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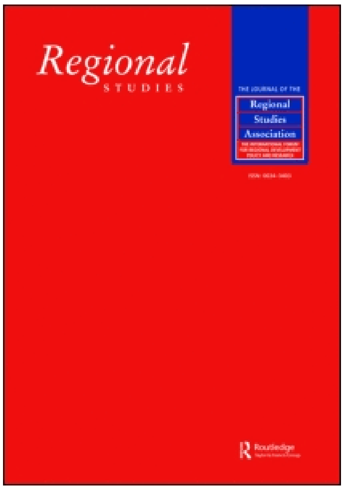

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Exploring the Effect of Geographical Proximity and University Quality on University-Industry Collaboration in the United Kingdom

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Exploring the Effect of Geographical Proximity and University Quality on University–Industry Collaboration in the United Kingdom

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LAURSEN K., REICHSTEIN T. and SALTER A. Exploring the effect of geographical proximity and university quality on university–industry collaboration in the United Kingdom, *Regional Studies*. This paper concerns the geographical distance between a firm and the universities in its local area. It is argued that firms' decisions to collaborate with universities for innovation are influenced by both geographical proximity to universities and the quality of these universities. The findings show that being located close to a lower-tier university reduces the propensity for firms to collaborate locally, while co-location with top-tier universities promotes collaboration. However, it is also found that if faced with the choice, firms appear to give preference to the research quality of the university partner over geographical closeness. This is particularly true for high-research and development intensive firms.

University–industry collaboration Geographical proximity University quality

LAURSEN K., REICHSTEIN T. and SALTER A. 探索地理毗邻性的作用以及英国大学－产业协作中大学的水平，研究区域。本文考察了企业与当地大学的地理空间距离。文章认为，地理空间毗邻与大学质量是影响企业与大学进行研究协作决策的两个因素。调查结果表明，如果与企业相邻的是一个较低层次的大学，这会降低企业在当地进行院校合作的倾向；然而，与一流的大学择邻而居则会促进地方性协作的产生。研究同时发现，如果面临选择，企业优先考虑的还是一所大学作为合作伙伴其研究水平的高低而非地理空间的远近。这一特征在高技术企业中表现尤为突出。

大学与产业合作 地理毗邻 大学质量

LAURSEN K., REICHSTEIN T. et SALTER A. Examiner l'impact de la proximité géographique et de la qualité des universités sur la collaboration industrialo-universitaire aux Etats-Unis, *Regional Studies*. Cet article traite de l'importance de la distance géographique entre une enterprise et les universités environnantes. On affirme que les décisions de l'entreprise quant aux possibilités de collaborer dans le domaine de l'innovation sont influencées à la fois par la proximité géographique des universités et par la qualité de ces universités. Les résultats laissent voir que la proximité des universités de rang inférieur réduit la propension des entreprises à collaborarer sur le plan local, tandis qu'un emplacement à proximité des universités de rang supérieur encourage la collaboration. Néanmoins, il s'avère aussi que, par choix, les entreprises semblent préférer un partenariat universitaire fondé sur la qualité de la recherche que sur la proximité géographique des universités. Cela vaut notamment pour les entreprises à fort niveau de recherche-développement.

Collaboration industrialo-universitaire Proximité géographique Qualité des universités

LAURSEN K., REICHSTEIN T. und SALTER A. Die Auswirkung der geografischen Nähe und der Qualität von Universitäten auf die Zusammenarbeit zwischen Universitäten und Industrie in Großbritannien, *Regional Studies*. In diesem Beitrag untersuchen wir den geografischen Abstand zwischen einer Firma und den Universitäten in ihrer Umgebung. Es wird argumentiert, dass die Entscheidungen von Firmen, im Bereich der Innovation mit Universitäten zusammenzuarbeiten, sowohl von der geografischen Nähe zu Universitäten als auch von der Qualität dieser Universitäten beeinflusst werden. Aus den Ergebnissen geht hervor, dass die Nähe zu einer Universität der unteren Stufe die Bereitschaft von Firmen zur lokalen Zusammenarbeit senkt, während die Nähe zu einer Universität der obersten Stufe die Zusammenarbeit fördert. Gleichzeitig stellen wir aber auch fest, dass Firmen,

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wenn sie die Wahl haben, offensichtlich der Forschungsqualität der Partneruniversität einen höheren Stellenwert einräumen als der geografischen Nähe. Dies gilt vor allem für Firmen mit einem hohen Anteil an Forschung und Entwicklung.

Zusammenarbeit zwischen Universitäten und Industrie Geografische Nähe Qualität von Universitäten

LAURSEN K., REICHSTEIN T. y SALTER A. Análisis del efecto de proximidad geográfica y la calidad universitaria en la colaboración entre la universidad y la industria en el Reino Unido, *Regional Studies*. Este artículo trata sobre la distancia geográfica entre una empresa y las universidades en su comunidad. Sostenemos que las decisiones de las empresas de colaborar con universidades para la innovación están influenciadas por la proximidad geográfica a las universidades y la calidad de las mismas. Los resultados muestran que si una empresa está ubicada cerca de una universidad de nivel inferior, se reduce su predisposición a colaborar localmente, mientras que estar ubicado cerca de una universidad de nivel superior fomenta la colaboración. Sin embargo, también observamos que si tienen la opción de elegir, parece que las empresas dan preferencia a la calidad de investigación de la universidad socia en vez de la proximidad geográfica. Este hecho se pone particularmente de manifiesto en empresas con alto nivel de investigación y desarrollo.

Colaboración universidad-industria Proximidad geográfica Calidad universitaria

JEL classifications: C25, D83, O31, R12

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INTRODUCTION

Universities play diverse roles in the economic system: they educate and train talented problem-solvers; they are the setting for most of the basic research undertaken in the economy; they provide cultural amenities to a local area; and they are sites, in their own right, of important economic activity (BOK, 2003; CHARLES, 2006). Given these roles, universities, which are often seen as crucial resource endowments within regions, are central to the creation and support of regional competitive advantages (GODDARD and CHATTERTON, 1999). Universities also may provide direct assistance to industrial firms in their innovative activities, providing advice, contacts or even ideas that can help firms to identify and incorporate valuable external knowledge into their innovation processes (CHESBROUGH *et al.*, 2006; MOWERY *et al.*, 2001). Research shows that firms with the ability to build links with university research may conduct more productive technological search (FLEMING and SORENSON, 2004), gain higher status and value from the commercial exploitation of their knowledge (ZUCKER *et al.*, 1998), and even may be more likely to innovate (FELDMAN, 1994).

Given the importance of universities for innovation, there has been much research effort to understand better the determinants of university–industry relationships (for example, AGRAWAL and HENDERSON, 2002; BEISE and STAHL, 1999; COHEN *et al.*, 2002; HENDERSON *et al.*, 1998; JAFFE *et al.*, 1993; LAURSEN and SALTER, 2004; LINK and SCOTT, 2005; MOHNEN and HOAREAU, 2003; MUELLER, 2006; PAVITT, 1991; and ROSENBERG, 1990). This body of work explores the range of factors and motivations that lead some firms to work with universities. It examines the character of the relationships between universities and industrial firms, including the types of knowledge exchanged in the innovation process. A part of this broad literature focuses on the geography of university–industry relationships (for example, ABRAMOVSKY *et al.*, 2007; ARUNDEL and GEUNA, 2004; BRAUNERHJELM, 2008; BRESCHI and LISSONI, 2001; FELDMAN, 1994; JAFFE, 1989; and MANSFIELD and LEE, 1996). This subset of the literature examines the important positive aspects of geographical proximity between firms and universities.

While it is not disputed that geography is an important determinant of firms' collaborative behaviour for innovation, this paper argues and substantiates empirically that the relationship between geographical proximity to a university and a firm's propensity to collaborate with a local university in the innovation process is influenced by both physical distance and the research quality of the local university. It is argued that a firm's decision to collaborate with its local university is more likely if this is one of the top-tier universities. Accordingly, it can be conjectured that geographical distance to the nearest top-tier university is positively related to the firm's propensities to collaborate with a local university, and that there is no or even a negative relationship between geographical distance to the nearest low-tier university and the propensity to collaborate locally. Based on three 'classes' of universities in terms of research quality, this paper provides overall empirical support for these ideas. Yet, while the findings indicate that the first-best choice – from the firms' point of view – is to collaborate with a local, top-tier university, in the absence of a high-quality local university, the second-best choice would seem to be collaborating with a non-local (presumably high-quality) university rather than cooperating with a local, lower-tier university. In addition, this study shows that firm–university relationships are moderated by research and development (R&D) intensity: firms with above-average R&D intensity are less prone to collaborate with (high-quality) local universities compared with firms with below-average R&D intensity. In other words, geographical proximity matters more for firms with lower absorptive capacity.

