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University-Industry Links and the Determinants of their Spatial Scope: A Study of the Knowledge Intensive Business Services Sector

Abstract

This paper examines the determinants of the spatial scope of collaborative linkages between Knowledge Intensive Business Services (KIBS) firms and universities in the UK. Drawing on data on Knowledge Transfer Partnerships (KTPs), it is found that the geographic scope of these linkages is determined by a complex mix of the particular characteristics of firms and universities, as well as the location of the firms. In particular, proximity increases with the participation of smaller firms, and firms located within areas with higher densities of KIBS employment. In contrast, the participation of larger firms or a university with greater levels of research activity increases the geographic scope of a linkage.

Key words: KIBS, Universities, University-Industry Linkages, Innovation, Geographic Proximity

JEL Classification: O31, O33

1. Introduction

The development of collaborative linkages with universities, while viewed as crucial to firm innovation, is not a straightforward process as it is surrounded by uncertainties regarding partner fit and overall success of the project (Petruzzelli 2011; Johnston and Huggins 2015). Furthermore, the extant literature suggests that due to the effectiveness of knowledge transfer decaying with distance, collaborative linkages between partners located in close spatial proximity are regarded as preferable (Jaffe 1989; Adams and Jaffe 1996; Breschi and Lissoni 2001a; Morgan 2004; Doring and Schnellenbach 2006). As such, geographic proximity to universities has been demonstrated to be an important determinant of the formation of these linkages (Abramovsky and Simpson 2011; Hewitt-Dundas 2011; D'Este et al. 2013; Muscio 2013)

While the geographic proximity of partners may be regarded as an important determinant of the university engagement process, its importance is not uniform across all firms; the spatial proximity of partners has been shown to vary according to a number of factors including the characteristics of both the firms and universities involved (D'Este and Iammarino 2010; Hewitt-Dundas 2011). These findings highlight a gap in the extant literature in terms of the factors underlying the variance in the spatial proximity between university and industrial partners. While this question has begun to be addressed in the literature (see D'Este & Iammarino, 2010) it appears pertinent to examine this factor in more detail as means of examining the factors determining the spatial research of both universities and firms. In particular, relatively little is known in terms of the relationships between universities and so-called Knowledge Intensive Business Service (KIBS) sector firms, which have been identified as important actors occupying a vital position in the modern economy (Hansen and Winther 2010).

KIBS are increasingly viewed as important actors in the economic development process, utilising high levels of human capital and turning this into innovative outputs in sectors such as computer consultancy, R&D consultancy, accountancy legal practitioners (Miles 2005). Consequently, these are among the most innovative service sector firms; with the wider real estate, renting and business activities sector (of which KIBS are a sub-sector) found to contain the highest proportion of innovating firms in the UK (BIS, 2014). As such, KIBS are regarded as important actors within innovation systems and knowledge networks due to their ability to both provide and transfer knowledge and skills to their clients, particularly within

de-industrialised economies (Doloreux and Muller 2007; Chadwick et al. 2008; Doloreux and Shearmur 2010; Huggins 2011). KIBS may undertake a number of functions within innovation systems including: (1) innovation facilitator—supporting a client firm in its innovation process, for example by bringing a new product to market; (2) innovation carrier—taking a role in transferring existing innovations from one firm or industry to a client firm or industry; and (3) innovation source—playing a role in initiating and developing innovation in client firms (Hauknes 2000; García-Quevedo and Mas-Verdú 2008). Accordingly, KIBS are viewed as complementing the publicly funded knowledge infrastructure and providing a ‘second knowledge infrastructure’ (Cooke and Memedovic 2003).

The focus of this paper is on examining the determinants of the spatial reach of collaborative linkages between universities and KIBS firms, specifically understanding the factors that influence the geographic proximity between partners. The extant literature on university engagement and collaborative linkages is rich and well developed, providing a focus on manufacturing firms and new economy sectors such as biotechnology (Lawton Smith and Bagchi-Sen 2006; Abramovsky and Simpson 2011; Hewitt-Dundas 2011; Hewitt-Dundas 2012). Due to the perceived importance of KIBS and the wealth of work examining this sector, scholars are now turning their attention towards examining their collaborative relationships with universities (Fernandez & Martinez, 2013; Pinto et al, 2014). Yet, despite the importance of both KIBS and the university sector, the links between the two are rather under-examined, although previous work demonstrates that KIBS are relatively prone to developing university linkages, (Harris et al. 2013), accounting for 22.7% of collaborative business grants awarded by the UK’s Engineering and Physical Sciences Research Council between 1999 and 2003 (D’Este et al. 2013).

This paper uses a unique dataset on formal collaborative linkages in form of Knowledge Transfer Partnerships (KTPs) between universities and KIBS firms in order to explore the factors that influence the geographic proximity of the partners involved. The paper contributes to the extant literature firstly through extending the existing work in this area to the consideration of innovative firms in the service sector, which have become important components of the economy in advanced de-industrialised economies (Sissons 2011), and, secondly, through broadening the factors under consideration to evaluate the importance of the socio-economic characteristics of the firms’ location to the geographic scope of their

linkages. The paper is structured as follows Section 2 develops the conceptual and theoretical framework regarding university engagement and the geographic scope of collaborative linkages. Section 3 outlines the data and analytical techniques used. Section 4 presents the results, while Section 5 discusses these results with respect to the theoretical framework and provides conclusions and policy implications, while also exploring possible future avenues for research suggested by the findings.

