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Drivers of University-Industry Links: The Case of Knowledge Intensive Business Service Firms in Rural Locations

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Abstract

The process of establishing collaborative links with university partners is potentially accompanied by uncertainties with respect to both the process and expected outputs. Partner selection is a difficult task influenced by a multitude of factors including location, geographic distance, compatibility of interests, shared understanding and prior experience of collaboration. Drawing on an analysis of Knowledge Intensive Business Service Firms (KIBS) firms located in predominantly rural districts of the UK, this paper examines the influences on partner selection when developing university links through knowledge transfer partnerships. The main focus of the paper is the extent to which geographic and organisational proximity influence the choice of university partner. The paper examines rural KIBS firms, which are generally less likely to be in close geographic proximity to a university. In the case of these firms, organisational proximity potentially has a strong role to play in partner selection. Indeed, the empirical analysis finds that both geographic and organisational proximity are significantly associated with partner choice, indicating that the formation of university-industry links are not only the result of locational factors, but also prior experience of collaboration. The findings indicate that partner choice is a complex process influenced by both geographic and organisational proximity, alongside university research prowess. The paper concludes by considering the policy implications of these findings and possible avenues for future research in this area

Key-words: Innovation, Knowledge Intensive Business Services, KIBS, University Industry Links, rural economy

1. Introduction

Uncertainty plays a significant role in establishing collaborative linkages between firms and universities. In the course of forming collaborative partnerships actors must manage problems of asymmetric information, as they may be unaware of the likely knowledge and capabilities possessed by the other party (Huggins et al. 2008). Partner selection, therefore, is often far from straightforward process (Petruzzelli 2011). Consequently, both universities and firms are required to overcome these information asymmetries in order to choose an appropriate partner (Das & Teng 2001; Das 1998; Lokshin et al. 2011). This paper argues that two factors can potentially moderate these asymmetries: geographic and organisational proximity. The former facilitates intense, i.e. repeated, interactions, observation and ease of communication (McCann 2007). Accordingly, a large proportion of the extant literature highlights the crucial role of geographic proximity in developing University-Industry (U-I) links (D'Este & Iammarino 2010; Muscio 2013). The latter promotes the effective transfer of knowledge through membership of similar epistemic communities, shared language and culture (Cowan et al. 2000; Henry & Pinch 2001). Similarly, organisational proximity has also been demonstrated to be an important determinant of U-I links (D'Este et al. 2013). This paper focuses on the development of formal collaborative linkages between universities and rural knowledge intensive business service (KIBS) firms, examining the relative importance of both geographic and organisational proximity in the partner selection process.

The focus on these actors is motivated by the fact that both are regarded as important members of knowledge networks (Huggins & Johnston 2010; Huggins 2011; Corrocher & Cusmano 2014; Kauffeld-Monz & Fritsch 2013). KIBS cover a number of sectors where knowledge is regarded as a significant input in the process of creating the service, including computer consultancy, R&D consultancy, accountancy services, legal services and architecture (Doloreux & Muller, 2007; Chadwick *et al.*, 2008; Shearmur & Doloreux, 2009; Doloreux & Shearmur, 2010). Essentially, KIBS provide market based services to firms with a specific focus on an issue the firm requires assistance with. As such, KIBS are also viewed as important components of knowledge networks, complementing publicly funded knowledge infrastructure and providing a 'second knowledge infrastructure' (den Hertog 2000; Cooke & Memedovic 2003).

KIBS are also regarded as an increasingly important and dynamic sector of the economy. Employment growth in these sectors has been higher than for all other sectors over the past two decades (Huggins 2011). Within the UK in 2011 there were over 300,000 KIBS firms accounting for over 3.85 million jobs and contributing over £96 billion to the economy. In percentage terms, KIBS currently account for 14.4% of UK employment, 7.1% of GDP and 15.9% of firms¹. Therefore, KIBS account for a significant proportion of economic activity. In addition, these sectors are viewed as important for the future development of the economy, providing prospects for future growth and innovative activity (Sissons 2011; Department for Business Innovation and Skills 2013). Despite the perceived importance of KIBS, the

¹ Authors' calculations based on data from the UK Office for National Statistics

interaction between this sector and universities is now only starting to attract the attention of academics, with the extant literature on collaborative links with universities tending to focus on sectors such as manufacturing and biotechnology (Lawton Smith 2007).

Universities are typically characterised as producers of knowledge to be transferred to the private sector for commercialisation (Mansfield 1995; Bok 2003; D'Este & Patel 2007; Huggins, Johnston & Stride 2012). The university's role as a knowledge broker makes it an important component of a knowledge network (Huggins & Johnston 2009; Kauffeld-Monz & Fritsch 2013). University knowledge is regarded as an important input in the innovation process, underpinning the development of new ideas (Mansfield 1995; Rutten et al. 2003). As a result policymakers worldwide are increasingly formalising the role of universities towards third mission activities, i.e. developing industry linkages and commercialising their knowledge (Lambert 2003; Huggins et al. 2008; Goddard et al. 2012; Wilson 2012), essentially pursuing a 'triple helix model' of regional development (Etzkowitz & Leydesdorff 2000; Etzkowitz 2003) in placing formal U-I linkages at the heart of such development. In light of the similar roles performed by universities and KIBS firms scholars are increasingly turning their attention to interaction between the two (Pinto et al. 2013; Fernandes & Ferreira 2013).