The empirical approach in the present paper involves combining data from a number of rich sources, including the 4th UK Innovation Survey, the UK's Research Assessment Exercise (RAE) 2001, and information on regional economic and labour resources. In order to calculate geographical distances, postcode grid data from GRIDLINK and Euclidean geometry are employed. The means of estimation is a nested logit model. The paper is structured as follows. The next section reviews the extant literature and produces a set of theoretical expectations. This is followed by a section that describes the data and methodology; and a results section. The final section provides conclusions and a discussion.

THE ROLE OF GEOGRAPHY IN UNIVERSITY–INDUSTRY COLLABORATION

Since the work of JAFFE (1989), there has been a strong focus on exploring the role of geographical proximity in shaping the relationship between private innovative activities and university research. Examining the extent of R&D spillovers at US state level, Jaffe found that corporate patenting responds positively to knowledge from academic research, providing evidence of the importance of geographical proximity in shaping patterns of university–industry interaction. Using an alternative measure of innovative output – taken from the US Small Business Administration innovation database – FELDMAN (1994) shows that regional innovativeness is correlated with geographical concentration of industrial and university R&D expenditure. This suggests that the co-location of complementary resources can provide increased opportunities for commercialization. Moreover, these results support the notion that university R&D activities can improve the technological opportunities in the region, providing an argument for public support for industrial R&D (BRESCHI and LISSONI, 2001; RODRIGUEZ-POSE and CRESCENZI, 2008).

These studies are consistent with the broad range of work on the continuing importance of geography in shaping innovative behaviour (BATHELT *et al.*, 2004; COOKE, 2001; MASKELL, 2001; MORGAN, 2004; STORPER and SCOTT, 1995; STORPER and VENABLES, 2004). This research tradition emphasizes the key role of geographical proximity in facilitating knowledge exchange. In other words, 'the more knowledge-intensive the economic activity seems to be, the more geographically clustered it tends to be' (ASHEIM and GERTLER, 2004, p. 291). Central to this perspective is the fact that territorial innovation systems create ecologies of knowledge, where knowledge exchange is sustained and supported through face-to-face contact, enabling the formation of 'swift trust' between different actors and creating informal traditions of reciprocity and mutual understanding (BROWN and DUGUID, 2000; GERTLER, 2001; MORGAN, 2004).

As BOSCHMA (2005) suggests, however, geographical (or physical) proximity alone is not enough to ensure collaboration or learning; other forms of proximity (in particular, cognitive, social, organizational, and institutional) may need to be present to enable successful knowledge exchange. However, in many cases, geographical proximity helps foster other forms of proximity (BOSCHMA, 2005). In the case of university–industry collaboration for innovation, social proximity is especially pertinent. Social proximity can be defined in terms of:

> socially embedded relations between agents at the micro-level. Relations between actors are socially embedded when they involve trust based on friendship, kinship and experience.
>
> (BOSCHMA, 2005, p. 66)

As MORGAN (2004, p. 12) explains, geographical proximity is important for knowledge exchange, especially when knowledge is 'person-embodied, concept-dependent, spatially sticky and socially accessible only through direct physical interaction'. This can be interpreted to mean that when knowledge has these key characteristics, geographical proximity may strongly facilitate cognitive and social proximity. Certainly, interactive learning and knowledge transfer between firms and universities, via collaboration for innovation, arguably involves this type of knowledge. In particular, much of the knowledge held by universities is 'sticky' and its transfer often requires extensive personal contact (PAVITT, 1991). Face-to-face contact is required, for example, to enable individuals to pass on the knowledge emerging from research activities that are still fluid and only partially formed (STORPER and VENABLES, 2004). Also, firms need to find ways to establish common interests and align incentives with their academic partners, which can only be done by 'being there' in order to establish a common background and shared set of expectations and understandings about the nature of the collaboration (GERTLER, 1995). Moreover, mutual concerns over the maintenance of reputation in the local setting can induce different actors with common backgrounds to form bonds quickly with one another. Trust can help to mitigate the problems of opportunism and lower the costs of writing contracts for knowledge sharing (NOOTEBOOM, 2002). This may be especially important in the context of university–industry collaboration where different norms and incentives often lead to clashes and disputes over the direction of research and the timing of disclosure of research findings (DASGUPTA and DAVID, 1994).

A geographically proximate university–industry link allows firms access to the research community's 'information network' – the local university partner

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being the necessary point of entry, which builds the goodwill and trust necessary for learning and productive knowledge sharing (Rosenberg, 1990). In order to gain access to university knowledge and the related networks, firms often need to invest considerable resources to build and maintain their university links through sponsored research, studentships, access to equipment, etc. (Garcia-Aracil and Fernandez de Lucio, 2008). In support of the arguments on the continuing importance of geographical proximity in shaping university–industry collaboration, there is a range of empirical studies on the importance of geographical proximity for university–industry links. Arundel and Geuna (2004) examine the role of geographical proximity in determining university–industry collaboration in terms of the type of knowledge being accessed. They find that when codified knowledge is involved in the interaction, physical closeness to the public science base is relatively less crucial. However, when the knowledge is tacit – and personal contact is necessary to make the exchange possible – the importance of geographical proximity is essential. Geographical proximity is defined by the importance firms give to the knowledge obtained from domestic versus foreign sources. Fabrizio (2006) uses a sample of biotechnology and pharmaceutical firms to examine the relationship between the number of citations to universities in firms' patents. Using a measure of minimum distance between a university and the focal firm, Fabrizio finds that the greater this distance, the lower will be that firm's rate of exploitation of public science. On the university's side, McFadyen and Cannella (2005) find that university researchers who look beyond the university for knowledge exchange partners that are geographically close have higher academic impacts than those scientists who collaborate only with scientists within their universities or with partners in very distant locations.

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Abramovsky *et al.* (2007) explore the relationship between the location of private sector R&D laboratories and university research departments in the UK. Using industry R&D data and data from the UK Research Assessment Exercise (RAE), the authors construct measures of the presence of business sector R&D activity at postcode level, for 111 postcode areas. The empirical results provide strong evidence of co-location in pharmaceutical R&D: the location of firms is disproportionately close to relevant university research, especially RAE 5- or 5*-rated chemistry departments. There is also some evidence of co-location for lower-level departments and machinery and communications equipment firms. The present study builds on this work, but instead of studying co-location decisions, it explores the decisions to collaborate for innovation and uses a more precise distance measure than that employed by Abramovsky *et al.*

Mansfield and Lee (1996) wrote a seminal piece on the role and nature of geographical distance in the relationship between research and industrial practice. They found that the probability of a firm funding academic R&D at a particular university is inversely related to the distance between the firm and the university. According to Mansfield and Lee, shorter distances facilitate interaction, lowering the costs of knowledge exchange. They looked especially at the effect of quality of university faculty on the propensity of firms to support academic R&D, finding that geographical proximity is particularly important for universities with 'adequate to good or marginal' facilities whose chances of industry support are low if they are located more than 100 miles from the firm. Although Mansfield and Lee broke new ground in examining how the importance of geographical proximity to collaboration differs according to the quality of the university, they employed rather broad distance measures (less than 100 miles away, 100–1000 miles away, and over 1000 miles away) and their firm sample was rather limited (some seventy-seven firms).

The present paper follows the previous literature in arguing that university–industry collaboration is related to geographical proximity, but it uncovers the more complex relationship, exploring the trade-offs between quality and proximity that firms face when choosing to work with universities. A firm must first decide whether or not to collaborate with a university, and it seems that, for most firms, setting up formal collaboration arrangements with universities is simply too difficult. Evidence from the European Innovation Surveys indicates that most firms choose not to cooperate, with fewer than 4% of European firms engaging in active collaboration for innovation with universities.[1] It is also not clear whether geographical proximity to a university plays the central role in the decision to collaborate: firm-level factors, such as size and R&D intensity, are liable to be more influential.