2. Theoretical Framework: Influences on the Spatial Reach of University Collaborative Linkages

The innovation process is increasingly characterised as 'open', i.e. reliant on collaborative linkages with a range of actors within inter-organisational networks promoting and facilitating the transfer of external knowledge and technology into the firm. Consequently, universities have been identified as important sources of external knowledge and, accordingly, placed at the centre of the innovation process (Mansfield 1995; Bok 2003; D'Este and Patel 2007; Huggins et al. 2012; Audretsch et al. 2012), with academic knowledge increasingly recognised as making an important contribution to the development of new ideas and innovation within firms (Rutten et al. 2003; Mueller 2006a; Huggins and Johnston 2009; Kauffeld-Monz and Fritsch 2013).

The development of collaborative linkages with universities has been shown to have a positive effect on firms through increasing their sales, research productivity and level of patenting (Fontana et al. 2006) through allowing to access additional resources, promoting learning within the firm and broadening the scope of their activities (Hagerdoorn et al. 2000; Abreu et al. 2008). In light of these findings, policymakers worldwide are increasingly pushing universities towards developing industry linkages and commercialising their knowledge (Huggins et al. 2008; Goddard et al. 2012), focussing on so called 'third mission' activities of business engagement (Lambert 2003; Wilson 2012). Consequently, the UK university system, for example, is now regarded as an important resource for domestic firms, with formal collaboration between UK businesses and universities growing at over 6% per annum, and the value of consultancy services provided by universities being in excess of £400m per annum (CBI 2015). As such, university-industry linkages are increasingly viewed as important to the economy as a whole, promoting the commercialisation of the 'science-base' and innovation within the private sector.

The extant literature demonstrates that the propensity to engage in and the strength of U-I linkages varies considerably by sector (Laursen et al. 2011). For example, the biotechnology sector has been shown to be especially prone to engaging with the university sector, whereas sectors such as textiles have had limited engagement (Laursen and Salter 2006; Lawton Smith and Bagchi-Sen 2006). Firms in other knowledge intensive sectors such as pharmaceuticals and chemicals have also been shown to co-locate their R&D activities with academic departments, producing high quality research outputs (Abramovsky et al. 2007;

Abramovsky and Simpson 2011). Thus, in general, the evidence suggests that it is larger firms in knowledge intensive sectors that rate collaborative links with universities as important for innovation, as they are more likely possess the necessary resources with which to develop and sustain these links (Mohnen and Hoareau 2003; Laursen and Salter 2004).

The conceptual framework underlying this study concerns the role of spatial proximity facilitating knowledge transfer between agents, with the general argument being that the spatial distance between knowledge transfer partners likely to vary according to the characteristics of these partners, as well the characteristics of the locational environment in which they are spatially situated (Jaffe 1989; Jaffe et al. 1993; Maggioni and Uberti 2008). In particular, firms may often be embedded in regional knowledge channels (Breschi and Malerba 2001; Breschi and Lissoni 2001b; Krätke 2010), with ready access to local public or private research institutes and universities facilitated through local knowledge flow routes (Mueller 2006b). In general, the extant literature on university-industry linkages has overwhelmingly demonstrated the importance of geographic proximity in the formation of collaborative partnerships (Maggioni et al. 2007; Ponds et al. 2007; D'Este and Patel 2007; Levy et al. 2009; Laursen et al. 2011; D'Este et al. 2013). In short, distance matters (Barrio-Castro & García-Quevedo 2005).

As a consequence, spatial proximity is viewed as an important determinant of higher intensity linkages, fostering face to face interaction and promoting collective learning (Storper and Venables 2004; Capello and Faggian 2005; McCann 2007). Thus, the spatial proximity of partners allows knowledge networks to function more efficiently through facilitating greater levels of contact between actors promoting repeated and enduring relationships, fostering trust between participants and reducing the maintenance costs of network activity (Kirat and Lung 1999; Lawson and Lorenz 1999; Wood and Parr 2005). Indeed, within knowledge based sectors the successful exploitation of knowledge has been found to depend on repeated and intense interaction (Yli-Renko et al. 2001),

While the importance of geographic proximity has been established in the literature, evidence on the actual spatial proximity of firms and universities engaged in collaborative linkages is somewhat mixed. For example, D'Este & Iammarino (2010) report an average distance between partners of over 354 Km; this average was, however, just one third of the average distance between partners in the dataset used by Autant-Bernard et al. (2012) of 1175 Km. Yet, firms in the wine sectors of Chile and Italy were, on average, collaborating with

universities 169 Km and 146 Km away, respectively, according to the dataset used by Giuliani and Arza (2009). Furthermore, Hewitt-Dundas (2011) found that around 50% of firms in her dataset were collaborating with universities within 100 miles of their location. Thus, in reality the geography of linkages varies considerably across datasets suggesting that both the internal characteristics of partnering organisations and the features of their spatial environment may play a role in determining the physical geographic distance between collaborators (Autant-Bernard et al. 2007; Giuliani and Arza 2009; D'Este and Iammarino 2010; Hewitt-Dundas 2011). The remainder of this section sets out a framework for investigating the determinants of the spatial reach and geographic proximity in the context the linkage between universities and KIBs through the development of series of testable hypotheses.