This paper seeks to contribute to the literature examining collaborative links between KIBS and universities through presenting the results of exploratory research examining rural KIBS firms (North & Smallbone 2000a; North & Smallbone 2000b; Wood 2009; Chadwick et al. 2008). Rural KIBS are often considered as being 'atypical' as the majority of KIBS firms tend to be located in predominantly urban areas, taking advantage of 'thick' networks to facilitate both traded and untraded relationships (Aslesen & Isaksen 2007; Wood 2006). Consequently, less attention has been paid to rural KIBS in the extant literature, despite the fact that KIBS are some of the most innovative service firms within rural areas (North & Smallbone 2000a). Furthermore, in the case of the UK rural KIBS firms account for over 360,000 jobs or 16% of the total for this sector, highlighting the fact that these firms can be considered to be making an important contribution to the economy.²

Within the UK, universities tend to be located in cities and larger settlements. As such, rural KIBS firms may be 'forced' to engage in inter-organisational knowledge networks of greater geographic scope than of their urban counterparts. Does this then limit the effectiveness of one of the factors that mitigates the uncertainty of forming U-I linkages, i.e. geographic proximity? Is it the case that for rural KIBS firms organisational proximity is more important than geographic proximity? As a result of these relative unknowns, this paper addresses the following research questions: (1) What factors influence partner selection for rural KIBS firms engaging in collaborative partnerships with universities? (2) How important is geographic proximity to the formation of collaborative U-I linkages involving rural KIBS firms? (3) How important is organisational proximity in the formation of collaborative U-I

² Authors' calculations based on data from the UK Office for National Statistics. Data is for 2005, the mid-point in the period of analysis for this paper.

linkages involving rural KIBS firms? (4) Do the characteristics of a university influence the development of collaborative linkages with KIBS firms and how?

The paper is structured as follows: Section 2 builds a theoretical framework based on collaborative linkages and the problem of moderating uncertainty. Section 3 provides the contextual background, outlines the sources of data and statistical methods used for analysis. Section 4 outlines the results while Section 5 provides discussion and conclusions.

2. Theoretical Background

2.1 University-Industry Linkages and Uncertainty

The resource-based and knowledge-based views of the firm suggest that competitiveness is derived from the resources, particularly network resources, controlled by a firm (Wernerfelt 1984; Barney 1991). In general, membership of external networks and the development of collaborative linkages are viewed as important mechanisms for expanding these resources in order to increase competitiveness and add to a firm's capabilities (Gulati 2007; Huggins, Johnston & Thompson 2012). Existing evidence suggests that the main motivation for the development of U-I linkages surrounds enhancing innovative capabilities through, for example, accessing external resources, promoting learning within the firm and broadening the scope of the firm's activities (Hagerdoorn et al. 2000). In addition, academics are viewed as possessing knowledge and expertise which adds to the capabilities of a firm (Abreu et al. 2008).

As these activities are aimed at ensuring the firm's development and, ultimately, survival, networking has been seen as a way of addressing the uncertainties faced by the firm (Beckman et al. 2004). Network creation and expansion occurs as a direct consequence of uncertainties, but the network creation process is itself an uncertain practice (Petruzzelli 2011). In particular, knowledge-based networks are often subject to considerable uncertainty, which often forces firms to go through a period of trial and error to build up an understanding of the norms, habits, and routines concerning different external knowledge channels (Cohen & Levinthal 1990; Laursen & Salter 2006). The success of knowledge networks hinges to a large extent on a cumulative process of learning-by-doing. In view of the greater uncertainties involved in obtaining knowledge from distant locations, firms are most likely to draw on those experiences they have gained from local interactions if they can (Huggins & Izushi 2007). Nevertheless, previous evidence suggests that a high proportion (around a half) of inter-firm collaborative linkages fail, with a lack of shared goals and the complexity of coordinating and managing these linkages cited as the most cited reasons for failure (Park & Ungson 2001). Indeed, technology partnerships can be inherently unstable and provide a 'bumpy road' to travel on (Lokshin et al. 2011). This instability results from the inability of firms to effectively predict or anticipate the intentions of their partners and the uncertainty this creates. Consequently, the existence of uncertainties in innovation and knowledge creation have been viewed as the motivation for developing external linkages with particular actors, i.e. 'safer' actors such as universities (Powell et al. 1996).

It is possible to moderate the effects of uncertainty through contractual means designed to deter opportunistic behaviour and encourage fair play. Transaction cost theorists stress the expense entailed when addressing uncertainty and ensuring collaborative partners adhere to the agreed plan of action (Williamson 1993). However, this may increase both the complexity and the cost of collaboration for firms, particularly smaller firms with fewer resources with which to commit to the network (Barney 1991). Tackling these uncertainties consumes firm resources, and expending scarce resources on tackling uncertainties may make collaboration

less worthwhile, especially when augmenting these resources is the motive for engaging in external collaboration in the first place. Accordingly, in order to avoid such issues, firms require a heuristic in order to combat uncertainty. For example, experience of a previous collaboration has been cited as an effective lens for evaluating future partner selection (Gulati 1995). More experience equates to a more diverse portfolio of partners (Faems et al. 2005) and facilitates the organisational learning necessary to create the capabilities and routines associated with effective partner selection and successful collaborations (Das & Teng 2001). Therefore, when developing external linkages, partner selection is focused on moderating uncertainty and ensuring a successful outcome.

Based on the above, it can be suggested that three factors potentially reduce the uncertainties associated with developing collaborative linkages with universities: geographic proximity; organisational proximity; and the characteristics of the university partner. These are now examined in turn.