Once the decision to collaborate has been made, firms have a wide choice of collaboration partners. As suggested above, in the face of institutional barriers, firms are likely to seek university partners that are geographically proximate to enable face-to-face contact to resolve problems and facilitate the formation of trust. Indeed, successful innovation collaboration with universities can take many different forms, from high informal knowledge sharing to formal and binding contractual research relationships (D'Este and Patel, 2007). Accordingly, firms often exploit a range of mechanisms, such as contract and joint research, student training, and placements. Creating and sustaining these types of interactions can be costly for firms in terms of managerial time and resources, but may provide access to rare and valuable resources, such as knowledge networks, knowledge on specific new technologies, and skilled problem-solvers, all of which provide competitive advantage. This would seem to indicate a preference for a geographically proximate university collaboration partner regarding innovation.

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However, not all universities are endowed equally with resources and networks. The most valuable resources are likely to be concentrated in well-endowed, top-tier universities. For example, in 2006/2007 in England, the top ten research-active universities accounted for over 50% of total university research income (Higher Education Statistical Agency (HESA), 2009). Moreover, in 2006/2007, the research income of the highest funded university in England, Cambridge, was equal to the combined research funding of eighty-four other English universities. In part, these figures are consistent with the idea that lower-tier universities specialize in teaching and community outreach programmes and receive modest research funding, reflecting their research effort. Although teaching and outreach activities can make a critical contribution to the economy, they are unlikely to offer the same rewards to innovation collaborators as are offered by research-intensive universities. In addition, given the problems that firms face in building and sustaining collaborations with universities for innovation, the potential benefits of cooperation with a lower-tier university may not justify the costs involved in overcoming the general reluctance to partner with universities. Therefore, given a choice of partners, firms will prefer to collaborate with top-tier universities.

Based on the advantages of local collaboration and the need in some cases for high-quality university research as an input to the innovation process, it can be expected that firms will prefer, if possible, to collaborate with local, top-tier universities. However, for many firms, the local universities are of lower quality, in which case the disadvantages of more distant links may be offset by the availability of state-of-the-art knowledge appropriate to a given innovation project, in a more distant, but high-quality university. Indeed, as Breschi and Lissoni (2001) argue, although face-to-face contact will be required in more distant collaborations as well, the benefits of non-local university knowledge may outweigh the high costs of such interactions:

> Particularly for firms located in regions and cities with a relatively small accumulation of knowledge, the development of relationships with universities and other firms (suppliers and customers) located in higher-order urban centres is a key factor in determining success in the development of new products and processes. The most dynamic and innovative firms look for knowledge embodied in engineers and scientists *wherever* they are available, and not necessarily constrained in this by geographical barriers.
>
> (p. 999; original emphasis)

This quotation suggests that in university–industry interaction involving the most advanced firms, geographical proximity may be only a secondary concern. That is, when firms have high levels of absorptive capacity (Cohen and Levinthal, 1990),[2] they will be better able to detect and orchestrate collaboration for innovation with universities over larger geographical distances. In this case, what is of central importance is where the required state-of-the-art knowledge can be found. Less advanced firms, on the other hand, may not have the capacity to search for and coordinate collaboration with geographically distant high-quality universities. Also, it may be that the benefits of collaborating with a high-quality university partner are more substantial for firms with higher levels of absorptive capacity, which typically are better at assimilating external state-of-the-art knowledge. Against this backdrop – and given the higher costs of non-local collaboration – one would expect firms with low levels of absorptive capacity to be more likely to choose local university partners, and that firms with higher levels of absorptive capacity would be less inclined to confine their choice of a university partner to the local area. In the present setting, this translates into the hypothesis that firms with high R&D intensity will rely less on distance in collaboration for innovation than firms with lower absorptive capacity.

In sum, it is expected that geographical distance to the nearest top-tier university will be positively related to firms' propensities to collaborate with local universities. However, this effect is likely to be much stronger for firms with low rather than high absorptive capacity. Also, it is expected that there will be no or even a negative relationship between geographical distance to the nearest lower-tier university and the firm's propensity to collaborate with a local university. This is because lower-tier universities may offer fewer rewards in terms of innovation collaboration, when set against the high costs to the firm of building and managing these formal relationships.

DATA, METHOD, AND THE MEANS OF ESTIMATION

Data

The analysis draws on a range of rich data sets. First, The 4th UK Innovation Survey, which was implemented in 2005 and covers the period 2002–2004, is based on the Organisation for Economic Co-operation and Development's (OECD) *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (2005) and the Eurostat Community Innovation Survey (CIS). It asks firms about their innovative activities, including questions on sources of knowledge for innovation. The innovation survey was sent by post to over 28 000 business units based on a sample of firms created by the Office of National Statistics (ONS). The sample includes only firms with over ten employees, but covers all sectors in the economy. In order to ensure adequate regional and industry response rates, the ONS carried out a census of all firms with over 250 employees and a stratified sample of firms with fewer than 250 employees. The small and medium-sized firms were sampled from twenty-three industries and twelve regions, using information from the ONS Inter-Departmental Business Register (Department of Trade and Industry (DTI), 2005a, p. 12). Although participation was voluntary, the survey achieved a response rate of 58%. The response rates for different sectors, regions, and size classes are consistent with the overall response pool (Robson and Ortmans, 2006). To avoid bias due to the fact that not all firms pursue innovation as a strategy, those firms that did not make active efforts to innovate during the period of the survey were excluded. Included were firms with abandoned process or product innovation projects and a previous engagement in innovation activities, excluding only those where no evidence was found of innovative activity (that is, 7350 firms). The result was a sample of 8724 firms with non-missing values, with evidence of engagement in past or current innovative activities.[3]

In order to calculate distances between firms and universities, GRIDLINK was used, which links grid values to postcodes. The geographical positioning accuracy of these grid values is within 100 metres. The grid values allow an estimation of the linear distance between two grid points using the postcodes; based on this information, the geographical distance between each firm in the innovation survey and all universities in the UK can be measured.

Data from the RAE 2001, provided by HESA, were used to assess the research quality of university departments. The RAE is a government initiative designed to assess the research quality of universities in the UK. It is the key mechanism for allocating central research funding under the 'dual-support' system, which also includes research council funding. The RAE has been conducted every five years and entails every department within the university sector providing detailed information on its research income, publications, and staff. Expert assessment is made by scientific panels whose members judge the research outputs of each 'unit of assessment' as well as the general research environment and esteem. In 2001, the RAE produced 2597 research assessment scores for 184 institutions. Each unit of assessment was awarded a score from 1 to 5*, with 5* representing international excellence. The overall 'research-quality' score of a university can be created by examining the share of all university staff who were assessed as being internationally excellent (5 and 5* in the RAE scoring system). This measure was used to define and assess the research quality of the universities. The authors obtained a sample of ninety-nine universities with at least 100 full-time-equivalent academic staff divided into three tiers: the first tier included the ten leading research universities; the second tier included the next forty universities; and the third tier included the remaining forty-nine universities (for a full list, see Table A1 in the Appendix). In the leading research universities, 50% of their staff are located in 5- and 5*-rated departments, whereas third-tier universities often had fewer than 10% of their staff operating at this level.

Finally, several variables from the regional data sets were exploited to examine the impact of the regional endowment on collaborative activities, from publicly available ONS regional data on gross value added by region and National On-line Manpower Information System (NOMIS) labour market data records, and information on patents and R&D expenditures by region from Eurostat's REGIO database.

Measures

Dependent variables. In order to obtain a measure of industry collaboration with universities, the authors drew on the responses to a question on the UK Innovation Survey on formal collaboration for innovation that asked: 'Did your enterprise co-operate on any of your innovation activities with other enterprises or institutes during the three-year period 2002–2004?' The questionnaire defined innovation cooperation as:

> active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation. (DTI, 2005b, p. 8)

The survey also asked firms whether they collaborated with a range of external partners, and to indicate the location of each of these partners. The questionnaire distinguishes between seven types of collaborative partners, including 'universities or other higher education institutions', and four different locations ('Local/regional within the UK', 'UK national', 'Other Europe', and 'All other countries'). This information allowed the construction of a variable representing whether a firm collaborates with a local university ('local' being defined as within a radius of approximately 100 miles from the firm), a non-local university (more than 100 miles from the firm), or does not collaborate with a university.