The first area of investigation concerns the characteristics of the firms involved in the collaboration. Previous work suggests that firm resources influence the spatial proximity of collaborative linkages with universities (Mohnen and Hoareau 2003; Laursen and Salter 2004). Due to the fact that the development and maintenance of collaborative linkages is not necessarily costless, the management of interactions and collaborative projects consumes firm resources in terms of time and administration. As such, those firms that are not able to commit the necessary resources to managing the collaboration effectively may find it difficult to ensure that knowledge is flowing productively into the firm (Teece 1998; Sorenson et al. 2006). Consequently, geographic proximity could be interpreted as a substitute for firm resources as it simplifies the process of partner selection and network maintenance, thus requiring fewer resources (Cooke and Huggins 2003; Huggins and Johnston 2010). The evidence suggests that, typically, smaller firms that are more prone to develop collaborative linkages with more geographically proximate partners and it is surmised that their lack of resources pushes them towards these more proximate relationships (Huggins et al. 2012).. Therefore, it appears that firm size may have an influence on the geographic proximity of KIBS and their university partners. This is formalised in Hypothesis 1:

Hypothesis 1: Smaller KIBS firms will pursue collaborative linkages with more geographically proximate university partners.

While the characteristics of the firm are important, it has also been established that the characteristics of the university involved also influences the geographic scope of collaborative linkages (Hewitt-Dundas 2011). Firstly, , institutions and departments that

perform well in metrics ranking institutional quality typically attract more distant partners (Hewitt-Dundas 2011; Laursen et al. 2011). Consequently, the perceived quality of a university is an important determinant of its spatial reach (Mansfield 1995; D'Este and Iammarino 2010). This is illustrated by the findings of Laursen et al. (2011) who report that firms are most likely to collaborate with a local top-tier university. Importantly, they also find that in the absence of a local top-tier university, firms are more likely to collaborate with a non-local university than a local lower-tier university; cementing the view that research prowess is an important factor in determining partner selection. Indeed, the process of engaging with external actors is an uncertain practice (Petruzzelli 2011), and to understand the uncertainties faced, the motivations for engagement must be understood. As the motivations for developing of U-I linkages are to enhance the innovative capacity of a firm through procuring additional resources, promote learning of new knowledge and techniques within the firm and increasing the breadth of a firm's activities (Hagerdoorn et al. 2000), the firm must ensure that its external partner will contribute to these aims. Consequently, the reputation of a university can reduce these uncertainties; and the fact that geographic proximity has been found to increase the distance between partners (Hewitt-Dundas 2011; Laursen et al. 2011) suggests that the two can be considered to be substitutes. This is captured in Hypothesis 2:

Hypothesis 2: Higher levels of engagement and research by a university will have a negative effect on the geographic proximity of collaborative linkages with KIBS

Firm location has been long regarded as a significant determinant of a firm's performance, especially with respect to co-location with other firms in similar areas and the competitiveness of the local business environment (Audretsch and Dohse 2007). Typically, a firm's external environment, or 'milieu', is viewed as providing a myriad of 'untraded interdependencies,' or network resources that are spatially proximate (Storper 1995; Huggins and Johnston 2010). Previous work has demonstrated that higher-technology, knowledge intensive sectors tend to be more prone to clustering (Audretsch and Feldman 1996), a feature that is partially observed in terms of the KIBS sector with these firms tending to exhibit a bias towards urban areas and cities (Chadwick et al. 2008; Wood 2009; Huggins 2011). In short, the KIBS sector appears to be prone to clustering. The literature on clustering is large and well developed; suffice to say universities can be considered to be key members of

knowledge-based clusters as indicated by their inclusion as 'associated institutions' in Porter's commonly used definition (Porter 1998).

Indeed, as the innovativeness of KIBS firms fades with distance from metropolitan or urban centres (Doloreux and Shearmur 2012), it can be argued that the local 'buzz' generated in densely populated firm environments with 'thick' networks contributes to this outcome (Gertler 2003; Storper and Venables 2004). Thus, within areas that are dense in KIBS employment, collaborative linkages with universities are more likely to be with those that are in close proximity.

Hypothesis 3: the clustering of firms is likely to promote more spatially proximate university-industry linkages.

3. Data and Method

This section explains the nature of the data collected and analysed for the study, as well the modes of analysis employed.

3.1 Dataset: University Linkages

University linkages are a diverse phenomenon, covering a wide range interactions with other organisations, both formal and informal (Perkmann and Walsh 2007). Consequently, scholars have looked at many types of interaction; co-publications (Ponds et al. 2007), co-location (Abramovsky and Simpson 2011), research grants (D'Este and Iammarino 2010), collaboration (Laursen et al. 2011) as well as links with other members of the academic community (Hughes and Kitson 2012). The data examined here focuses on Knowledge Transfer Partnerships, which consist of formal university linkages with other actors – principally firms - through inter-organisational agreements designed to pursue a collaborative R&D project (Council on Competitiveness 1996; Perkmann and Walsh 2007).