2.2 Geographic Proximity

Following Jaffe's pioneering work highlighting the regional delimitation of spillovers of knowledge from universities (Jaffe 1989; Jaffe & Trajtenberg 1996), geographic proximity is viewed as one of the most important determinants of U-I links (Morgan 2004; Sonn & Storper 2008; Ponds et al. 2007; Muscio 2013). This is especially true in the university sector as knowledge spillovers from universities have been demonstrated to be more locally focussed than those from firms (Adams 2002). As a result, geographic proximity may be an important factor in moderating the uncertainty that surrounds developing collaborative linkages. Firstly, geographic proximity to one's partners allows actions to be observed and fosters trust between the two parties enhancing the smooth transfer of knowledge (Wood & Parr 2005). The observation of a partner or potential partner allows the confirmation or rejection of beliefs as to their effectiveness and probable contribution to a collaborative venture (Gulati, 2007). This may not necessarily be direct observation but may be more indirect in character. Geographic proximity promotes localised interaction through labour mobility, offering a method of gathering information and knowledge on other organisations within the area as individuals move between them (Almeida & Kogut 1997). As such, geographic proximity has been found to facilitate the creation of social networks encouraging the interaction of agents and the spillover of knowledge and information within a locale (Singh 2005), providing a feedback loop through which information on the potential effectiveness of a partner is gathered, and moderating the uncertainties faced in this process.

The intensity of collaborative links tends to increase with geographic proximity, with increased face-to-face interaction promoting collective learning (Capello & Faggian 2005; Storper & Venables 2004). 'Communication externalities' have been identified as an important outcome of the geographic proximity of agents (Charlot & Duranton 2004; Charlot & Duranton 2006) facilitating the face-to-face interaction necessary for the effective transfer of knowledge between partners (Gittelman 2007). Therefore, a knowledge network will

function more efficiently with greater levels of contact between actors reducing the maintenance costs of network activity (Kirat & Lung 1999; Lawson et al. 1999; Wood & Parr 2005) These assertions form the building blocks of the model proposed by McCann (2007), which posits that proximity or distance is inversely related to levels of face-to-face interaction, suggesting that within highly dynamic sectors, where firms rely on high levels of intensive interaction, economic activity will be concentrated in those locations where the benefits of developing more intense collaborative relationships outweigh any increased land rents.

Despite the advantages of geographic proximity outlined in the literature, it has been established that it is neither a sufficient nor necessary condition for the successful formation of collaborative links between firms and universities (Torre & Rallet 2005). As such, scholars increasingly stress the global nature of inter-organisational networks (Bathelt et al. 2004; Bathelt 2005; Maskell et al. 2006; Teixeira et al. 2006). Here the innovation process involves seeking and exploiting knowledge through more dispersed networks, with the focus on procuring relevant knowledge rather than linking with a nearby partner. These 'global knowledge pipelines' have been demonstrated to be as important as local networks in high-tech sectors such as software and biotechnology, challenging the pre-eminence of local knowledge in the innovation debate (Gertler & Levitte 2005; Tripl et al. 2009). Within these global networks, uncertainty is mitigated through temporary proximity based on less frequent face-to-face interaction and driven by activities such as international trade fairs (Bathelt & Schuldt 2008; Rychen & Zimmermann 2008).

2.3 Organisational Proximity

In general, collaborative linkages can, and do, develop, over significant distances, and in seeking to explain this outcome scholars highlight the importance non-spatial proximity in the development of links (Boschma 2005). Typically, non-spatial proximity is conceptualised in terms of the similarities between agents based on: shared knowledge bases or skills (cognitive proximity); shared methods and procedures (organisational proximity); shared relationships (social proximity); and shared culture (institutional proximity) (Aguilera et al. 2012). In addition, the importance of epistemic communities has also been highlighted as an important determinant of collaborative links (Cowan et al. 2000) as well as shared codebooks (Pinch et al. 2003; Henry & Pinch 2001).

Despite its multi-faceted nature, non-spatial proximity is typically referred to as organisational proximity and is encapsulated as consisting of the ease with which agents can interact through following similar routines and behaviours (Torre & Rallet 2005). In this sense organisational proximity is analogous to belonging to an epistemic community where interaction is facilitated through a shared language, culture, norms, values and behaviours (Cowan et al. 2000). If individuals share these facets, or a similar 'codebook' (Pinch et al, 2001), it can be argued that co-location is unnecessary as the ability to communicate effectively and understand one another will facilitate interaction (Torre & Gilly 2000; Moodysson & Jonsson 2007).

The fact that organisational proximity is seen as a sign of reduced barriers to communication highlights the role it may play as a moderator of uncertainty in developing collaborative links. Organisational proximity suggests a shared understanding between actors, and with it the ability to communicate effectively (Moodysson & Jonsson 2007). Therefore, if actors are able to understand each other and possess an equal absorptive capacity (Cohen & Levinthal 1990) to successfully transfer knowledge then there is less likely to be uncertainty around whether a particular collaboration will prove effective. In addition, a shared culture also signals an ability to work together (Nonaka et al. 2000), with organisational proximity characterised not just by a shared understanding but also a shared experience of collaboration (D'Este et al. 2013). Prior collaboration, therefore, allows participants to build knowledge not just of each other but also the collaborative process as a whole and the relative success and/or failure of methods and approaches to working together.

Two points should be noted with respect to the importance of this type of proximity. First, prior evidence suggests that the effect of organisational proximity is weaker than that of geographic proximity (Ponds et al. 2007; D'Este et al. 2013). Second, on its own, organisational proximity is not necessarily sufficient for facilitating collaborative links between firms and universities. However, within the extant literature it has not been clearly established whether or not organisational proximity is required for a link to develop in the first instance. Indeed, the minority of university-industry linkss tend to be repeat collaborations, accounting for approximately only 2% of linkages in engineering and science fields (D'Este et al. 2013) and 27% of KIBS' formal university linkages (Johnston & Huggins 2013). Furthermore, the relationship between organisational and geographic proximity is not clearly established; for instance, it is not clear whether one substitutes for, or complements, the other? Where a relationship between the two has been examined, it has been found that in some cases geographic proximity can substitute for a lack of organisational proximity (Ponds et al. 2007), whereas others have found no relationship between the two (D'Este et al. 2013).