Independent variables. The measures of geographical distance focus on the distance between the focal firm and all major UK universities. The first is a simple distance measure based on the log distance between the firm and the nearest university measured in miles (−log of the distance to the closest university). The logarithmic transformation ensures that the results are not determined by skewed or high values based on longer distances. The second set of measures is based on the log of the distance from the focal firm to universities of different levels of research quality: the distance to the nearest first-, second-, and third-tier university, respectively. It should be noted that all distance measures are 'as the crow flies' and take no account of actual travel times or local amenities, such as airports, motorways, etc. Also, the distance measures are not

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exact point-to-point references for each firm or university. The information on the detailed postal area of the firm covers a relatively small urban area: the centre point of this postal area is the reference point in this study.

In order to explore firm-level factors on the propensity to collaborate, a wide range of variables were included that characterize firms' structural features, and may shape the likelihood that they collaborate with universities. First, since innovative firms are more likely to collaborate with universities (FONTANA *et al.*, 2006), a measure was included of innovativeness based on whether the firm had introduced a product that was new to the market. Second, R&D intensity of the firm was measured by a continuous variable representing R&D expenditure for 2004 divided by total sales for the same year. R&D intensity provides a measure of firms' search investment and absorptive capacity and is likely to be associated with collaborating with and drawing knowledge from universities (LAURSEN and SALTER, 2004; MOHNEN and HOAREAU, 2003). Third, the proportion of total employees with science or engineering degrees was used to control for a firm's human capital level. Higher human capital should increase the likelihood of university collaboration since it increases the chances of the firm successfully absorbing external knowledge. Fourth, LAURSEN and SALTER's (2004) measure of openness was used to account for firms' attitudes to drawing on external sources of knowledge and information in general. This measure counts the number of different external sources the firm draws on in its innovative activities. Fifth, local collaboration activities is a variable indicating whether the firm cooperates with other enterprises within the enterprise group, suppliers, clients and customers, or competitors. It indicates whether there is a 'local' orientation in the firm's overall collaboration strategy. Sixth, the importance of public support for innovation in shaping patterns of relationships between firms and local universities is based on the responses to a question in the survey on public support for innovation which asks whether firms received public support from European, national, regional, or local governments to support their innovative activities. Seventh, a measure of firm size (logarithm of employment) was included since previous research shows that large firms are more likely to collaborate with universities (TETHER, 2002). This is the natural logarithm of the total number of employees in 2004. Eighth, three binary variables (Market – UK, Market – Europe, and Market – All Other Countries) measured whether the market orientation of a firm shapes its patterns of collaboration, based on whether its goods or services are sold in the UK, other European countries, or to the rest of the world. Ninth, given that new firms are likely to behave differently from established firms in terms of collaboration patterns, firm age was measured by a binary variable (newly established firm) that states whether or not the firm was a start-up (established after 1 January 2000). Finally, the authors controlled for whether the firm was part of an enterprise group or is an autonomous unit. All these measures were based on data taken from the UK Innovation Survey.

The decision to collaborate with a university might also be shaped by the regional environment of the firm. Two regional variables capture regional effects.[4] Both measures are based on the Nomenclature des Unités Territoriales Statistiques (NUTS)-2 and cover the reference period of the survey.[5] The availability of skills in a local region may shape collaborative behaviour: a measure was included of the percentage of the economically active population (labour pooling) at the NUTS-2 sub-regional level with higher degrees (Masters, PhD, or degrees in nursing or teaching). This information is drawn from the ONS NOMIS data set. A measure of the region's scientific and technology resources expressed by the share of R&D expenditures in total regional gross domestic product was also included. This measure is drawn from Eurostat's REGIO records. Finally, eleven industry dummies were included for a range of services, manufacturing, and construction industries.

Econometric method

The decision to collaborate with a local university is considered to be made in hierarchical nests. The second level nest decisions are limited by the decisions made in the first nest. In the present context, the decision to collaborate locally is based first on a decision to collaborate with a university (or not), and then whether to collaborate locally or non-locally (Fig. 1). A nested-logit regression technique (MCFADDEN, 1981) is used to model the decision to collaborate with a local university. In this example, the decision tree is asymmetrical since the decision to collaborate locally is available only if the firm has decided in the first place to collaborate with a university. To obtain the determinants of the (nested) local collaboration decision, the specification is implemented with interaction effects, following DRUCKER and PURI (2005). This modelling technique requires that the data are reshaped so that each observed firm is registered three times (one for each of the three possible outcomes of the decision tree: (1) do not use universities as a collaboration partner; (2) use a non-local university as a collaboration partner; or (3) use a local university as a collaboration partner). The 8724 observations thus become 26 172 and generate three new dummy variables, which are evenly distributed, with 8724 positive outcomes for each of the three possible outcomes. Two of these dummies (non-local and local university collaboration) are interacted with the variables in the second level nest, explaining local collaboration. In the set-up of the model, distance measures are used to

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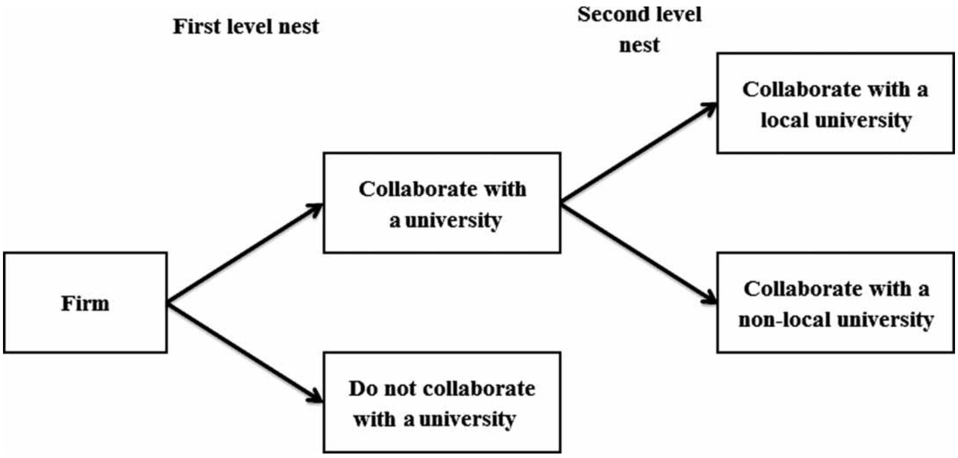

Fig. 1. Nested decision tree for university collaboration

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explain local versus non-local collaboration with a university, while the remaining variables explain the decision to collaborate with a university or not.

RESULTS

Table 1 outlines inter-industry differences in levels of formal collaboration with universities, and R&D intensities before the data were reshaped. In general, and as expected, only a modest share (4.4%) of UK firms have collaborative arrangements with a local university. However, there are significant industry differences. In science-based manufacturing industries, such as communication and medical equipment, the share of collaborators increases to 9.25% of the sample, while the incidence of collaboration in low-technology manufacturing industries is extremely small. In services, knowledge-intensive services, such as business services, show above-average levels of collaboration. These results are generally consistent with KLEVORICK *et al.* (1995) and COHEN *et al.* (2002), although the overall incidence of collaboration appears to be much lower than the findings in these studies, which are based on surveys of R&D managers. When the sample of firms is broader and based on firms that engage in formal R&D and those that do not, the incidence and level of collaboration between universities and industries is lower (for further elaboration on this point, see LAURSEN and SALTER, 2004).