The data are derived from a unique dataset compiled specifically for this analysis from publicly available information on Knowledge Transfer Partnerships (KTPs), which are defined as formal collaborations between universities and outside organisations designed specifically to transfer knowledge between the two for innovation¹. Consequently, KTPs cover a wealth of different activities, covering the six areas of innovation that are principally undertaken by KIBS: product, process, delivery, strategic, managerial and marketing innovations (Amara et al. 2009). The dataset comprises of records of all KTPs involving KIBS firms and was derived from a freely available online resource (www.ktponline.org.uk) containing details of every project and its participants. The dataset contains details of 568 formal collaborations between KIBS firms and universities² across the UK during the period 2001-2008, thereby capturing a broad insight into formal university- industry (U-I) linkages involving KIBS firms. The 568 collaborative linkages identified represent 410 different firms, with 158 of the linkages representing a repeated collaboration. In total, 108 universities were involved in a partnership with a KIBS firm during this time period. For each participating

¹The partnerships are facilitated through grants available from UK Government agencies plus a contribution from the collaborating organisation. KTPs involve organisations from all sectors of the economy, including both manufacturing oriented firms and service sector firms as well as public and third sector organisation

²Only KTPs involving recognised higher education institutions (as defined by HESA) were included in the sample. Those involving collaborations between KIBS firms and further education institutions were excluded.

firma full postal address was obtained utilising Company's House data³, including those no longer trading; the address of the firm was that at the time the KTP commenced for those firms that had subsequently moved. The full postal address for the specific academic department involved in the KTP was also obtained.

3.2 Dependent Variable

The dependent variable measures the geographic proximity of the two partners in the collaboration. In order to calculate this, the distance in kilometres between the two collaborators in the partnership was measured utilising the Euclidian, or crow-fly, distance between the two parties in line with other studies (D'Este and Iammarino 2010; Laursen et al. 2011; D'Este et al. 2013). The discrete distance between the parties is used as an alternative to examining pre-defined geographic units, i.e. cities, postcode districts or regions as this provides a more accurate picture of the geography of these links (Wallsten 2001). Following this the distance between the two parties was used to calculate the spatial reach of each project partnership, which, following D'Este et al. (2013), is the inverse of the square root of the distance between the partners $(1/d_{ij}) * 100$ where d_{ij} is the square root of the distance between firm i and university j in kilometres, with a minimum distance of 100 metres where the two partners are located in the same postcode district.

3.3 Independent Variables

In order to examine the influence of resources on the spatial reach of collaborative linkages two proxy variables were included. Firstly, each firm was categorised by size according to the number of employees: micro firms with fewer than 10 employees, small firms with between 10 and 49 employees, medium-sized firms with between 50 and 249 employees and large firms, with over 250 employees. The research intensity of an institution was defined as the proportion of academic staff classed as research active as a proportion of total academics within the university based on data from the 2008 Research Assessment Exercise (RAE)⁴. In addition, a proxy for the relative openness and commercial bias of each institution was

³ The DueDil website - www.duedil.com (Due Diligence) make Company's House data freely available for this purpose

⁴ RAE is a peer reviewing exercise that ranks research outputs for all Higher Education Institutions within the UK

included, consisting of total intellectual property income per academic for each institution between 2003/04 – 2008/09⁵.

In order to examine clustering effects, a variable measuring regional KIBS employment density, calculated by dividing KIBS employment per NUTS 3 region by the geographic size of the region in square kilometres is included in the model. Following Ponds et al., 2010, this data are averaged across the study period. Finally, a variable is included that controls for the firm's previous participation in the KTP programme, with continued engagement being used as a sign that the firm is able to successfully engage with universities, following previous studies of this type (D'Este et al. 2013; Johnston and Huggins 2015).

3.4 Econometric Methods

Prior diagnostic tests established the dependent variable - the geographic proximity of partners - has a negative significant skew and a kurtosis score just over 16. As well as having a negative skew, the dependent is also significantly over-dispersed with the variance of the sample (1460.010) being significantly greater than the mean (37.57). The existence of both the skew and the over-dispersion necessitated the use of logged variables in order to utilise standard OLS regression techniques. Table 2 provides the descriptive statistics for the dataset. Table 3 also provides a correlation matrix for the variables used. In general, it is found that the correlation coefficients are low and do not pose any problems with multicollinearity.

[Table 2 around here]

[Table 3 around here]

⁵ This was calculated from the Higher Education Funding Council's Business and Community Interaction Survey, for which data at the institution level is only available from 2003-04 onwards

4. Results

4.1 Descriptive Statistics

In terms of firm size, it is observed that formal collaborative links between KIBS and universities mainly involve micro and small firms (<50 employees); three-quarters of the firms in the sample have fewer than 50 employees, with 23% employing fewer than 10 and 52% employing between 11 and 49. Medium and large firms account for the remaining quarter of the sample, with 16% of the sample firms employing between 50 and 249 staff and 9% employing over 250 staff. Interestingly, these vary widely from the UK distribution of KIBS firms by size, whereby micro firms with fewer than 10 employees account for 98% of all firms, small firms account for 1.8% of all KIBS firms and medium and large KIBS firms account for 0.3% and 0.1% respectively (authors' calculations based on ONS data). Thus, higher than proportionate numbers of small, medium and large KIBS firms are developing collaborative linkages with universities.

4.2 Econometric Results

The results of the regression analysis are shown in Table 4, which indicates that the geographic scope of collaborative linkages between KIBS and universities is determined by the particular characteristics of firms and universities, as well as the nature of the location and region in which they are situated. Each of research hypotheses are analysed in turn below.