2.4 Organisational Characteristics: Universities

Universities are heterogeneous organisations varying widely in terms of specialism, research intensity and quality (Geuna & Muscio 2009). Consequently, the characteristics of the universities involved in collaborative partnerships may have an important bearing on the development and nature of these links. As such, the perceived quality of the academic partner has also been found to be important (Mansfield 1995; D'Este & Iammarino 2010). Universities producing world-leading research have been shown to be members of more extensive knowledge networks (Bathelt et al. 2004). Similarly, universities that are rated highly in terms of ranking metrics typically attract more distant partners (Hewitt-Dundas 2011; Hewitt-Dundas 2012; Laursen et al. 2011).

Clearly, the degree to which a university is able to commercialise the knowledge it creates is also attractive to potential collaborative partners (Huggins et al. 2008). Consequently, the reputation of a university and the quality of its research outputs are important drivers of collaborative linkages, acting as a signal of quality and highlighting the fact that they are likely to be reliable and effective partners (Huggins et al. 2008; Hewitt-Dundas 2011; Laursen et al. 2011). Therefore, the characteristics of a university partner may also be important in moderating the uncertainty associated with establishing linkages as these provide clear signals as to the competences and capabilities of each institution.

Existing evidence suggests that the research prowess of a university acts as a significant draw for firms pursuing collaborative linkages; firms are most likely to collaborate with a local top-tier university, i.e. an institution that is research intensive and geographically proximate (Laursen et al. 2011). Interestingly, these findings also suggest that a local lower-tier university may not act as a substitute; instead firms may collaborate with a non-local top tier university (Laursen et al. 2011). Hence, the process of partner selection concerns searching for an appropriate partner rather than a nearby partner. The characteristics of the university in terms of its ability to undertake research may increase the propensity for links which may or may not be aided by the geographic proximity of the two..

2.5 Organisational Characteristics: Knowledge Intensive Business Services

KIBS sectors include computer consultancy, R&D consultancy, accountancy services, legal services and architecture, i.e. services that require knowledge and human capital as an essential input (Doloreux & Muller, 2007; Chadwick *et al.*, 2008; Shearmur & Doloreux, 2009; Doloreux & Shearmur, 2010). Indeed, the presence of KIBS has been shown to be strongly correlated with the overall economic performance of a city or region (Simmie & Strambach, 2008). Further evidence suggests that this boost in performance is due to the fact that KIBS enable the absorption and transformation of knowledge that enables innovation to occur (Strambach, 2008). Consequently, KIBS have been conceptualised as ‘bridges of innovation’ (Corrocher and Cusmano, 2013), facilitating change and improvement through the provision of services tailored to the needs of their customers (Strambach 2008). As such, KIBS are regarded as increasingly important to knowledge networks by providing and transferring knowledge and skills to their clients. (Muller & Doloreux 2007; Chadwick et al. 2008; Doloreux & Shearmur 2012; Huggins 2011). KIBS may potentially fulfil a number of roles 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 & Mas-Verdú 2008). This has led to the suggestion that KIBS firms are creating a so-called “second knowledge infrastructure” complementing the “first knowledge infrastructure” which typically constitutes universities and other “public” actors (den Hertog 2000; Cooke & Memedovic 2003; Simmie & Strambach 2006).

KIBS firms tend to not only focus on their core competencies, but in tandem are also high-users of external knowledge for innovation (den Hertog 2000; Muller & Zenker 2001; Wood 2006; Aslesen & Isaksen 2007). These activities typically rely on knowledge as a key input and comprise services in areas such as computer consultancy, R&D consultancy, accountants and legal practitioners (Miles 2005). As such, KIBs have been characterised as relying on academic knowledge as potentially an important input for their activities (Faulconbridge 2007). The innovation role of KIBS consists of knowledge exchange through both traded and untraded relationships. It is generally asserted that the traded and untraded relations of KIBS, in the form of market transactions and knowledge networks, are both likely to be geographically bounded (Aslesen & Isaksen 2007). Indeed, the blurring of the boundaries between markets and knowledge networks in terms of client interaction and innovation has led to some authors referring to the 'inseparability' of these functions (Herstad & Ebersberger 2013). The growth of KIBS is related to the institutional formation of markets for knowledge based upon processes of localized knowledge appropriation. This has led to the establishment of concentrations of KIBS firms in key locations as they seek to maintain close contact with their core client base (Antonelli 1999).

3. Empirical Focus and Methodology

3.1 Rural KIBS

The empirical analysis undertaken in this paper focuses on the links formed with universities by KIBS firms located in geographic areas that are classified as rural in nature. As Herstad & Ebersberger (2013) note "from the perspective of KIBS, location in an urban economy is conducive to securing a knowledge supply base and enables demand specialisation" (pg. 3). Accordingly, KIBS located in non-urban areas tend to be embedded in less 'thick' labour markets and a reduced knowledge base on which to draw (O'Farrell et al. 1996). This suggests that rural KIBS, given their location, may be at a serious disadvantage when compared to their urban counterparts. Nevertheless, rural regions are far from innovation deserts; SMEs located in rural areas have been found to be equally or more innovative than their urban counterparts (Cosh & Hughes 1996). In light of this, KIBS firms have been demonstrated to be some of the most innovative service sector SMEs in rural regions (North & Smallbone 2000a). Despite the evidence suggesting that their productiveness wanes in relation to distance from an urban centre (Shearmur & Doloreux 2009). Recent research from Norway shows that KIBS firms in non-urban areas are likely to be involved in innovative collaborations with partners located outside of their region

