-0.054	0.251	-0.154	0.67	1		
6<R&D<10	0.136	0.11	-0.038	-0.044	0.017	0.49	-0.075	1	
1<R&D<5	0.027	0.027	0.161	0.157	0.18	0.432	-0.066	-0.049	1

Table 4 Determinants of Innovation, Results from Probit Estimation

VARIABLES, **Pr(Y=1, innovation and 0 otherwise)**	Marginal Effects	Marginal Effects
International Formal Knowledge Sources	-0.047***	-0.043***
	[0.014]	[0.001]
National Public and Professional Knowledge Sources	-0.016***	-0.015
	[0.003]	[0.012]
Regional and National Commercial Knowledge Sources	0.069*	0.066
	[0.041]	[0.043]
International Customers and Informal Knowledge Sources	0.044***	0.034***
	[0.008]	[0.007]
Regional Informal and Business Knowledge Sources	0.132***	0.139***
	[0.026]	[0.031]
Regional and National Research Cooperation	-0.037***	-0.036***
	[0.002]	[0.012]
Regional Public Knowledge Infrastructure	-0.037	-0.038
	[0.047]	[0.083]
Regional and National Patents and Literature	0.001	0.005
	[0.009]	[0.012]
Regional and National Customers	0.056***	0.062***
	[0.006]	[0.003]
Regional and National Employees	-0.025	-0.026
	[0.083]	[0.081]
Regional and National Competitors	0.006	0.007
	[0.027]	[0.042]
Regional and National Suppliers	-0.036	-0.039
	[0.037]	[0.044]
Regional and National Licences	0.025***	0.027***
	[0.004]	[0.003]
R&D(1=R&D active, 0=R&D inactive)	0.259***	
	[0.008]	
R&D Expenditure>10%		0.260***
		[0.007]
R&D Expenditure 6-10%		0.375***
		[0.041]
R&D Expenditure 1-5%		0.031***
		[0.007]
Size	0.003	0.004
	[0.003]	[0.002]
Age	0	0
	[0.002]	[0.001]
Region (1=North East, 0=West Midlands)	-0.080***	-0.099***
	[0.017]	[0.001]
T- KIBS vs. P- KIBS	0.034***	0.037***
	[0.009]	[0.006]
Observations	237	235
Probability of positive outcome (Y=1)	0.565	0.569
Chi2(1)/pvalue	22.99/0.00	20.33/0.00
Pseudo R-squared	0.128	0.14
Log-likelihood	-142.4	-139.3

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. The likelihood ratio (LR) test from using the trichotomous R&D variable in the second column is 6.32(0.04), which implies a significant improvement in the model fit.

Table 5 Two Stages Probit Estimation for Innovation

	R&D (1=R&D Active; 0=R&D inactive)	**Innovation**
	Marginal Effects	Marginal Effects
International Formal Knowledge Sources		-0.023***
		[0.003]
National Public and Professional Knowledge Sources		0.05***
		[0.001]
Regional and National Commercial Knowledge Sources		0.096*
		[0.06]
International Customers and Informal Knowledge Sources		0.055**
		[0.03]
Regional Informal and Business Knowledge Sources		0.132***
		[0.009]
Regional and National Research Cooperation		-0.039***
		[0.007]
Regional Public Knowledge Infrastructure		0.008
		[0.031]
Regional and National Patents and Literature		0.014
		[0.013]
Regional and National Customers		0.061***
		[0.015]
Regional and National Employees		-0.041
		[0.081]
Regional and National Competitors		0.021
		[0.034]
Regional and National Suppliers		-0.014***
		[0.000]
Regional and National Licences		0.031*
		[0.013]
Profitability 0	0.187	
	[0.541]	
Profitability 0-1	0.594**	
	[0.240]	
Profitability >1-5	0.438***	
	[0.087]	
Profitability >5-10	0.539***	
	[0.118]	
Profitability>10	0.160**	
	[0.081]	
R&D predicted values		0.07
		[0.15]
Size	0.002**	
	[0.001]	
Age	0	
	[0.001]	
Region (1=North East, 0=West Midlands)	0.029***	
	[0.007]	
T-KIBS vs. P-KIBS	0.02	
	[0.059]	
Observations	267	267
Probability of positive outcome	0.156	0.564
Chi(2)/pvalue	17.2/0.06	22.4/0.06
Pseudo R-squared	0.154	0.098
Log-likelihood	-108.9	-183.8

Note1: Standard errors in brackets with *** p<0.01, ** p<0.05, * p<0.1. Estimates refer to a two stage procedure. In the first stage, the probability of firm to invest in R&D is estimated. In the second stage, predicted values of the R&D equation are used as the determinant in the innovation decision equation. Further details about the two stage estimation can be found in the text.

Table 6 Determinants of Innovation, Interaction between Regional Dummy and Knowledge Sources

VARIABLES, **Pr(Y=1, innovation and 0 otherwise)**	Marginal Effects	Marginal Effects
Region ×International Formal Knowledge Sources	-0.154	-0.134
	[0.13]	[0.113]
Region ×National Public and Professional Knowledge Sources	0.03	0.016
	[0.053]	[0.055]
Region ×Regional and National Commercial Knowledge Sources	0.143***	0.150***
	[0.047]	[0.049]
Region ×International Customers and Informal Knowledge Sources	-0.004	-0.008
	[0.051]	[0.054]
Region ×Regional Informal and Business Knowledge Sources	0.087**	0.078
	[0.028]	[0.049]
Region ×Regional and National Research Cooperation	-0.114	-0.122
	[0.149]	[0.095]
Region ×Regional and National Customers	0.011	0.019
	[0.042]	[0.044]
Region ×Regional and National Licences	-0.027	-0.028
	[0.053]	[0.054]
Region ×R&D(1=R&D active, 0=R&D inactive)	0.011	
	[0.011]	
Region ×R&D Expenditure>10%		0.134
		[0.171]
Region ×R&D Expenditure 6-10%		0.184
		[0.163]
Region ×R&D Expenditure 1-5%		-0.309*
		[0.188]
Region ×Size	0.005***	0.006***
	[0.002]	[0.002]
Region ×Age	-0.002	-0.002
	[0.001]	[0.001]
Region ×(T- KIBS vs. P- KIBS)	0.088*	0.096*
	[0.052]	[0.055]
Observations	267	267
Probability of positive outcome	0.60	0.609
Chi(2)/pvalue	43.71/0.01	46.24/0.00
Pseudo R-squared	0.09	0.10

Notes: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1. The coefficients are interaction terms between knowledge factors and a Regional dummy (*Region*) of whether the KIBS is located in North East=1 or in West Midlands=0.