Firstly, Hypothesis 1 examined the effect of firm resources on the geographic proximity of formal collaborative linkages between KIBS and their university partners. Previous work suggests that the greater the geographic scope of a linkage then the greater the resources required to manage that linkage, leading to the hypothesis that larger KIBS firms, which by definition possess greater levels of resources, will engage in partnerships over greater distances. The results from the econometric models suggest that firm size is an important determinant of the geographic scope of collaborative linkages between KIBS and universities. Model 1 examines this factor in isolation and shows a significant positive sign on the size variable in the case of micro firms (those with fewer than 10 employees), suggesting that these firms form linkages with universities that are more geographically proximate than larger firms. In addition there is weak evidence ($p < 0.10$) that small firms are also more likely to be involved in geographically proximate collaborative linkages than large firms. These

effects are also observed in Models 2 and 3, which introduce further variables, with the magnitude of these effects being constant across all three models suggesting that this is a robust result. Therefore, this evidence presented here suggests that KIBS are subject to similar patterns with respect to firm size as other sectors, in that spatial proximity is more important for smaller firms (Lawton Smith and Bagchi-Sen, 2006; Hewitt-Dundas, 2011; Laursen et al., 2011). Thus, Hypothesis 1 is confirmed and firm size does appear to be a significant factor in determining the geographic scope of a linkage.

Hypothesis 2 suggests that the characteristics of the university partner influences the geographic scope of the linkage, namely that more 'engaged' institutions will be involved with more distant links with KIBS firms. The results find that research intensity and commercial focus of a university both have a significant influence on the geographic scope of collaborative links with KIBS firms. First, higher densities of research active staff within an institution have a negative effect on the geographic proximity of the project partners. This suggests that higher levels of research activity within an institution are responsible for an institution having a greater spatial reach, attracting more distant partners. Thus, the research intensity of a university clearly influences the geographic scope of collaborative linkages with KIBS, in line with evidence from other sectors (Laursen et al., 2011; Hewitt-Dundas, 2012). In contrast, the results also suggest that higher levels of commercial engagement within a university promote closer linkages with KIBS firms. Thus, the evidence only partly confirms Hypothesis 2 given that collaborating with more engaged universities has a negative effect on the proximity of the partners in terms of research engagement. However, higher levels of commercial engagement promote more proximate links.

Hypothesis 3 examines the effects of firm location on the geographic scope of their university linkages, suggesting that higher levels of clustering would promote more local linkages. The results suggest that higher densities of KIBS employment promote closer linkages between these firms and their university partners. Thus, locational factors in terms of clustering effects are important determinants of the geographic scope of collaborative linkages between KIBS and universities. Therefore, Hypothesis 3 is confirmed.

[Table 4 around here]

5. Discussion and Conclusions

This paper set out to examine the factors that influence the geographic scope of collaborative linkages between KIBS firms and universities. The findings suggest that this varies according to a wide range of factors, in particular the characteristics and location of the firm, as well as the characteristics of the partner university involved. Therefore, it is clear that KIBS firms cannot be considered to be homogenous in terms of the geographic scope of their collaborative links with universities. Thus, within this particular sector, the results highlight the diverse nature of the geographic scope of the firms' university linkages.

The results show, firstly, that firm size is important; the geographic scope of the linkages is smaller for firms with fewer employees. Secondly, the characteristics of the university partner are also important with higher levels of research active staff increasing the geographic scope of collaborative linkages with KIBS firms, although a greater number of commercial links was found to have the opposite effect. Finally, firm location has been shown to be important; firms located in areas with higher densities of KIBS employment are more likely to develop collaborative linkages with partners in close proximity. Thus, there is no uniform effect and these results indicate a complex process of partner selection in terms of developing collaborative linkages.

The findings have a number of theoretical implications. The theoretical framework on systemic innovation largely assumes that the 'intensity' of a collaboration is facilitated by geographic proximity (cf. Breschi and Lissoni, 2001; Gertler, 2003; Storper and Venables, 2004). Yet, in terms of university-industry linkages, this paper has established that this may be more of a relative term as the average distance between collaborators actors varied considerably. Consequently, this suggests that a deeper understanding of the determinants of geographic proximity is necessary. Through focusing on formal collaborative linkages of a single sector, KIBS, the results suggest that the geographic proximity of collaborators varies considerably. Research intensive universities and larger KIBS firms are more prone to engage in non-localised networks. This indicates that they possess the resources necessary to develop and sustain such linkages. However, this does not suggest a simple dichotomy around firm size and university engagement in research; the commercial engagement of an institution and also the location of the firm also influence the proximity of partners.

Overall, the paper provides evidence that the location of firms is important in the determination of geographic proximity of collaboration. Location in an area dense in KIBS employment indicates that, whilst organisational characteristics play an important role in determining the extent to which innovative collaboration is localised, spatial dynamics play a complementary role drawing KIBS into a milieu, cluster or agglomeration. This is theoretically important to the extent that the geographic scope of collaboration, particularly with regard to U-I links, has implicitly concerned factors related to interactions related to shared physical resources, such as plant and machinery, across sectors related to engineering, medical devices, and other STEM related areas of knowledge (cf. Abramovsky and Simpson, 2011). In the case of ‘lighter’ sectors such as KIBS the spatial nature of collaboration is more of complex mix between the network externalities available to firms in a particular location as well as the resource base available to them and potential partners.

The results have shown that within a dynamic knowledge-based service sector such as KIBS similar results are observed in terms of the determinants of the geographic scope of collaborative linkages with universities as in the extant literature. This makes an important contribution to theory building in terms of collaborative linkages in that these service sector firms are bound by the same influences as other high technology/knowledge intensive sectors such as biotechnology, pharmaceuticals and advanced manufacturing (Lawton Smith 2007; Abramovsky and Simpson 2011; Laursen et al. 2011).