Given the above, the empirical focus of this paper is on rural KIBS firms and the factors influencing partner selection with respect to developing collaborative links with universities. First, the literature has established that geographic proximity may play an important role in terms of moderating the uncertainty of entering into collaborative links (e.g. Storper & Venables, 2004). However, rural KIBS may be at a disadvantage due to their relatively isolated locations and consequent lack of geographic proximity to universities. However,

geographic proximity has also been shown to be neither a necessary nor sufficient factor in the formation of collaborative linkages (e.g. Torre & Rallet, 2005). Therefore, the first objective of the empirical analysis is to assess the importance of geographic proximity to rural KIBS firms in influencing the selection of a university partner. Second, the conceptual framework has established that organisational proximity may also be an important determinant of university linkages and in some circumstances may complement geographic proximity (Ponds et al, 2007). The analysis seeks to assess the role of organisational proximity in the partner selection process, its relative importance vis a vis geographic proximity for relatively isolated rural KIBS firms, and the potential relationship between the two forms of proximity. Finally, the analysis looks beyond proximity as a facilitator of collaborative links and examines whether the characteristics of the university itself influences partner selection.

3.2 Data

The analysis within the paper utilises a dataset comprising of the details of Knowledge Transfer Partnerships (KTPs) involving KIBS firms that commenced between 2001 and 2008, which was compiled from publicly available data sources (www.ktponline.co.uk). KTPs are publicly funded formal collaborations designed to transfer technology and knowledge between universities and other organisations through a specific project. The partnerships involve the employment of an 'associate' who is employed by the firm or organisation in order to facilitate cooperation through a close working relationship between the two partners, involving repeated interactions and encouraging the development of an ongoing collaboration.

Details of all firms and universities involved in these collaborations are freely available, providing access to the names of the firms, the region of the UK in which they are located, the size of the firm, SIC code, dates of commencement and duration of the partnership, details of the specific project and collaborating university involved. Therefore, it is a relatively straightforward task to identify KIBS firms involved in formal collaborations through the KTP programme. The available information also makes it possible to obtain a full postal address for each firm utilising Company's House data (at the time the KTP commenced for those that had subsequently moved), including those no longer trading. In addition, the full postal address for each university is also obtained, allowing crow fly distances between the two partners to be calculated.

In total, 568 KIBS firms are identified as having participated in KTPs between 2001 and 2008 (accounting for roughly 19% of total KTPs during this period). Possessing the firms' postcodes allows the local authority district in which they were located to be determined. Following this step, the firms are then categorised as to whether they were located in districts that were urban, significantly rural or predominantly rural, as classified by the UK Office for National Statistics (see Table 1 for characteristics of each district type). In total, 94 firms are identified as being located in predominantly rural districts, i.e. those dominated by small settlements and sparse populations also defined as remote rural regions (North & Smallbone

2000b; North & Smallbone 2000a) , accounting for 16% of KTPs involving KIBS firms in this period. After mapping the location of each of these 94 firms, it was confirmed that they were indeed located in relatively isolated small settlements outside of the main urban areas of the UK. Therefore, in the context of a relatively small country such as the UK they can be considered to be remote.

[table 1 about here]

These 94 collaborations involved 74 different firms, with 13 firms being involved in multiple collaborative links during the period 2001-2008. Forty-two different universities were involved in the 94 collaborations, with 17 of these being involved with more than one, and the remaining 25 accounting for just a single link each.

3.3 Dependent variable

The analysis employs a logit model in order to assess which characteristics influence the choice of university partner for each firm. The dependent variable is binary representing whether a collaboration occurred between a rural KIBS firm and a given university, taking the value 1 where a collaboration occurred and 0 otherwise. Each firm can potentially collaborate with any university. Therefore, for each collaboration the counterfactual is also examined by identifying collaborations that did not occur with other universities. Within the UK there are 127 potential university partners for each firm (for the purposes of this analysis specialised institutions, e.g. music and drama schools, medical schools and agricultural/veterinary schools, are excluded). Given that the conceptual model outlined in Section 2 established that the spatial reach of rural KIBS firms collaborative links may be more non-local in nature the analysis is based around the premise that every UK university is a potential partner for each firm. Therefore, for each KTP that actually occurred there are 126 non-occurrences, giving a data set containing 11844 observations (94 firms x 126 potential partners) of which 94 represent an actual collaborative link.

3.4 Independent Variables

The independent variables are included in order to capture the geographic proximity of the firms to each university, organisational proximity and the characteristics of the universities involved. Firstly, the distance between the two partners was used to calculate geographic proximity. Following D'Este et al. (2013), this was operationalised as $(1/d_{ij})$, 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. Organisational proximity is included through two variables; the first being a binary variable that controlled for whether a university had been involved in a previous collaboration, the second measured the number of previous collaborations a university had with KIBS firms during the period of the study (2001-2008).

In terms of university characteristics, a number of variables are used to capture the features of each institution. First, the knowledge generating capability and knowledge stocks of each institution are measured via a proxy that recorded the total number of patents held by each university per academic post. As this varies from year to year an average for the period 2003/04 - 2008/09³ is used in line with other studies of this nature (Ponds et al. 2007). A proxy for the relative networking capability and commercial focus of each institution is included using the total number of external links reported per academic for each institution for the entire period between 2003/04 - 2008/09. This encompasses all links between the university and external organisations for the purposes of undertaking contract research reported in the Business and Community Interaction Survey administered by the Higher Education Funding Council. This includes links with SMEs, the non-SME commercial sector, and non-commercial organisations. Finally, the research intensity of an institution is 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, further transformations were undertaken in order to include quadratic variables, in order to assess non-linear relationships, and interaction variables in order to assess the existence of complementary effects or substitute effects with geographic proximity. The quadratic terms are calculated as the squared variables and the interaction variables involving research intensity, linkages and patents are all multiplied by proximity to create these new variables. In addition, in order to assess the potential complementarity between geographic and organisational proximity an interaction variable is created by multiplying the two together. Table 2 highlights the descriptive statistics for the dataset.