Table 2 reports descriptive statistics and simple correlations of the reshaped data. The average minimum distance between a firm and the nearest university is 11.1 miles. The corresponding average minimum distances for first-, second-, and third-tier universities are 49.6, 17.8, and 14.7 miles. It is not surprising that first-tier universities are on average more distant than second- and third-tier universities as they are less numerous,

Table 1. Number of observations, percentage of local university collaborators, and average research and development (R&D) intensities across industries

	Number of firms	Percentage collaborating with the local university	Average R&D intensity
Food, Beverages and Tobacco	290	3.10	0.003
Textile, Leather Clothes and Leather	132	6.06	0.007
Wood, Pulp, Paper and Printing	492	1.22	0.005
Coke, Chemicals, Rubber, Plastic, None and Basic Metals	542	6.83	0.012
Fabricated Metals and Machinery	704	4.83	0.009
Electrical and Optical Equipment and Electrical Machinery	216	6.48	0.021
Communication and Medical Equipment	292	9.25	0.030
Motor Vehicles, Trailers and Other Transport Equipment	277	4.33	0.015
Manufacturing not elsewhere classified	348	3.45	0.011
Electricity, Gas and Construction	646	4.80	0.002
Wholesale/Retail Trade; Repair of Motor Vehicles, Motor	1165	3.26	0.003
Hotels and Restaurants	368	4.62	0.005
Transport, Storage and Communication	748	1.74	0.008
Financial Intermediation	410	2.93	0.014
Real Estate, Renting and Business Activities	2000	5.40	0.025
Mining and Quarrying	94	5.32	0.007
Total	8724	4.39	0.012

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Table 2. Descriptive statistics and correlations (n = *26 172)*

		Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1	Local University Collaboration Choice	0.33	0.47											
2	Local * −log(Distance to the closest university)	−0.60	1.09	**0.34**										
3	Not Local * −log(Distance to the closest university)	−0.60	1.09	**0.34**	**−0.30**									
4	Local * −log(Distance to the closest first-tier university)	−1.14	1.74	**0.40**	**0.83**	**−0.36**								
5	Local * −log(Distance to the closest second-tier university)	−0.76	1.26	**0.37**	**0.91**	**−0.33**	**0.86**							
6	Local * −log(Distance to the closest third-tier university)	−0.71	1.20	**0.36**	**0.94**	**−0.32**	**0.86**	**0.86**						
7	Not Local * −log(Distance to the closest first-tier university)	−1.14	1.74	**0.41**	**−0.36**	**0.83**	**−0.43**	**−0.40**	**−0.39**					
8	Not Local * −log(Distance to the closest second-tier university)	−0.76	1.26	**0.37**	**−0.33**	**0.91**	**−0.40**	**−0.37**	**−0.35**	**0.86**				
9	Not Local * −log(Distance to the closest third-tier university)	−0.71	1.20	**0.36**	**−0.32**	**0.94**	**−0.39**	**−0.35**	**−0.34**	**0.86**	**0.86**			
10	University Collaboration Choice	1.67	0.47	**−0.87**	**−0.39**	**−0.39**	**−0.47**	**−0.43**	**−0.41**	**−0.47**	**−0.43**	**−0.41**		
11	Introduced Products that are New to the Market (Dummy)	0.26	0.44	0.00	−0.01	−0.01	0.00	−0.01	−0.01	0.00	−0.01	−0.01	0.00	
12	R&D Intensity	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.17**
13	Proportion of the Employed with a Science/Engineering Degree	7.25	16.77	0.00	**0.03**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.00	**0.16**
14	Openness	1.23	1.53	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.00	**0.13**
15	Local Collaboration Activities (Dummy)	0.12	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.14**
16	Public Support (Dummy)	0.15	0.35	0.00	−0.01	−0.01	**−0.02**	−0.01	−0.01	**−0.02**	−0.01	−0.01	0.00	**0.20**
17	Logarithm of Employment	4.21	1.54	0.00	**0.03**	**0.03**	**0.03**	**0.03**	**0.02**	**0.03**	**0.03**	**0.02**	0.00	**0.09**
18	Newly Established Firm (Dummy)	0.15	0.36	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	−0.01
19	Part of an Enterprise Group (Dummy)	0.41	0.49	0.00	**0.03**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.00	**0.11**
20	Market – UK (Dummy)	0.34	0.47	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	**−0.11**
21	Market – Europe (Dummy)	0.13	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.03**
22	Market – All Other Countries (Dummy)	0.29	0.45	0.00	0.00	0.00	**0.02**	0.00	0.00	**0.02**	0.00	0.00	0.00	**0.24**
23	Labour Pooling (NVQ4) (Share)	27.24	5.50	0.00	**0.13**	**0.13**	**0.14**	**0.11**	**0.11**	**0.14**	**0.11**	**0.11**	0.00	0.01
24	R&D by Regional GDP, 2003	1.85	1.00	0.00	**−0.09**	**−0.09**	**−0.03**	**−0.09**	**−0.09**	**−0.03**	**−0.09**	**−0.09**	0.00	**0.04**

		12	13	14	15	16	17	18	19	20	21	22	23
13	Proportion of the Employed with a Science/Engineering Degree	**0.31**											
14	Openness	**0.08**	**0.10**										
15	Local Collaboration Activities (Dummy)	**0.04**	**0.05**	**0.13**									
16	Public Support (Dummy)	**0.20**	**0.19**	**0.10**	**0.12**								
17	Logarithm of Employment	**−0.02**	−0.01	**0.12**	**0.05**	0.01							
18	Newly Established Firm (Dummy)	**0.04**	**0.03**	**0.01**	0.00	0.01	**−0.11**						
19	Part of an Enterprise Group (Dummy)	**0.07**	**0.10**	**0.09**	**0.05**	**0.03**	**0.41**	**−0.04**					
20	Market – UK (Dummy)	**−0.06**	**−0.08**	**−0.03**	**−0.05**	**−0.10**	0.00	**0.03**	**−0.05**				
21	Market – Europe (Dummy)	**−0.02**	**0.01**	0.00	**−0.02**	−0.01	**0.05**	**−0.03**	**0.05**	**−0.28**			
22	Market – All Other Countries (Dummy)	**0.16**	**0.21**	**0.09**	**0.05**	**0.19**	**0.16**	**−0.07**	**0.20**	**−0.45**	**−0.24**		
23	Labour Pooling (NVQ4) (Share)	**0.03**	**0.09**	**0.03**	**0.01**	**−0.04**	**0.11**	−0.01	**0.10**	**−0.02**	0.00	**0.07**	
24	R&D by Regional GDP, 2003	**0.04**	**0.04**	0.01	0.01	**−0.05**	**0.02**	−0.01	**0.02**	**−0.02**	0.01	**0.02**	**−0.08**

Notes: Coefficients shown in bold are significant at the 5% level.
GDP, gross domestic product; NVQ4, National Vocational Qualification 4; SD, standard deviation.

representing only 10% of the sample of universities. About 9% of the sampled firms have a university within a 1 mile radius, and more than 60% have a university within 10 miles. These results suggest that there is considerable co-location among firms and universities in the UK. The greatest distance between a firm in the sample and a university in the UK is 221.4 miles. The distance of firms from universities is highly variable, with the biggest distances applying to firms in the Highlands and Islands of northern Scotland and shortest applying to firms in inner London.

There is a high correlation between the first distance measure, capturing the distance between the focal firm and its nearest university, and the distance measures to second- and third-tier universities. Since these two sets of measures are not used simultaneously as explanatory variables, this should not raise concerns with respect to multicollinarity. However, there is substantial correlation between the different university tier-distance measures and this might be a cause for concern. However, excluding them one by one leaves the results more or less unchanged, suggesting that the estimates are robust regardless of the possibility of multicollineairity.

Table 3 reports the first regression results using the distance to the closest university as an explanatory variable; Table 4 reports the results the three separate distance measures for first-, second-, and third-tier universities. The results in both tables are based on the total sample of firms and a split sample of between below-average and above-average R&D-intensity firms. The split between high and low R&D-intensive firms is interpreted as a split between high and low absorptive-capacity firms. Table 3 shows that geographical proximity between the focal firm and the nearest university is insignificant, indicating that it is not geographical proximity alone that shapes university–firm collaboration arrangements. This result persists for firms with both above-average and below-average R&D intensity.

Table 4 splits the university sample into three tiers and includes distance measures for each type of university. This division provides significances indicating that adjusting the analysis of distance by university quality provides additional information. Overall, it is found that being geographically close to a first-tier university increases the likelihood of collaborating with a local university, while being located close to a third-tier university decreases the probability of collaborating with a local university: the results for first-tier universities are significant at the 1% level, while for third-tier universities they are significant only at the 10% level. These findings are consistent with the authors' initial expectations.