Regarding policy implications, the dual role of factors both internal and external to collaborative partners in determining the spatiality of collaboration indicates that a one size fits all model should be avoided in encouraging the development of collaborative links between KIBS and universities (D’Este and Iammarino, 2010). Instead, policymakers need to be aware of the differing influences on the development collaborative linkages and act accordingly. For example, a starting point may be that small KIBS firms tend towards more local linkages than their larger counterparts and policies should therefore reflect this. However, the results suggest that such a simple policy directive would be effective; when there are variations pertaining to the location of the firm that contribute to the differing geographic scope of collaborative links then these should also be considered. Thus, context is important. Thus policymakers are urged to consider the local and regional socio-economic characteristics and how these may influence the geographic scope of KIBS collaborative

linkages with universities. Accordingly, policy interventions could start by recognising that KIBS firms may require assistance in finding the right linkage with a university not just the nearest. Therefore, it may be that a matching process can be utilised in order to engage firms with suitable partners. Encouraging collaborative links merely on a local or regional basis is clearly not the best basis for this in all cases.

In terms of limitations of the study, this paper focuses on one type of proximity, geographic proximity. While this has been the focus of the literature on innovation, and innovation systems, it is recognised that proximity is a much wider factor than merely focussing on space. Organisational, cognitive, social and institutional proximity are all important determinants of collaborative linkages and the transfer of knowledge; yet, this dataset used does not fully capture these factors. The focus of this paper has been on the knowledge intensive business services sector and one further area to explore would be to assess the extent to which these results reflect the wider services sector.

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References

- Abramovsky L, Harrison R, Simpson H (2007) University Research and the Location of Business R&D. *Economic Journal* 117:C114–C141
- Abramovsky L, Simpson H (2011) Geographic proximity and firm-university innovation linkages: Evidence from Great Britain. *Journal of Economic Geography* 11:949–977
- Abreu M, Grinevich V, Hughes A, et al. (2008) Universities, business and knowledge exchange. The Council for Industry and Higher Education, London
- Adams H, Jaffe A (1996) Bounding the effects of R&D: An investigation using matched establishment-firm data. *RAND Journal of Economics* 27:700–721
- Amara N, Landry R, Doloreux D (2009) Patterns of innovation in knowledge-intensive business services. *Service Industries Journal* 29:407–430
- Audretsch DB, Dohse D (2007) Location: A Neglected Determinant of Firm Growth. *Review of World Economics* 143:79–107
- Audretsch DB, Feldman MP (1996) R&D spillovers and the geography of innovation and production. *American Economic Review* 86:630–640
- Audretsch DB, Lehmann EE, Wright M (2012) Technology transfer in a global economy. *Journal of Technology Transfer* 39:301–312
- Autant-Bernard C, Billand P, Frachisse D, Massard N (2007) Social distance versus spatial distance in R&D cooperation: Empirical evidence from European collaboration choices in micro and nanotechnologies. *Papers in Regional Science* 86:495–519
- Barrio-Castro T D, García-Quevedo J (2005) Effects of university research on the geography of innovation. *Regional Studies* 39:1217–1229
- Bok D (2003) *Universities in the Marketplace: The Commercialization of Higher Education*. Princeton University Press, Princeton
- Breschi S, Lissoni F (2001a) Knowledge spillovers and local innovation systems: A critical survey. *Industrial and Corporate Change* 10:975–1005
- Breschi S, Lissoni F (2001b) Localised knowledge spillovers vs. innovative milieu: Knowledge “tacitness” reconsidered. *Papers in Regional Science* 80:255–273
- Breschi S, Malerba F (2001) The geography of innovation and economic clustering: some introductory notes. *Industrial and Corporate Change*. 10:817–813
- Capello R, Faggian A (2005) Collective learning and relational capital in local innovation processes. *Regional Studies* 39:75–87
- CBI (2015) *Best of Both Worlds: guide to business-university collaboration*. Middlesex University London, London

- Chadwick A, Glasson J, Smith HL (2008) Employment Growth in Knowledge-Intensive Business Services in Great Britain during the 1990s - Variations at the Regional and Sub-Regional Level. *Local Economy* 23:6–18
- Cooke P, Huggins R (2003) High-technology clustering in Cambridge. In: Sforzi F (ed) *The Institutions of Local Development*. Ashgate, Aldershot, pp 51–74
- Cooke P, Memedovic O (2003) *Strategies for Regional Innovation Systems*. UNIDO, Vienna
- Council on Competitiveness (1996) *Endless frontier, limited resources: U.S. R&D policy for competitiveness*. Council on Competitiveness, Washington
- D’Este P, Guy F, Iammarino S (2013) Shaping the formation of university-industry research collaborations: what type of proximity does really matter? *Journal of Economic Geography* 13:537–558
- D’Este P, Iammarino S (2010) The spatial profile of university-business research partnerships. *Papers in Regional Science* 89:335–350
- D’Este P, Patel P (2007) University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy* 36:1295–1313
- Doloreux D, Muller E (2007) The key dimensions of Knowledge Intensive Business Services (KIBS) analysis. A decade of evolution. Working Paper on Firms Reg. U1/2007 Frahofer-Institut für Syst. und Innov. (ISI), Karlsruhe
- Doloreux D, Shearmur R (2012) Collaboration, information and the geography of innovation in knowledge intensive business services. *Journal of Economic Geography* 12:79–105
- Doloreux D, Shearmur R (2010) Exploring and comparing innovation patterns across different knowledge intensive business services. *Economics of Innovation and New Technology* 19:605
- Doring T, Schnellenbach J (2006) What do we know about geographical knowledge spillovers and regional growth?: A survey of the literature. *Regional Studies* 40:375–395
- Fontana R, Geuna A, Matt M (2006) Factors affecting university–industry R&D projects: The importance of searching, screening and signalling. *Research Policy* 35:309–323
- García-Quevedo J, Mas-Verdú F (2008) Does only size matter in the use of knowledge intensive services? *Small Business Economics* 31:137–146
- Gertler M (2003) Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). *Journal of Economic Geography* 3:75–99
- Giuliani E, Arza V (2009) What drives the formation of “valuable” university–industry linkages? *Research Policy* 38:906–921