[Table 2 about here]

³ 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 RAE is a peer reviewing exercise that ranks research outputs

4. Results

4.1 Descriptive Statistics

The first finding is that collaborative links between rural KIBS firms and universities are much more geographically dispersed than those of their urban counterparts (Table 3). The average distance between the partners is over 73 Km for collaborations involving rural KIBS firms, whereas for all KIBS firms the mean distance is around 43 Km and just under 38 Km for urban firms. Furthermore, the difference in the means between the three groups is found to be statistically significant (Mann-Whitney U-Test; $p < 0.01$). Therefore, collaborative linkages between rural KIBS and universities are shown to be much less localised than those of urban KIBS, echoing the evidence of Herstad & Ebersberger, (2013).

One explanation for these dispersed linkages is the fact that rural KIBS firms are faced with a more limited choice of local partners. This is borne out by the fact that there are significantly fewer universities within a 50 Km radius of these firms. It is observed that rural KIBS have, on average, around 6 universities within 50 Km of the firm compared with over 15 for urban KIBS firms (Mann-Whitney U-Test; $p < 0.01$; see Table 3). Therefore, while rurally based KIBS firms are involved in collaborations over greater distances than their urban counterparts, and they have significantly fewer universities within the surrounding area with which to collaborate, they are not completely isolated as there are still institutions with which to partner located in their vicinity. However, a mean distance between partners is 73 Km suggests that these firms are generally developing links beyond their immediate region.

Furthermore, the evidence suggests that the more dispersed nature of collaborative links among rural KIBS firms cannot be attributed to the differing sizes of firms found in urban and rural districts. Table 3 demonstrates that the underlying structure of KIBS firms engaging with universities by size is broadly similar in both urban and rural districts. While it is noted that the extant literature suggests that larger firms tend to engage in more geographically dispersed linkages with universities (Mohnen & Hoareau 2003; Laursen & Salter 2004), particularly in the case of the KIBS sector (Johnston & Huggins 2013), the observed differences in link patterns cannot be attributed to a greater proportion of larger firms being located in rural districts.

[Table 3 about here]

4.2 Regression Analysis

Table 4 presents estimates from the logistic regression model. Model 1 includes only the variables examining university characteristics, geographic and organisational proximity as regressors in order to establish a baseline. Model 2 adds in the quadratic terms in order to assess non-linear relationships and Model 3 the interaction terms to examine the effect of

geographic proximity on each university characteristic, interpreted as whether they reinforce or diminish the effect of geographic proximity.

The estimates obtained from the models show that geographic proximity is an important determinant of rural KIBS firms' choice of university partner, with a significant and positive coefficient observed on the variable GProx. Despite the fact that the distances between the firms and their university partners may be greater for rural firms than their urban counterparts, as demonstrated in Table 3, firms still tend to develop collaborative links with those institutions that they are located nearest to. Therefore, in line with the extant literature, geographic proximity to an institution has a significant and positive effect on the probability a collaborative link will develop (D'Este & Iammarino 2010; Muscio 2013; Hewitt-Dundas 2011). This result is interpreted to highlight the importance of geographic proximity in overcoming the uncertainties involved in developing collaborative links with universities. Clearly, the closeness of the two partners plays an important role in moderating uncertainty.

Furthermore, the significance of the squared proximity variable highlights the existence of a non-linear relationship between the probability of a collaborative link developing and the geographic proximity of the two partners. The negative coefficient on the squared terms indicates the existence of an inverted 'U' shaped relationship. This is interpreted as indicating that an optimum level of geographic proximity exists beyond which increased proximity between firms and universities actually decreases the likelihood of a link occurring. In the case of KIBS firms in predominantly rural areas, this most likely highlights the fact that relative close proximity of the firms and universities is not observed in the data to extend found for firms in more urban locations. The importance of geographic proximity, therefore, may be bounded by the location of the firm. In other words, although it may be that a firm is collaborating with the university that is closest geographically, there still may be a considerable distance between partners. This highlights an important finding in light of the fact that the extant literature suggests that geographic proximity is important in facilitating collaboration. In this case, although geographic proximity is undoubtedly relevant, in reality 'proximity' may be a more fluid concept that is dependent on location of actors, especially the rural or urban nature of these locations.

The results indicate that organisational proximity plays an important role in the development of collaborative links between rural KIBS firms and universities. Both organisational proximity variables (Prevcol and Totcol) show significant and positive coefficients, signalling that they increase the probability of a collaborative link occurring. Organisational proximity, therefore, appears to be an important factor in the partner selection process. The fact that a firm has been involved in a previous collaboration with a university appears to allow the development of a shared understanding to develop facilitating further collaboration. However, it must be noted that this effect is only the case for collaborations with any university, not necessarily the same university (when a variable for a previous collaboration with the same university is tested it was not found to be significant).

The results show that a previous collaboration between actors has a much greater effect on partner selection than the total number of collaborations with KIBS firms. Therefore, it is not an institution's overall previous collaborative ties with the KIBS sector that is important, as a whole but previous collaboration by the firm with a university that is the key to partner selection. Consequently, it is the experience of the previous interactions of firms with a university, rather than the experience of the university with the KIBS sector, that is the significant determinant of partner selection. The magnitude of these effects are smaller than that of geographic proximity suggesting that organisational proximity is of less importance in the partner selection process.

