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**The spatio-relational nature of urban innovation systems:
Universities, knowledge intensive business service firms, and collaborative networks**

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Abstract

The need to better identify the spatio-relational nature of urban innovation systems and spaces is increasingly acknowledged. The aim of this paper, therefore, is to provide an enhanced understanding of the knowledge networks existing between urban Knowledge Intensive Business Services firms (KIBS) and universities, which are often key components of such systems and spaces. Drawing on an analysis of urban KIBS firms and universities in the UK, it is found that the nature of firms, the location in which they are based, and the research intensity of their university partners are important determinants of the spatiality and localisation of the networks they form. The results show that the smallest urban KIBS firms have the highest propensity to engage in local links with universities, suggesting that they rely most significantly on their own urban innovation system for collaborative network ties.

Keywords: innovation systems; urban innovation spaces; knowledge-based development; proximity; networks; KIBS; universities.

1. Introduction

The idea of knowledge-based urban development has emerged as a means of systematically examining the role of knowledge and networks as key components of urban economic evolution (Knight 1995; Knight 2008; Kunzmann 2008; Yigitcanlar & Lönnqvist 2013; Yigitcanlar 2009). In essence, this approach takes the view that knowledge is a key construct for understanding the means and modes of urban development (Yigitcanlar 2009), with an explicit focus on identifying the knowledge assets of urban environments (Kunzmann 2008; Lönnqvist et al. 2013). Consequently, the starting point for this paper is the argument that the development path of a city economy is dependent upon the quality of the urban innovation system it possesses and the knowledge based assets within it. The extant literature places both universities and Knowledge-Intensive Business Service (KIBS) firms in the centre of the knowledge-based development process, regarding them as crucial nodes within urban innovation systems (Muller & Zenker 2001; Lawton Smith 2007; Doloreux & Shearmur 2012; Corrocher & Cusmano 2014; Huggins et al. 2008). Yet, less is known about the interactions of KIBS in urban locations with the university sector, and while some scholars have begun to address this area the specifics surrounding the participation of KIBS firms with universities within the same urban innovation systems is still relatively unexplored.

KIBS firms are characterised as predominantly urban in nature due to their reliance on thick networks for their inputs in terms of human capital and knowledge (Miles 2005; Wood 2006; Huggins 2011). As KIBS are involved in the provision of tailored services to their clients their work is increasingly collaborative in nature, typically regarded as the co-creation of knowledge (Muller & Zenker 2001; Muller & Doloreux 2007). As such, location and proximity are regarded as important factors in the network formation process. Firstly, location, especially urban locations, are important for the creation of 'buzz' and spatial proximity that promotes the intense interactions required for this process to succeed (Storper & Venables 2004). However, the importance of proximity is not without controversy; on one hand a broad section of the literature considers this to be one of the central tenets of innovation systems theory, with evidence suggesting that the effectiveness of knowledge transfer decays with distance, resulting in local collaborative linkages being critical to the innovation process (Jaffe 1989; Breschi & Lissoni 2001; Morgan 2004; Doring & Schnellenbach 2006). Alternatively, others have questioned the importance of geographic

proximity for the facilitation of collaborative network linkages (Rallet & Torre 1999; Torre & Rallet 2005; Boschma 2005; Huber 2012).

Underlying this focus on location and proximity is the view that the innovation process is now more 'open' and systemic in nature, with the acquisition of knowledge from sources external to the firm providing significant competitive advantage to firms (Chesbrough 2003; Lechner & Dowling 2003; Pittaway et al. 2004). The aim of this paper is to contribute towards an enhanced understanding of the knowledge networks existing between urban KIBS firms and universities, in order to better identify the spatio-relational nature of the innovation systems and spaces of which they are often key components. In particular, the paper examines the factors underlying the spatial pattern of the networks through which urban KIBS firms engage in collaborative relationships with universities. In order to achieve this aim, the paper utilises a dataset containing details of formal collaborative linkages between urban KIBS firms and universities in the UK. Using a logistic regression model, the empirical analysis examines the factors influencing the spatio-relational scope of these linkages, specifically the propensity to enter into collaborations beyond the immediate vicinity of the firm. The analysis provides a novel contribution to understanding the factors that underlie the development of urban innovation systems, especially the spatial limits of effective knowledge networks, through examining the scope of interactions undertaken by urban KIBS firms. It finds that the nature of firms, the location in which they are based, and previous collaboration patterns are important determinants of the spatiality and localisation of the networks they form. This leads to the conclusion that while KIBS may be key players in urban innovation systems and key actors in knowledge-based urban development processes, their networks may in fact be more porous across spatial boundaries than is currently acknowledged by the substantive literature.