- Goddard J, Robertson D, Vallance P (2012) Universities, Technology and Innovation Centres and regional development: the case of the North-East of England. *Cambridge Journal of Economics* 36:609–627
- Hagerdoorn J, Link A, Vonortas N (2000) Research partnerships. *Research Policy* 29:567–586
- Hansen H, Winther L (2010) The Spatial Division of Talent in City Regions: Location Dynamics of Business Services in Copenhagen. *Tijdschrift voor economische en sociale geografie* 101:55–72
- Harris R, Li QC, Moffat J (2013) The impact of higher education institution-firm knowledge links on establishment level productivity in British regions. *Manchester School* 81:143–162
- Hauknes J (2000) Dynamic innovation systems: What is the role of services? in M. Boden & I. Miles, eds. *Services and the Knowledge-based Economy*. London: Routledge
- Hewitt-Dundas N (2011) The role of proximity in university-business cooperation for innovation. *Journal of Technology Transfer* 38:93–115
- Hewitt-Dundas N (2012) Research intensity and knowledge transfer activity in UK universities. *Research Policy* 41:262–275
- Huggins R (2011) The Growth of Knowledge-Intensive Business Services: Innovation, Markets and Networks. *European Planning Studies* 19:1459–1480
- Huggins R, Johnston A (2009) The economic and innovation contribution of universities: A regional perspective. *Environment and Planning C* 27:1088–1106.
- Huggins R, Johnston A (2010) Knowledge flow across inter-firm networks: the influence of network resource, spatial proximity and firm size. *Entrepreneurship and Regional Development* 22:457–484
- Huggins R, Johnston A, Steffenson R (2008) Universities, knowledge networks and regional policy. *Cambridge Journal of Regions Economy and Society* 2:321–340
- Huggins R, Johnston A, Stride C (2012) Knowledge networks and universities: Locational and organisational aspects of knowledge transfer interactions. *Entrep Reg Dev* 24:475–502.
- Hughes A, Kitson M (2012) Pathways to impact and the strategic role of universities: new evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development. *Cambridge Journal of Economics* 36:723–750
- Jaffe AB (1989) Real effects of academic research. *American Economic Review* 79:957–970.
- Jaffe AB, Trajtenberg M, Henderson R (1993) Geographic localisation of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics* 108:577–598

- Johnston A, Huggins R (2015) Drivers of University-Industry Links: The Case of Knowledge Intensive Business Service Firms in Rural Locations. *Regional Studies*. doi: 10.1080/00343404.2015.1009028
- Kauffeld-Monz M, Fritsch M (2013) Who are the knowledge brokers in regional systems of innovation? A multi-actor network analysis. *Regional Studies* 47:669–685
- Kirat T, Lung Y (1999) Innovation and proximity: Territories as loci of collective learning processes. *European Urban and Regional Studies* 6:27–38
- Krätke S (2010) Regional knowledge networks: a network analysis approach to the interlinking of knowledge resources. *European Urban and Regional Studies* 17:83–97
- Lambert R (2003) Lambert review of business university collaboration. HMSO, Norwich
- Laursen K, Reichstein T, Salter A (2011) Exploring the Effect of Geographical Proximity and University Quality on University-Industry Collaboration in the United Kingdom. *Regional Studies* 45:507–523
- Laursen K, Salter A (2006) Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal* 27:131–150.
- Laursen K, Salter A (2004) Searching high and low: What types of firms use universities as a sources of innovation? *Research Policy* 33:1201–1215
- Lawson C, Lorenz E (1999) Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies* 33:305–317
- Lawton Smith H (2007) Universities, innovation, and territorial development: a review of the evidence. *Environment and Planning C* 25:98–114
- Lawton Smith H, Bagchi-Sen S (2006) University-industry interactions: the case of the UK biotech industry. *Industry and Innovation* 13:371–392
- Levy R, Roux P, Wolff S (2009) An analysis of science–industry collaborative patterns in a large European University. *Journal of Technology Transfer* 34:1–23
- Maggioni MA, Nosvelli M, Uberti TE (2007) Space versus networks in the geography of innovation: A European analysis. *Papers in Regional Science* 86:471–493
- Maggioni MA, Uberti TE (2008) Knowledge networks across Europe: which distance matters? *Annals of Regional Science* 43:691–720
- Mansfield E (1995) Academic research underlying industrial innovations: Sources, characteristics, and financing. *Review of Economics and Statistics* 77:55–65
- McCann P (2007) Sketching out a model of innovation, face-to-face interaction and economic geography. *Spatial Economic Analysis* 2:117–134