Not all university characteristics influence partner choice. The only significant coefficient is for the research active staff variable, which highlights a positive relationship with the probability of a link occurring. Therefore, a university with greater numbers of staff counted publicly as research active increases the probability that a rural KIBS firm will develop a collaborative link with that institution. As this variable is essentially an indicator of the esteem and research prowess of an individual university, this finding chimes with the extant literature suggesting that institutional reputation is a significant determinant of collaborative links (Laursen et al. 2011; Hewitt-Dundas 2012). This result has an important implication for universities themselves. Research intensity is a heuristic that acts as a proxy for status and reputation, factors that should reduce uncertainty regarding the ability of an institution to deliver. Research activity also facilitates collaboration, as this type of activity engages researchers with the world beyond academia, i.e. it is a clear signal that a university has the capabilities and expertise to enable the production of the knowledge required by firms and other organisations.

There is also some (albeit weak) evidence that the number of commercial links an institution possesses is reinforced by geographic proximity. This variable is insignificant when included as a standalone variable, yet is weakly significant when interacted with geographic proximity. This is interpreted as meaning that commercial links alone do not influence partner selection, with firms needing to share a location with a university in order to observe or be aware of these links. Without a shared location the extent of these links is an unknown factor to firms, and consequently does not moderate the uncertainty surrounding the partner selection process. In this case, therefore, geographic proximity provides the lens through which to observe this characteristic.

Finally, the relationship between the two types of proximity is complex. First, the coefficient for the $Prevcol * Gprox$ variable is not significant, indicating that there is no relationship between previous collaboration and geographic proximity. This suggests that these variables are distinct from one another; they do not act as either complements or substitutes, neither reinforcing nor diminishing the effect of the other. In contrast, a significant and positive coefficient is observed on the $totcol * gprox$ variable suggesting that these two complement each other. Therefore, where a particular university has a high number of linkages with the KIBS sector the probability of another KIBS firm forming a link increases, and this probability is further reinforced by geographic proximity. This can be interpreted as

highlighting the importance of embeddedness within both the sector, in terms of high levels of existing interaction with similar firms, and spatial embeddedness, in as far as both firm and university are operating within the same local environment, suggesting that even in rural locations milieu-type effects are important.

[Table 4 about here]

5. Discussion and Conclusions

This paper proposes that the process of establishing collaborative knowledge-based links with university partners is potentially an uncertain activity for business and industrial partners. Based on an analysis of KIBS firms located in rural areas of the UK, the extent to which both geographic and organisational proximity influence the choice of university collaborators through knowledge transfer partnerships is examined. The theoretical framework underpinning the paper posits that potential problems of information asymmetry may result in uncertainty issues related to the development of collaborative links. In particular, firms cannot be sure that a particular university will be an appropriate partner for them to ensure a successful outcome. It is hypothesised that the extent to which either form of proximity is associated with partner selection is an indication that firms consider such proximity a means of mitigating the uncertainties inherent in new network formation. Overall, the results of the study show clear evidence that both forms of proximity are significantly associated with partner choice.

The findings from the study reinforce the extant literature suggesting that geographic proximity has a significant influence on the partner selection within a knowledge-based environment (D'Este & Iammarino 2010; Muscio 2013; Hewitt-Dundas 2011). In particular, the findings indicate that geographic proximity is important for KIBS in more remote locations when developing collaborative links with universities. Whilst they engage with universities over a greater distance than urban KIBS, these firms still tend to form links with universities located within the same wider, mainly regional, geographic area. Therefore, the evidence suggests that rural KIBS are similar to urban KIBS firms in that geographic proximity to their collaborators is still important.

The study has shown that for rural KIBS firms organisational proximity does have a significant influence on the partner selection process, although it is of less importance than geographic proximity. A prior collaboration with a university influences the partner selection process and suggests there is a role for shared values, practices and language in this process. However, the results highlight that general experience of university collaboration is important rather than repeated linkages with the same partner. This evidence requires some clarification. Indeed, the evidence in the literature is mixed with respect to repeated ties, with some evidence supporting their importance and other research showing no relationship (Ponds et al. 2007; D'Este et al. 2013). KTP projects are self-contained in nature and generally last for 2-3

years, and these characteristics possibly lend themselves to more discrete collaborations with clear objectives to be met. Evidence suggests they are successful in nature, with over half (52%) being graded as outstanding or very good in evaluation (Ternouth et al. 2012) and 78% of participating firms and 90% of participating academics being very satisfied or satisfied with the programme (Regeneris Consulting Ltd 2010) at the natural end point to the collaboration. Also, when firms engage in a new project the funding arrangements mean that it has to be demonstrably different, rather than repeating previous efforts, with a focus on the 'additionality' to the business (www.ktponline.org.uk), a process which may lend itself to selecting a new partner. Of course, the movement of academics over time may mean that the firms are merely following the academics involved as they move institutions. However, the limitations of the dataset are such that these questions need to be tackled by further work in this area.

The role of organisational proximity in complementing geographic proximity is a potentially important finding as it indicates that the formation of university-industry linkages are not always only the result of locational factors and spatial proximity, but also previous experience of engagement with similar actors (Gulati & Gargiulo 1999; Gulati 2007; Gulati 1999; Huggins 2010; Huggins, Johnston & Stride 2012). This adds a degree of weight to theories suggesting that within knowledge-based environments network-related factors play an important role not only in determining strategic decision-making but also in predicting the potential for growth and success (Huggins & Johnston 2010; Huggins & Thompson 2013). While this has not been explicitly examined in this study it is clear that these findings suggest that this is a direction to be explored in future research in this field. In particular, although it has been established that rural and urban KIBS firms share certain similarities the results suggest the need for further research to examine how rural KIBS firms may be different or similar to firms rural firms in other sectors with a propensity to establish collaborative links with universities.