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

2. Conceptual and Theoretical Background

This section presents the key conceptual and theoretical context upon which the paper's empirical analysis is based. It firstly argues that the key to knowledge-based urban development are urban innovation systems, which provide a contemporary and reframed perspective on urban economic evolution and highlight the networks between actors in these systems as well as forming the principal component underpinning the dynamic nature of this evolution. Second, it highlights the contested role of geographic proximity in relation to such networks. It then frames the role of both KIBS firms and universities as key connected actors within these networks.

2.1 Urban Innovation Systems and Knowledge-Based Urban Development

The openness of firms and their engagement in a more systemic innovation process has been demonstrated to lead to higher levels of innovation (Laursen & Salter 2006; Van de Vrande et al. 2009). Therefore, reference to an era of open innovation is increasingly apparent within innovation studies with the emergence of the idea that firms must combine internal and external knowledge for innovation (Chesbrough 2003; Dahlander & Gann 2010). As a result, innovation is now characterised as involving inter-organisational networks with innovative outputs the product of collaborative linkages with a range of external actors including, customers, suppliers and universities (Huggins & Johnston 2009; Clifton et al. 2010; Huggins et al. 2012). Consequently, knowledge from providers such as universities is considered to be a key factor within modern innovation processes and the formulation of innovation systems (Nelson & Rosenberg 1993; Freeman 1995; Freeman 1987; Cooke et al. 2004; Lawton Smith & Bagchi-Sen 2006).

The concept of 'regional innovation systems', is a recognition of the role of knowledge for growth through innovation, and provides an explicitly spatial dimension to the process (Cooke 2004). As such, innovation systems theory views an economy as an interlinked systemic network of components facilitating innovation (Freeman 1987; Lundvall 1992). Cooke (2004) suggests that regional innovation systems are a vital component for economic development, while others have focused on the notion of clusters as the key focus of urban development theory and policy, with the underlying argument being that competitiveness is determined by the strength of key concentrations of specific industries (Porter 1998; Huggins & Izushi 2011).

The innovative milieu of urban settings means that they are often singled out by scholars as being key territorial units within which endogenous forms of development flourish (Maillat 1998; Fischer et al. 2001; Vazquez-Barquero 2007). In an evolutionary context, the knowledge-based urban development involves multiple threads of relationships among its actors and resources at both a firm and spatial level, which interact in a complex manner (Maskell & Malmberg 2007). Fundamentally, a key driver of urban growth consists of the capability of organizations in a city or region to access and subsequently utilize appropriate economically beneficial knowledge. According to Storper (1997: 44), ‘the status of the region is now not merely as a locus of true externalities, but – for the lucky regions – as a site of important stocks of relational assets’. These relational assets in the form of the network capital of firms and other organizations (Storper 1997; Huggins 2010; Huggins & Thompson 2013; Huggins et al. 2012; Huggins & Johnston 2010) and the social capital of individuals (Tura & Harmaakorpi 2005; Hauser et al. 2007; Lorenzen 2007; Walter et al. 2007; Tappeiner et al. 2008) distinguish Storper’s (1997) ‘lucky’ from ‘unlucky’ cities and regions, as well as forming part of the territorial capital of places, which includes not only relational assets but the wider set of natural, human, and organizational assets underpinning economic competitiveness (Camagni & Capello 2013; Camagni & Capello 2010; Capello et al. 2011).