Table 4 shows also that for firms with below-average R&D intensity, the likelihood of collaboration increases if they are located geographically close to a first-tier university (significant at the 1% level), whereas for firms with higher-than-average levels of R&D intensity, geographical proximity to a top university has no effect. Therefore, the positive effect of geographical proximity among the total sample can be attributed mainly to the sample of below-average R&D-intensive firms. This finding supports the expectation that firms with low absorptive capacity are much more dependent on the presence of local, high-quality universities. Indeed, low R&D-intensive firms choose to collaborate only locally when a high-quality university is close by. In contrast, high R&D-intensive firms – which should be able to search for, orchestrate, and assimilate external university knowledge more easily – are not more likely to collaborate with universities as a function of geographical proximity. However, the findings suggest that being close to a third-tier university decreases the likelihood of collaboration for firms with high levels of R&D intensity (significant at the 5% level).

The nested logit specification also allows for inferences about non-local collaboration with universities. The results are in line with the overall findings and show that when firms are located close to a third-tier university, the probability of collaborating with a non-local university increases, while being located close to a first-tier university decreases the probability of collaborating with a non-local university (this goes for firms with low as well as high absorptive capacity). These findings are interpreted as indicating that local firms demand access to high-quality scientific research (if they demand it at all); to gain such access, the first-best choice is to collaborate with a local, high-quality, university, because local collaboration is much easier to manage. However, if a high-quality local university is not present, the second-best choice seems to be to collaborate with a non-local (presumably high-quality) university, rather than with a local lower-tier university. In other words, if forced to choose, firms favour quality over proximity.

Three waves of supplementary analysis (not reported here for reasons of space) were conducted to check the robustness of results and ensure they were not sensitive to small changes in the key variables. First, the universities were split into tiers, since the present classification of universities is open to question. The simple first- and second-tier split is based on above-average and below-average numbers of staff in 5 or 5* departments, in total staff. Results were checked for sensitivity against the large number of former polytechnics (converted to universities in the 1992 educational reforms) in the sample by creating a new third tier based on these universities. The results for each round of analysis were generally consistent with findings reported. Second, because London is an outlier in the UK setting since it is home to many universities and firms within a relatively small area, an analysis was conducted that excluded London firms. Again, results were consistent. Finally, to check for substantial differences between new and established firms, a separate analysis was run for each population. The results held for the population of

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Table 3. Determinants of local university collaboration – results of robust logistic regressions

	Total sample		Above-average R&D Intensity	Firms	Below-average R&D Intensity	Firms
Local university collaboration choice equation						
Local * −log(Distance to the closest university)	−0.066	[0.118]	−0.359	[0.237]	0.073	[0.140]
Not Local * −log(Distance to the closest university)	0.090	[0.110]	0.281	[0.173]	−0.042	[0.147]
University collaboration choice equation						
Introduced Products New to the Market	0.732 ***	[0.098]	0.456**	[0.190]	0.740***	[0.115]
R&D Intensity	1.076 *	[0.626]	0.253	[0.742]	43.842***	[12.147]
Proportion of the Employed with a Science/Engineering Degree	0.015 ***	[0.002]	0.011***	[0.004]	0.015***	[0.003]
Openness	0.141 ***	[0.025]	0.116**	[0.049]	0.143***	[0.030]
Local Collaboration Activities	2.473 ***	[0.101]	2.255***	[0.204]	2.583***	[0.115]
Public Support	1.084 ***	[0.105]	1.165***	[0.185]	0.993***	[0.128]
Logarithm of Employment	0.187 ***	[0.033]	0.268***	[0.070]	0.182***	[0.038]
Newly Established Firm	−0.185	[0.139]	−0.281	[0.267]	−0.093	[0.164]
Part of an Enterprise Group	−0.051	[0.102]	0.087	[0.192]	−0.116	[0.122]
Market orientation dummies						
UK Orientation	−0.122	[0.146]	−0.224	[0.408]	−0.099	[0.164]
Europe – Orientation	0.228	[0.178]	0.078	[0.454]	0.225	[0.201]
All Other Countries Orientation	0.525 ***	[0.145]	0.500	[0.398]	0.426**	[0.175]
Local Orientation	Benchmark		Benchmark		Benchmark	
Labour Pooling (NVQ4) (Share)	−0.006	[0.010]	−0.023	[0.020]	0.000	[0.011]
R&D by Regional GDP, 2003	−0.094 *	[0.048]	−0.033	[0.084]	−0.154**	[0.061]
Industry dummies						
Textile, Leather Clothes and Leather	−0.120	[0.467]	−1.037	[1.012]	0.139	[0.489]
Wood, Pulp, Paper and Printing	−0.496	[0.364]	0.264	[0.663]	−0.695*	[0.414]
Coke, Chemicals, Rubber, Plastic, None and Basic Metals	0.467	[0.296]	1.062**	[0.518]	0.173	[0.339]
Fabricated Metals and Machinery	0.047	[0.307]	0.271	[0.525]	−0.014	[0.351]
Electrical and Optical Equipment and Electrical Machinery	0.466	[0.342]	1.159*	[0.626]	0.118	[0.405]
Communication and Medical Equipment	0.594 *	[0.313]	1.002*	[0.542]	0.229	[0.375]
Motor Vehicles, Trailers and Other Transport Equipment	−0.156	[0.356]	0.129	[0.615]	−0.261	[0.402]
Manufacturing not elsewhere classified	−0.332	[0.366]	−0.420	[0.725]	−0.300	[0.414]
Electricity, Gas and Construction	0.215	[0.309]	1.276**	[0.580]	−0.170	[0.366]
Wholesale/Retail Trade; Repair of Motor Vehicles, Motor	−0.090	[0.291]	0.178	[0.562]	−0.157	[0.327]
Hotels and Restaurants	0.058	[0.338]	0.928	[0.803]	−0.131	[0.395]
Transport, Storage and Communication	−0.834 **	[0.357]	−0.653	[0.747]	−0.903**	[0.376]
Financial Intermediation	−0.802 **	[0.396]	−15.694	[153.335][a]	−0.769*	[0.404]
Real Estate, Renting and Business Activities	−0.077	[0.280]	0.601	[0.521]	−0.342	[0.315]
Mining and Quarrying	−0.034	[0.544]	−0.889	[1.060]	0.297	[0.592]
Food, Beverages and Tobacco	Benchmark		Benchmark		Benchmark	
Constant	−6.561***	[0.617]	−6.505***	[1.260]	−6.505***	[0.689]
Number of observations	26 172		4053		22 119	
Log-likelihood	−2278.5		−614.1		−1633.2	
Chi-square (χ^2)	1218.8***		243.0***		807.6***	
LR test for independence of irrelevant alternatives	183.4***		39.4***		134.8***	

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$; standard deviations (SD) are given in brackets.

[a]Large standard errors are attributed to small samples. The effect of these estimates on the overall results was tested, and no cause for concern was found.

GDP, gross domestic product; LR, likelihood ratio; NVQ4, National Vocational Qualification 4.

established firms, but not for the new firms. There are several possible reasons for these results, including the low number of new firms in the sample, the high number of missing variables for new firms in the CIS (leading to severe sample attribution), and the potential for new firms' collaboration decisions to be driven by different factors to those influencing established firms.