Furthermore, an exploration of other measures of organisational proximity may provide further insights. In this case, the regression results indicate complementarity between geographic and organisational proximity when it is operationalised as a university's level of involvement with the KIBS sector as a whole. Yet, where it is operationalised as previous collaboration having occurred between both actors then there is no relationship. In the absence of a formal measure of organisational proximity within the literature, different studies may yield differing results. From the analysis presented in this paper it can be suggested that the network resources resulting from organisational proximity in the form of previous links with universities, rather than the same university, are associated with the management of uncertainty.

The results further demonstrate that not all characteristics of a university are important determinants of partner selection. The fact that the level of research activity within a university has a positive influence on partner selection suggests that these process focus on accessing knowledge and capabilities that complement rather than overlap. This adds further

weight to the extant literature highlighting the importance of research quality for the partner selection process (Hewitt-Dundas 2012; Laursen et al. 2011; Bishop et al. 2011).

The implications of the results to practitioners and policymakers are threefold. First, policymakers, technology transfer officers and university academics are encouraged to view both the urban area and surrounding rural hinterlands as fertile grounds for developing collaborative links. Second, engaging more widely with the KIBS sector is likely to have a positive effect on developing further links. Third, geography is not the only important factor. Practitioners and policymakers should not merely focus on facilitating links among co-located firms and universities. The selection of an appropriate partner is a complex process influenced by a combination of location, shared cultures and languages and the research prowess of an individual university.

The main limitations of this study is that it is restricted to firms based in Britain. Further work is required to assess the nature of KIBS links with universities in other countries, and the extent to which there is similar or different pattern to that found here for the UK case. Furthermore, the study focuses on formal interactions rather than the range of informal or 'hidden' linkages between academics and industry uncovered by other studies (Hughes & Kitson 2012). One area of interest is to better understand how these collaborative links initially develop, and future research should focus on opening the 'black box' in order to understand the partner selection process and functioning of these innovation partnerships, as well as the types of interaction that occur within the realms of such partnerships (Bodas Freitas et al. 2013; Bruneel et al. 2010).

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Table 1: Classification of Urban and Rural Local Authority Districts in the UK
(Pateman 2011)

District Type	Urban Population	Rural Population	Total KTPs in Districts
Urban	Up to 74%	Less than 26%	395
Significantly Rural	Less than 74%	Up to 26%	79
Predominantly Rural	Less than 50%	50% or over	94

Table 2: Descriptive Statistics

Variable	Description	Min	Max	Mean	S.D
Collab-	Collaboration between firm and University occurred	0	1	-	-
Prevcol	Firm has previously collaborated with a university	0	1	0.167	0.374
Totcol	Total number of KTPs involving KIBS firms for each university	0	44	4.50	6.13
GProx.	Geographic Proximity of firm and university	0.03	1.28	0.08	0.04
Resactivity	Proportion of academic staff returned in 2008 RAE	0.00	0.82	0.28	0.16
Links	Commercial linkages per academic staff member	0.00	64.75	2.88	6.93
Pat.	Number of patents per academic staff possessed by university	0.00	0.44	0.045	0.08

Table 3: Partners, Partner Choice and Types of Firms

Variable	All KIBS	Urban KIBS	Predominantly Rural KIBS
Mean Distance between partners (Km)	43.79*	37.82*	73.47*
Mean number of universities within 50 Km	14.02*	15.65*	5.92*
Small Firms (1-49 employees)	74.8	74.2	77.9
Medium Firms (50-249 employees)	19.0	19.7	15.8
Large Firms (250+ employees)	6.2	6.1	6.3
N	568	474	94

*difference is significant at the 1% level (Mann-Whitney U-Test).

Table 4: Logit Partner Choice Model

	Model 1	Model 2	Model 3
GProx	18.089*** (1.428)	31.975*** (2.244)	30.636*** (3.144)
PrevCol	4.903*** (0.638)	4.726*** (0.670)	5.818*** (1.733)
Totcol	0.059*** (0.10)	0.215*** (0.038)	0.160*** (0.045)
Resactivity	1.726*** (0.782)	7.707** (3.683)	9.441** (4.243)
Links	0.014 (0.014)	0.042 (0.052)	-0.145 (0.119)
Pat.	-2.656 (1.972)	-5.902 (5.201)	-5.976 (5.257)
GProx ²		-21.655*** (2.217)	-21.259*** (2.407)
Resactivity ²		-8.266 (5.861)	-7.971 (6.201)
Links ²		0.000 (0.001)	0.001 (0.001)
Pat ²		3.288 (16.088)	5.573 (15.961)
Totcol ²		-0.004*** (0.001)	-0.004*** (0.001)
Resactivity*GProx			-13.569 (8.589)
Links*GProx			0.860* (0.475)
Prevcol*Gprox			-6.727 (11.884)
Totcol*Gprox			0.426** (0.199)
Intercept	-7.662*** (0.328)	-10.394*** (0.644)	-10.111*** (0.784)
	Number of observations: 11844 Log Likelihood: -753.356; R ² = 0.028	Number of observations: 11844 Log Likelihood: -662.818; R ² = 0.035	Number of observations: 11844 Log Likelihood: -662.818; R ² = 0.035

(standard errors in parentheses)

***significant at the 1% level; **significant at the 5% level; *Significant at the 10% level