At the urban and city level the notions of ‘knowledge cities’ (Carrillo 2004; Carrillo 2006; Yigitcanlar & Velibeyoglu 2008) and ‘knowledge-based urban development’ (Knight 1995; Knight 2008; Kunzmann 2008; Yigitcanlar & Lönnqvist 2013; Yigitcanlar 2009) have emerged as a means of examining in a systematic manner the role of knowledge and networks as key components of urban economic evolution. In particular, the knowledge city concept takes a broad view of knowledge as a key construct for understanding the means and modes of urban development (Yigitcanlar 2009), with an explicit focus on identifying the knowledge assets of urban environments (Kunzmann 2008; Lönnqvist et al. 2013). The knowledge city and knowledge-based urban development schools of thought encompass the knowledge construct within a framework that seeks to integrate the economic, social, and environmental assets and factors underpinning development (Yigitcanlar 2009; Yigitcanlar 2010).

In essence, the knowledge-based urban development concept is rooted in the notion that the sources of high rates of economic performance and subsequent growth stem from the role that the production, distribution, and use of knowledge play within and across economies, with

networks playing a fundamental role (Carrillo et al. 2014; Yigitcanlar et al. 2012), in particular the linkage between universities and firms (Perry 2008). More recently, the role of particular places within urban environments, which are variously described as urban innovation spaces, districts or precincts, and conceptualised here as urban innovation systems, are viewed as key catalysts of knowledge-based urban development (Yigitcanlar et al. 2008; Yigitcanlar et al. 2012; Carrillo et al. 2014). It is the harnessing of these urban innovation systems that forms a key feature of the reframing of contemporary urban economic development (Yigitcanlar 2011; Sarimin & Yigitcanlar 2012; Benneworth & Ratinho 2014). For example, in their study of the role of universities within such urban areas, Benneworth and Ratinho (2014) argue that it is the dynamic interrelation of both proximity and networks that best fosters urban upgrading. Similarly, it has been argued that the most effective urban innovation districts in the US have a high degree of network assets, along with more traditional physical and economic assets, producing a dynamic environment that strengthens proximity and knowledge spillovers (Katz & Wagner 2014).

It is noted within the extant literature that knowledge may take many different forms, with one of the most familiar typologies suggesting that knowledge is either explicit/codified or tacit (Nonaka & Takeuchi 1995). More codified forms of knowledge are usually considered to be relatively less space sensitive than tacit knowledge (Bathelt et al. 2004). Tacit knowledge, on the other hand, is considered not to travel well, making it a key factor underlying ‘the geography of innovation’ (Asheim & Gertler 2005). In this sense, therefore, it may well be that more place-based notions of urban innovation spaces have higher applicability to flows of tacit knowledge, while the wider space of flows notion is more in keeping with the transfer of codified knowledge. However, there is a growing school of thought that geographically non-proximate actors are often equally, if not better, able to transfer complex knowledge across such spatial boundaries, providing a high-performing network structure is in place (McEvily & Zaheer 1999; Dunning 2000; Lissoni 2001; Davenport 2005; Palazzo 2005; Zaheer & Bell 2005).

2.2 Geographical Proximity and Networks

Despite the conceptual developments reviewed above, the apparent role of geographic proximity as contributor to development and sustainability of effective relational and networks assets remains a somewhat controversial issue that has been extensively examined, resulting in no clear consensus on its function (Huber 2012; Howells & Bessant 2012). The

importance of geographic proximity to sources of external knowledge is predicated on the fact that knowledge has been demonstrated to decay with distance, increasing the importance of localisation (Jaffe 1989; Breschi & Lissoni 2001; Wallsten 2001). Allied to this is further evidence that many firms tend to be localised, with high technology sectors exhibiting higher a propensity for co-location (Audretsch & Feldman 1996; Ellinson & Glaeser 1997). Subsequently, this provides support for assertions that knowledge crosses a hallway or street more easily than an ocean or continent (Glaeser et al. 1992; Feldman 1994; Ter Wal 2013), while concurrently underpinning the localisation of collaboration thesis that “the geographic distance between two inventors negatively affects the probability that they will engage in collaboration” (Ter Wal, 2013, p. 6).