All the models examine firm-level characteristics and their effects on collaboration with universities. As might be expected, product innovation, R&D intensity, the proportion of employees with science or engineering degrees, openness, local collaboration strategy, and public support are significantly associated with university collaboration. Large firms are also more likely to use universities as collaboration partners. However, whether or not the firm is a start-up makes little or no difference to its likelihood of collaborating. In general, the findings concerning firm-level variables are consistent with the prior research. However, regional variables appear to have a limited effect on the likelihood of collaboration: only regional R&D intensity appears to have an influence. This variable exhibits a rather puzzling negative effect, indicating that R&D-intensive regions have relatively fewer

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Table 4. Determinants of local university collaboration – results of robust logistic regressions

			Above-average R&D		Below-average R&D	
	Total sample		Intensity	Firms	Intensity	Firms
Local university collaboration choice equation						
Local * −log(Distance to the closest first-tier university)	0.402***	[0.119]	0.101	[0.257]	0.501***	[0.144]
Local * −log(Distance to the closest second-tier university)	−0.132	[0.234]	0.456	[0.394]	−0.208	[0.216]
Local * −log(Distance to the closest third-tier university)	−0.413*	[0.221]	−1.035**	[0.406]	−0.338	[0.213]
Not Local * −log(Distance to the closest first-tier university)	−0.549***	[0.155]	−0.495*	[0.278]	−0.611***	[0.220]
Not Local * −log(Distance to the closest second-tier university)	0.270	[0.274]	−0.159	[0.360]	0.286	[0.265]
Not Local * −log(Distance to the closest third-tier university)	0.485*	[0.272]	0.941**	[0.421]	0.469*	[0.277]
University collaboration choice equation						
Introduced Products New to the Market	0.736***	[0.098]	0.462**	[0.192]	0.740***	[0.115]
R&D Intensity	1.136*	[0.618]	0.455	[0.750]	44.260***	[12.141]
Proportion of the Employed with a Science/Engineering Degree	0.015***	[0.002]	0.011**	[0.004]	0.015***	[0.003]
Openness	0.141***	[0.026]	0.114**	[0.049]	0.142***	[0.030]
Local Collaboration Activities	2.473***	[0.101]	2.254***	[0.205]	2.584***	[0.115]
Public Support	1.075***	[0.106]	1.131***	[0.186]	0.996***	[0.129]
Logarithm of Employment	0.185***	[0.033]	0.277***	[0.070]	0.180***	[0.038]
Newly Established Firm	−0.189	[0.139]	−0.291	[0.270]	−0.092	[0.164]
Part of an Enterprise Group	−0.049	[0.102]	0.104	[0.193]	−0.118	[0.122]
Market orientation dummies						
UK Orientation	−0.126	[0.146]	−0.187	[0.410]	−0.100	[0.164]
Europe – Orientation	0.218	[0.178]	0.113	[0.456]	0.216	[0.201]
All Other Countries Orientation	0.527***	[0.145]	0.541	[0.400]	0.424**	[0.175]
Local Orientation	Benchmark		Benchmark		Benchmark	
Labour Pooling (NVQ4) (Share)	−0.005	[0.012]	−0.011	[0.023]	−0.002	[0.013]
R&D by Regional GDP, 2003	−0.079	[0.050]	0.015	[0.087]	−0.147**	[0.063]
Industry dummies						
Textile, Leather Clothes and Leather	−0.148	[0.466]	−1.029	[1.013]	0.111	[0.489]
Wood, Pulp, Paper and Printing	−0.503	[0.363]	0.293	[0.665]	−0.700*	[0.413]
Coke, Chemicals, Rubber, Plastic, None and Basic Metals	0.445	[0.296]	1.077**	[0.523]	0.149	[0.338]
Fabricated Metals and Machinery	0.029	[0.308]	0.304	[0.528]	−0.038	[0.350]
Electrical and Optical Equipment and Electrical Machinery	0.442	[0.344]	1.150*	[0.628]	0.095	[0.404]
Communication and Medical Equipment	0.583*	[0.313]	1.084**	[0.546]	0.207	[0.374]
Motor Vehicles, Trailers and Other Transport Equipment	−0.156	[0.357]	0.206	[0.622]	−0.277	[0.402]
Manufacturing not elsewhere classified	−0.347	[0.366]	−0.330	[0.727]	−0.321	[0.414]
Electricity, Gas and Construction	0.192	[0.310]	1.330**	[0.583]	−0.188	[0.366]
Wholesale/Retail Trade; Repair of Motor Vehicles, Motor	−0.104	[0.292]	0.253	[0.565]	−0.170	[0.326]
Hotels and Restaurants	0.051	[0.337]	0.902	[0.807]	−0.139	[0.395]
Transport, Storage and Communication	−0.847**	[0.355]	−0.617	[0.749]	−0.916**	[0.375]
	−0.814**	[0.395]	−15.726	[1166.484][a]	−0.781*	[0.404]
Real Estate, Renting and Business Activities	−0.090	[0.280]	0.621	[0.524]	−0.356	[0.315]
Mining and Quarrying	−0.077	[0.548]	−1.005	[1.079]	0.280	[0.593]
Food, Beverages and Tobacco	Benchmark		Benchmark		Benchmark	
Constant	−6.623***	[0.828]	−7.755***	[1.649]	−6.342***	[0.939]
Number of observations	26 172		4053		22 119	
Log-likelihood	2271.8		−610.1	–	1627.9	
Chi-square (χ^2)	1229.8***		245.0***		810.9***	
LR test for independence of irrelevant alternatives	99.6***		30.4***		68.8***	

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$; standard deviations (SD) are given in brackets.

[a]Large standard errors are attributed to small samples. The effect of these estimates on the overall results was tested, and no cause for concern was found.

GDP, gross domestic product; LR, likelihood ratio; NVQ4, National Vocational Qualification 4.

firms collaborating with universities. However, the associated estimates are significant at a very weak level with the exception of below-average R&D-intensive firms. Industry differences appear to matter, with communication and medical equipment firms being generally more likely to collaborate, whereas transport, storage and communication, and financial intermediation firms are less likely to collaborate.

CONCLUSIONS

This study uses detailed data on the geography of university–industry collaboration with the aim of expanding the knowledge on how the geographical proximity and research quality of universities shapes firm-level decisions to collaborate with universities. The results confirm that geographical proximity plays a role in shaping university–industry interaction, but that

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positive effects on the propensity for innovation collaboration of geographical proximity by itself are not general. However, geographical closeness to a top-tier university increases the likelihood of collaboration in general, and for low research and development (R&D)-intensive firms in particular, and geographical proximity to a third-tier university decreases the likelihood of collaboration for the group of high R&D-intensive firms. Thus, in this respect, the importance of geographical proximity is contingent on the type of university in the local area. In general, firms prefer to engage in collaborative arrangements with first-tier universities as these universities are likely to offer the most valuable resources and capabilities. Proximity to these universities, therefore, increases the potential for collaboration by reducing the costs of interaction and by supporting the formation of trust through social proximity. However, firms with high levels of absorptive capacity are able to expand their number of potential partners, going beyond the geographically proximate area because they are better able to search for and coordinate interaction with distant partners. Also, the potential gains from collaborating with the right (high-quality) partner are substantially higher for these firms, which counters the costs associated with collaborating over greater geographical distances. Thus, for firms with high levels of absorptive capacity, geographical proximity is of less concern when choosing a university partner to collaborate on an innovation project.

Nevertheless, the findings from this study suggest that the first choice for firms is to collaborate with a local, top-tier university; in the absence of a high-quality university near by, the second-best choice is collaboration with a non-local university. That is, if required to make a choice, firms appear to favour quality over geographical proximity. These findings may be demonstrating a trade-off between geographical proximity and quality in the case of university–industry collaboration. The implication of this trade-off is that the first-best option involves both local links and top universities, while the second-best option involves preference to research quality over geographical proximity. By focusing on the contingent nature of the effect of geographical proximity on the likelihood for firms to collaborate with universities, this paper extends the understanding on how the quality of local universities may shape university–industry collaboration patterns. Much of the research on university–industry links adopts perspectives that either ignore the geographical context of such collaborations or focus only on the co-presence of industrial and academic research within or between administrative regions. In contributing to a new wave of work that attempts to look at local effects more directly, this paper helps to broaden the understanding of when and how geographical proximity matters for university–industry collaboration, and suggests that its effects on collaboration are significant only when it is combined with firm-level capabilities. This suggests that the relationship between proximity and innovation is a complex one, in which both the quality of the local university and the capabilities of the firm matter. The present study draws attention to the winding processes that lead some firms to work with their local universities and provides some insights into the motivations and incentives for firms partnering with non-local universities.

There are a number of policy implications from this study. First, the results indicate that firms and universities are more likely to collaborate locally for innovation if the local firms have relatively low absorptive capacity. This implies that policies that aim to promote university–industry collaboration are likely to have different effects, depending on whether the given policy programme is aimed at supporting university–industry collaboration in general or whether it is aimed at supporting local collaboration. In the latter case, such a programme is likely to help facilitate collaboration between local high-quality universities and firms with relatively low absorptive capacity in terms of R&D intensity. This may be desirable under some circumstances, but should be borne in mind by policy-makers responsible for the design of policy programmes aimed at promoting university–industry collaboration. Second, it seems that regardless of their level of absorptive capacity, local firms are less likely to collaborate with a local university if their nearest university is a third-tier university. Firms are generally more interested in collaborating with top-tier universities to cooperate over innovation. Policies aimed at encouraging lower-tier universities to collaborate with their local firms are unlikely, therefore, to be successful. Third, policy-makers should support high-quality scientific research, partly because access to such research (and to related networks) is of great importance to capable local and non-local firms. It is also clear that leading firms are less constrained by geography in their choice of university partners. Thus, attempts to encourage collaboration locally may be unsuccessful when the rewards for distant collaboration might be much greater.