- Miles I (2005) Knowledge intensive business services: prospects and policies. *Foresight* 7:39–63
- Mohnen P, Hoareau C (2003) What type of enterprise forges close links with universities and government labs? Evidence from CIS 2. *Managerial and Decision Economics* 24:133–146
- Morgan K (2004) The exaggerated death of geography: learning, proximity and territorial innovation systems. *Journal of Economic Geography* 4:3–21
- Mueller P (2006a) Exploring the knowledge filter: How entrepreneurship and university-industry relationships drive economic growth. *Research Policy* 35:1499–1508
- Mueller P (2006b) Entrepreneurship in the region: breeding ground for nascent entrepreneurs? *Small Business Economics* 27:41–58
- Muscio A (2013) University- industry linkages: What are the determinants of distance in collaborations? *Papers in Regional Science* 92:715–739
- Perkmann M, Walsh K (2007) University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews* 9:259–280
- Petrizzelli AM (2011) The impact of technological relatedness, prior ties, and geographical distance on university–industry collaborations: A joint-patent analysis. *Technovation* 31:309–319
- Ponds R, van Oort F, Frenken K (2007) The geographical and institutional proximity of research collaboration. *Papers in Regional Science* 86:423–443
- Porter M (1998) *On Competition*. Boston: HBS Press
- Rutten R, Boekma F, Kuijpers E (2003) HEIs, regions and the knowledge-based economy. In: Rutten R, Boekma F, Kuijpers E (eds) *Economic Geography of Higher Education: Knowledge Infrastructure and Learning Regions* Routledge, London, pp 244–252
- Sissons A (2011) *Britain's Quiet Success Story: Business services in the knowledge economy*. The Work Foundation, London
- Sorenson O, Rivkin JW, Fleming L (2006) Complexity, networks and knowledge flow. *Research Policy* 35:994-1017
- Storper M (1995) The resurgence of regional economics, ten years later. *European Urban and Regional Studies* 2:191–221
- Storper M, Venables A (2004) Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography* 4:351–370
- Teece D (1998) Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California Management Review* 40:55–79

- Wallsten SJ (2001) An empirical test of geographic knowledge spillovers using geographic information systems and firm-level data. *Regional Science and Urban Economics* 31:571–599
- Wilson T (2012) A review of business-university collaboration. Department for Business Innovation and Skills, London
- Wood GA, Parr JB (2005) Transaction Costs, Agglomeration Economies, and Industrial Location. *Growth and Change* 36:1–15
- Wood P (2009) Service competitiveness and urban innovation policies in the UK: The implications if the “London Paradox.” *Regional Studies* 43:1047–1059
- Yli-Renko H, Autio E, Sapienza HJ (2001) Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. *Strategic Management Journal* 22:587–613

Table 1. KIBS Sub-Sectors

Sub-Sector	Activities Included (SIC Code)
T-KIBS	Hardware consultancy (72.1); Software consultancy (72.2); Data processing (72.3); Database activities (72.4); Maintenance and repair of office, accounting and computer machinery (72.5); Other computer related activities (72.6)
R-KIBS	Research and experimental development in natural sciences and engineering (73.1); Research and experimental development in social sciences and humanities (73.2)
P-KIBS	Legal activities (74.11); Accounting, book-keeping and auditing activities, tax consultancy (74.12); Market research and opinion polling (74.13); Business management and consultancy activities (74.14); Architectural and engineering activities and related technology consultancy (74.2); Technical testing and analysis (74.3); Advertising (74.4); Other business activity n.e.c (74.84)

Table 2. Descriptive Statistics

Variable	Mean	S.D	Min.	Max.
Distance Between Partners (Km)	36.99	38.29	4.0	316
University IP Income (£, per academic)	1492.43	2202.19	0	10834.92
Research Intensity	0.28	0.15	0.04	0.81
KIBS Employment Density (firms per KM ²)	262.15	691.72	0.58	2736.85

Table 3. Correlation Matrix

Variable	1	2	3	4
Proximity Between Partners (1)	-			
Commercial Focus of University (2)	0.012	-		
Research intensity (3)	-0.201**	0.599**	-	
KIBS Employment Density (4)	0.276**	-0.060	-0.156**	-

**significant at the 5% level

**Table 4. Parameter Estimates and Results from the Regression Model (OLS regression;
Dependent Variable: GProx)**

Independent Variable	Model 1	Model 2	Model 3
Firm Size: < 10 employees ¹	0.449** (0.155)	0.438** (0.151)	0.465** (0.145)
Firm Size: 10-49 employees ¹	0.284* (0.146)	0.251* (0.143)	0.258* (0.137)
Firm Size: 50-249 employees ¹	0.046 (0.159)	0.041 (0.154)	0.008 (0.148)
Previous Collaboration	0.048 (0.113)	0.103 (0.109)	0.137 (0.105)
IP Income per academic (Ln)		0.076*** (0.017)	0.072*** (0.017)
Research Intensity (Ln)		-0.407*** (0.064)	-0.342*** (0.062)
KIBS Employment Density (Ln)			0.149*** (0.021)
Intercept	2.985*** (0.137)	1.981*** (0.219)	1.678*** (0.215)
n	568	568	568
R ²	0.025	0.068	0.155
F	4.606***	5.713***	15.817***

¹large firms omitted as the base group

*significant at the 10% level

**significant at the 5% level

***significant at the 1% level