It is suggested that localised collaboration is reinforced by the fact that proximity increases the intensity of collaborative linkages as it fosters face to face interaction and promotes collective learning (Capello & Faggian 2005; Storper & Venables 2004). Localisation of collaboration, therefore, allows knowledge networks to function more efficiently through facilitating greater levels of contact between actors, fostering trust between participants and reducing the maintenance costs of network activity (Kirat & Lung 1999; Lawson & Lorenz 1999; Wood & Parr 2005). These assertions form the building blocks of a 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 face to face interaction, economic activity will be concentrated in particular locations where the benefits of developing more intense collaborative relationships outweigh any increased land rents. Similarly, research on agglomeration economies has identified ‘communication externalities’ as an important factor that sits alongside externalities pertaining from factors such as human capital (Charlot & Duranton 2004; Charlot & Duranton 2006).

Despite the wealth of arguments highlighting the importance of geographic proximity, it has been suggested that inter-organisational knowledge networks are increasingly global in scope (Bathelt 2005; Bathelt et al. 2004; Maskell et al. 2006; Huggins et al. 2012). The reasons for this are two-fold; firstly, temporary proximity is considered by some to be sufficient to facilitate face-to-face communication (Bathelt & Schuldt 2008; Rychen & Zimmermann 2008). Secondly, it is argued that, on its own, geographic proximity is insufficient to create synergies and foster interaction between firms (Rallet & Torre 1999; Torre & Rallet 2005;

Boschma 2005). Instead other types of non-spatial proximity are regarded as important facilitators of collaborative links (Torre & Rallet 2005; Rallet & Torre 1999; Boschma 2005; Huggins & Thompson 2013).

Typically, non-spatial proximity is conceptualised in terms of 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). Cowan et al. (2006) model the innovation process as a search process in which firms face a trade off between developing collaborative linkages with a familiar partner or a partner with complementary knowledge. One important finding from this work is that as a firm's network becomes denser it does not grow in geographic scope, thus "reinforcing local coherence" (Cowan et al. 2006). Therefore, within this model it is the notion of organisational proximity that drives the localisation of collaboration.

3. Contextual Background

3.1 Knowledge-Intensive Business Services

KIBS firms are providers of business to business services such as computer consultancy, R&D consultancy, accountancy legal practitioners (Miles 2005). KIBS are based around activities and services that utilise specialist knowledge to provide bespoke problem specific solutions. The service provided is essentially a problem solving process, supplying specialist knowledge to other businesses (Bettencourt et al. 2002). Accordingly, the KIBS sector is driven by high levels of interaction with their clients and involves mutual learning between parties, developing know how; as such, the interaction between KIBS and their clients is often referred to as the co-production of knowledge (Galloway 2002; Freel 2006). Furthermore, KIBS increasingly both provide and transfer knowledge and skills to their clients, particularly within de-industrialised economies (Huggins 2011). Consequently they are characterised as 'bridges of innovation' (Corrocher and Cusmano, 2014, p. 4), acting as consultants and facilitators of business to business interaction through providing services that are typically tailored to the needs of their customer (Strambach 2008), complementing the publicly funded knowledge infrastructure and providing a 'second knowledge infrastructure' (Cooke & Memedovic 2003).