This research has several limitations. First, one cannot state which universities firms collaborate with in their local areas. The survey defines local area rather broadly to include universities at distances of over 100 miles from the focal firm. Their partners could be any university in this wide area or more than one university in this area. Although the approach in this study is not dyadic (in that the authors do not have information on the collaborations between specific firms and universities), it is consistent with previous work on the spillovers from university research to private-sector R&D, which rely on inferences about the importance of proximity, based on general regional or geographic information. The advantage of the approach in this paper over a dyadic approach is that it allows investigation of the behaviour and attitudes of both non-collaborators and collaborators (to be sure, it is acknowledged that the dyadic approach

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has other advantages). In most dyadic studies of university–industry collaborations, only actual collaborations are included in the analysis and the attitudes of non-collaborators tend to be ignored. This can lead to an overemphasis of the importance of geographical proximity on the likelihood of collaboration since the decision to collaborate is made prior to the analysis. Access to information from the Eurostat Community Innovation Survey (CIS) allows one to control for many different aspects of firm-level collaboration decisions, and helps to exclude alternative explanations of collaboration.

Second, the present analysis considers distance from the three closest universities (and their research quality). However, it may be that it is the availability of research resources generally in the area that shapes firms' attitudes towards working with a university. Third, the scientific capabilities of universities differ by field. Third-tier universities often have pockets of research excellence: this specialization may shape the importance of the local university to a local firm. For example, pharmaceutical firms may be attracted to a university with a strong chemistry or biology department, even if the reputation of the university overall is poor. The present analysis does not attempt to control for department-level effects or industry dependence on different scientific fields. One reason for this is that it is difficult to attribute a field of research to a single industry. Industries draw upon a diverse range of the sciences and it is not clear how the distance to departments or fields of science should be weighted. Fourth, it is possible that the results obtained by this study were shaped by the location decision of managers, who may self-select locations close to universities in order to facilitate university–industry collaboration. The current set-up does not allow this possibility to be excluded totally.

Future work could extend the analysis in several directions. The present study relies on a relatively simple measure of the characteristic of local universities: research quality as measured in the Research Assessment Exercise (RAE). However, there is much richer information available on UK universities and their activities and it would be useful to explore how universities' commercial activities, such as patents and licensing, shape the decisions of local firms to collaborate. It might be that increased commercialization by a local university may reduce or increase the likelihood of it being chosen as a collaboration partner. In addition, it would be useful to explore the effect of student population size in a local area, on rates and incidence of collaboration with universities. It would be interesting to study whether the availability of new graduates from local universities, especially doctoral and post-doctoral researchers, has an effect – whether local availability of skilled and talented problem-solvers may induce higher rates of industry exploitation of university research for their innovative activities. Also, why and when firms choose local over distant partners for innovation collaborations, and the impact of their choices on subsequent performance, is an underdeveloped area of research. Little is known about how the movement of people from research to industry may shape university–industry collaboration: it is highly likely that this movement will be strengthened by geographical proximity. Finally, future research should address the topic of this paper by considering the university and the firm decision processes simultaneously. This would open up debate on the matching processes that firms and universities follow, which result in very few suitable partners being identified. The matching process proposed in MINDRUTA (2007) seems promising in this respect.

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APPENDIX

Table A1. Research quality of UK universities by the percentage of staff within 5 or 5 departments divided into three tiers – shares reported*

First tier					
London School of Economics & Political Science (LSE)	0.94	University of Warwick	0.83	University College London (UCL)	0.77
University of Cambridge	0.93	Imperial College	0.81	University of St Andrews	0.73
University of Oxford	0.90	University of York	0.78	University of Southampton	0.71
London School of Hygiene & Tropical Medicine	0.89				
Second tier					
Royal Holloway, University of London	0.66	University of East Anglia	0.51	Queen's University Belfast	0.34
University of Bristol	0.66	University of Reading	0.51	Keele University	0.33
University of Durham	0.66	University of Glasgow	0.50	University of Kent	0.27
Lancaster University	0.64	King's College London (KCL)	0.49	University of Strathclyde	0.26
Birkbeck College, University of London	0.63	University of Surrey	0.48	University of Aberdeen	0.25
University of Bath	0.63	University of Exeter	0.48	Brunel University	0.23
University of Edinburgh	0.63	University of Newcastle	0.47	City University, London	0.22
School of Oriental and African Studies (SOAS), University of London	0.62	Goldsmiths College, University of London	0.47	University of Hull	0.22
University of Sheffield	0.62	University of Liverpool	0.45	University of Bradford	0.21
University of Essex	0.60	Queen Mary, University of London	0.42	University of Salford	0.20
University of Sussex	0.59	University of Stirling	0.39	Heriot-Watt University	0.19
Aston University	0.58	University of Dundee	0.34	University of Wales Swansea	0.18
University of Nottingham	0.57	University of Leicester	0.34	University of Ulster	0.13
University of Leeds	0.54				
Third tier					
University of Brighton	0.12	Manchester Metropolitan University	0.01	University of Central Lancashire	0.00
University of Portsmouth	0.08	University of Hertfordshire	0.01	Buckinghamshire Chilterns University College	0.00
Open University	0.07	University of West of England, Bristol	0.01	Kingston University	0.00
St George's Hospital Medical School, University of London	0.07	University of Paisley	0.00	University of Derby	0.00
University of Huddersfield	0.06	Staffordshire University	0.00	Canterbury Christ Church University	0.00
Nottingham Trent University	0.05	University of Abertay Dundee	0.00	Northumbria University	0.00
Sheffield Hallam University	0.05	Napier University	0.00	University of Chester	0.00
University of Plymouth	0.04	University of Greenwich	0.00	Southampton Solent University	0.00
Roehampton University	0.04	Edge Hill University	0.00	University of Sunderland	0.00
University of Westminster	0.04	University of Glamorgan	0.00	Liverpool Hope University	0.00
University of East London	0.04	London South Bank University	0.00	Coventry University	0.00
De Montfort University	0.03	St Martin's College	0.00	University of Wolverhampton	0.00
University of Teesside	0.03	University of Wales Institute, Cardiff	0.00	University of Lincoln	0.00
Liverpool John Moores University	0.02	University of Bolton	0.00	Robert Gordon University	0.00
Middlesex University	0.02	Cranfield University	0.00	University of Worcester	0.00
Bournemouth University	0.02	Leeds Metropolitan University	0.00	Glasgow Caledonian University	0.00
Anglia Ruskin University	0.02				

Note: The classification is based on the percentage of total university staff located in departments that received a 5 or 5* in the Research Assessment Exercise (RAE), 2001. The higher education institutes were ranked accordingly, and then the upper 10% was defined to be the first tier, the following 40% to be second tier, and the remaining 50% to be third tier. The first tier includes universities with more than 70% of their total staff in 5 or 5* departments; the second tier covers universities with between 13% and 70% of their total staff in 5 or 5* departments; and the third tier covers universities with below 12% of their total staff in 5 or 5* departments.

NOTES

1. This is not to say that these firms do not benefit from university activities, as they may draw on students and other university outputs.
2. Cohen and Levinthal (1990, p. 128) define absorptive capacity as the 'ability to recognize the value of new information, assimilate it, and apply it to commercial ends'.
3. Since the present authors were unable to obtain regional data on Northern Ireland, Northern Ireland firms are excluded from the analysis.
4. Several other regional variables were also investigated, including the logarithm of the gross value added in the region and the number of patent applications per 1000 inhabitants in 2002–2004. They are excluded for reasons of multicollinearity. The main results remained virtually unaltered.
5. In addition, in the case of Scotland, the authors do not have disaggregated NUTS-2 regional data for R&D intensity. Scotland's national R&D intensity is used in this study for all three of its NUTS-2 regions.

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