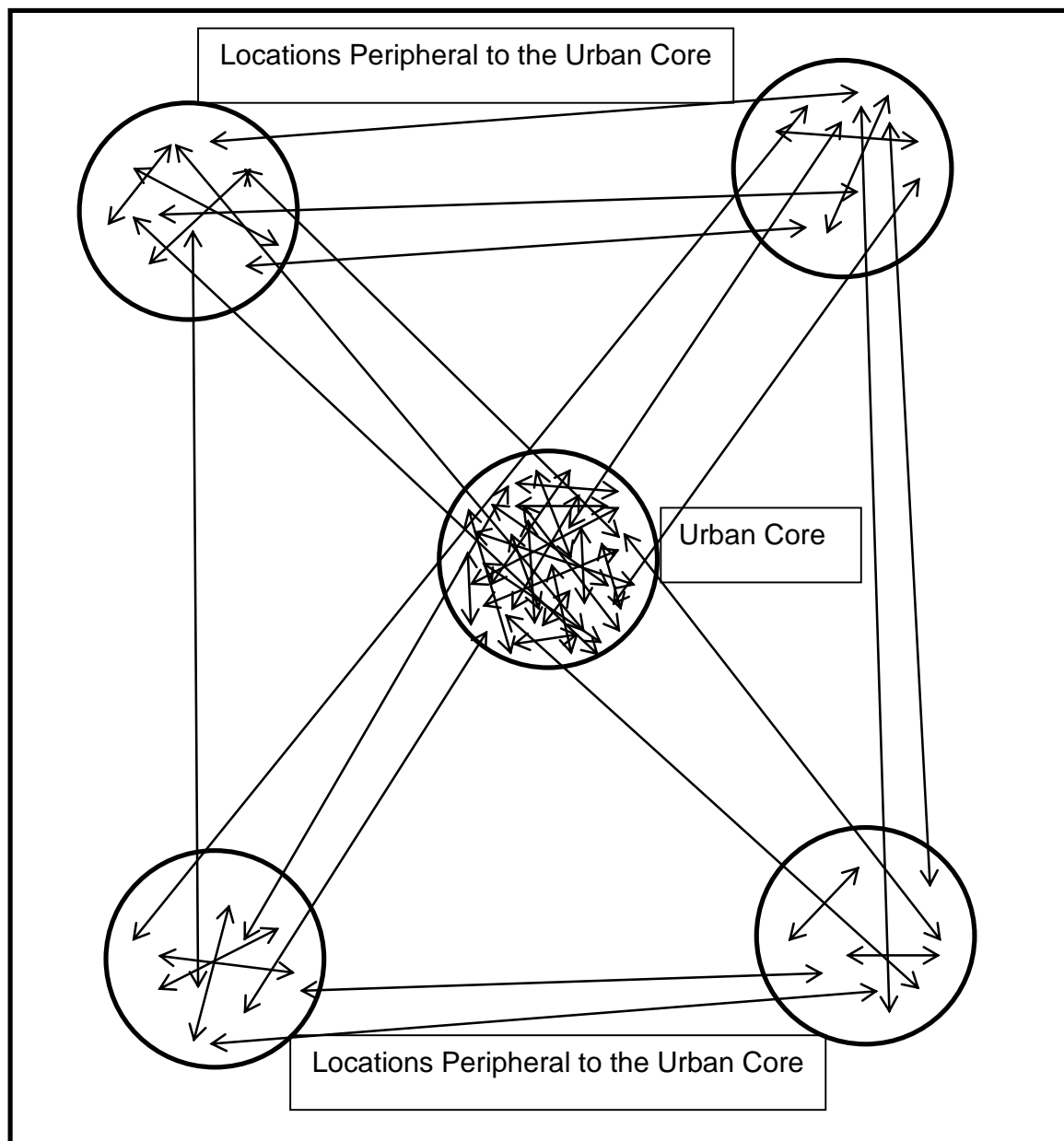
The KIBS sector is far from homogenous; the sectors that comprise KIBS are diverse in terms of the type of service they provide and the activities they undertake (Muller & Zenker 2001; Strambach 2008). The focus tends to be differentiating technology based firms from knowledge based services (Glucker et al. 2011); consequently, the distinction that is generally applied involves sub-dividing the sector into technology based activities (T-KIBS) and professional service based services (P-KIBS), plus a third sub-sector covering research based services (R-KIBS) (Doloreux & Muller 2007; Muller & Zenker 2001; Miles 2008). These distinctions are not solely based on the types of services provided but also the knowledge base of each sub-sector, which centre on different communities of practice; for example, architects and engineers utilise very different forms of knowledge in the course of their work, architects using symbolic and synthetic knowledge and engineers using analytical and synthetic knowledge (Strambach 2008; Faulconbridge 2010; Tether et al. 2012).

As noted previously, intense interaction between partners in the innovation process often requires face to face interaction (McCann 2007). Thus, the proximity of partners may facilitate the face-to-face interaction required for co-production of knowledge. Indeed, McCann's (2007) model suggests that sectors where continuous face-to-face contact is important are more likely to be located in urban areas which are dense with firms but command higher rents, compared with locations peripheral to the urban, as depicted by Figure 1. The evidence confirms this in the case of KIBS, as these firms tend to be concentrated in cities and urban areas (Chadwick et al. 2008; Wood 2009). This clustering is attributed to the local 'buzz' generated in dense and dynamic urban environments (Gertler 2003; Storper & Venables 2004; Todtling & Trippl 2005). KIBS located in urban centres, therefore, are likely to be more innovative than those located in more peripheral areas, and are more likely to engage in the co-production of knowledge (Shearmur & Doloreux 2009; Doloreux & Shearmur 2012).

In other knowledge intensive sectors the co-production of knowledge has also been shown to be a significant determinant of firm location (Audretsch & Feldman 1996; Audretsch 1998). For example, geographic proximity to universities has been shown to influence firm location for knowledge intensive manufacturing sectors (Abramovsky & Simpson 2011). In terms of the broader services sector, while regarded as 'lighter' and more 'weightless' than manufacturing industries (Quah 1996; Coyle 1999), geographic proximity has also been demonstrated to be of importance to the formation of collaborative network links between

firms in these sectors and universities (Johnston & Huggins, 2015). As such, while KIBS are regarded as important knowledge generators and facilitators of innovation within an urban innovation system, scholarly work in this area has largely examined the co-location of other firms with KIBS and is only now beginning to explore issues related to their relationship with other knowledge generators such as universities (Pinto et al. 2013).

Figure 1: Conceptualising the Network Reach and Densities of Urban KIBS Firms



3.2 Universities

Universities are increasingly portrayed as core knowledge-producing entities that can play an enhanced role in driving innovation and development processes by providing knowledge for business and industry (Foray & Lundvall 1996; Garlick 1998; Kitagawa 2004; Thanki 1999; Fritsch 2002; Huggins et al. 2008). A growing body of work examining university knowledge transfer demonstrates that many institutions are developing policy initiatives designed to increase such activity (Tornatzky et al. 2002; Paytas et al. 2004; Palminteri 2005; Perkmann & Walsh 2007; Abreu et al. 2008), but less is known about the nature and pattern of the networks and interactions emerging from such knowledge transfer practices, and what may be the appropriate enabling mechanisms (Pickernell et al. 2009).

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 have an important bearing on the development of these linkages. 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 2012; Hewitt-Dundas 2011; Laursen et al. 2011).

In addition, 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 reliable partners (Huggins et al. 2008; Hewitt-Dundas 2011; Laursen et al. 2011). Thus, the characteristics of the university partner can 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 (Johnston & Huggins, forthcoming.; Johnston & Huggins 2015).

4. Empirical Analysis

The empirical analysis focuses on the extent to which KIBS firms and universities which, as argued above can be considered as key players in urban innovation systems, are engaging in formal network collaborations with each other within the same urban area. This section explains the nature of the data collected and analysed for the study, as well the modes of analysis employed.

4.1 Dataset: University Linkages

University linkages are a diverse phenomenon, covering a wide range interactions with other organisations, both formal and informal (Perkmann & Walsh 2007). The data utilised in this proceeding analysis focuses on Knowledge Transfer Partnerships (KTPs), i.e. formal collaborative linkages between firms and universities in the UK. The dataset comprises of 568 KTPs involving KIBS firms that commenced between 2001 and 2008, derived from a freely available online resource (www.ktponline.org.uk). Thus, the analysis is based on formal networks and the explicit agreement to collaborate together on a particular project. As such, the empirical focus of the paper is on what are described as knowledge alliances where the transfer of more explicit/codified knowledge is the basis of the relationship (Huggins et al. 2012).

On identifying the firms a full postal address (at the time the KTP commenced for those that had subsequently moved), including those no longer trading, was obtained. The full postal address for the specific academic department involved in the KTP was also obtained allowing the distance between the two parties to be measured. The full postal address of the firm was also used to determine whether it was located in an urban area as measured by the UK Office for National Statistics' classification of Local Authority Districts (Pateman 2011). In total, 394 firms were deemed to be located in urban districts.

4.2 Dependent Variable

A logistic regression model was used to examine the propensity of urban KIBS firms to engage in collaborations within their immediate vicinity. The binary dependent variable measures the existence of a local collaboration in terms of whether the geographic distance between the collaborating university and the KIBS firm is either less than 25 Km or 50 Km.

These distances are used as they are deemed to represent collaborations that are either within the same urban area or wider metropolitan region. While previous work has shown that university knowledge spillovers are effective at distances of between 97 Km and 161 Km (Woodward et al. 2006; Warren et al. 2008; Hausman 2012) the following analysis utilises a lower threshold to deliberately capture the intra-urban nature of collaborative network linkages in the UK. The UK is a densely populated nation, with an urban population density of over 4300 per KM, compared with around 430 for the country as a whole (ONS, 2013). Outside of London, the UK's major urban centres vary in size from 75 Km² to 599 Km² (ONS, 2013), highlighting the fact that, in general, urban areas are relatively compact. Therefore, it is appropriate to use distances of 25 Km as a proxy for collaborative linkages within the core urban centre and 50 Km as a proxy for linkages in the wider hinterland of an urban area. In measuring the distances between partners Euclidian, or crow-fly, distances between the two parties was used (D'Este & Iammarino 2010) as the discrete distance between the parties is preferable to examining pre-defined geographic units as they are regarded as more accurate (Wallsten 2001).

4.3 Independent Variables

Each firm was categorised according to four groups based on 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. Finally, as it has been established that a number of different KIBS sub-sectors exist and that they differ in terms of their knowledge base we sought to investigate the influence of this on the localisation of collaborative links with universities (Strambach 2008; Tether et al. 2012). Therefore a dummy variable was included that coded each firm in terms of their sub-sector, T-KIBS, P-KIBS or R-KIBS based on their standard industrial classification code, 72 for T-KIBS, 74 for P-KIBS and 73 for R-KIBS (Miles 2008). In terms of the breakdown of firms in each sector, T-KIBS accounted for 42.1% of the firms, R-KIBS 17.5% and P-KIBS, 40.4% respectively.

Variables that controlled for the research intensity and the commercialisation activity of the collaborating universities were also included. First, research intensity was measured using on data from the 2008 Research Assessment Exercise (RAE)¹ based on the proportion of

¹ RAE is a peer reviewing exercise that ranks research outputs

academic staff classed as research active (the total number of academics included in the 2008 RAE) as a proportion of total academics within the university. In addition, a proxy for the relative openness and commercialisation activity was included, consisting of total intellectual property income per academic for each institution from 2003/04 – 2008/09².

In order to examine the effect of the environment in which KIBS operate on the localisation of collaboration regional variables were included in the model. Firstly, localisation or clustering effects were controlled through measuring regional KIBS employment density, calculated by dividing KIBS employment per NUTS 3 region by the geographic size of the region in square kilometres. Human capital effects were included by calculating each region's endowment of knowledge workers as measured by the proportion of the NUTS 3 region's working age population (i.e. those aged 16-64) with a degree level qualification. Finally, the dynamism of the regional economy was measured through the net firm formation rate during the period. In line with other studies, all data were averaged across the study period (2001-2008) to provide a snapshot of local and regional socio-economic characteristics (Ponds et al. 2010).

5. Results

Table 1 shows that the geographic scope of the collaborative linkages of urban KIBS firms with universities varies across the UK by region. On average, an urban KIBS firm collaborates with a university around 35 Km distant, around two-thirds of their linkages are with universities located within 25 Km and three-quarters are with universities located within 50 Km. Therefore, the descriptive statistics suggest that KIBS firms tend towards actors within their own urban innovation system when developing collaborative linkages with universities.

Furthermore, across the majority of UK regions the mean distance between urban KIBS firms and their university partners is less than 50 Km, indicating that the average collaboration takes place with universities within the same city/metropolitan region as the firm. Urban KIBS firms located in the East of England, South East England and Wales engage in linkages that are, on average, the most distant (averaging 57, 53 and 135 Kms respectively), suggesting that these firms may be prone towards looking beyond their immediate

² 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

surroundings for potential partners. In addition, Table 1 shows that the variance differs across the regions with the North East and Yorkshire and Humberside exhibiting the smallest variance, and Wales and the West Midlands exhibiting the highest. Therefore, the evidence suggests that the importance of a firm's own urban innovation system does vary from region to region.

Table 1: Average Geographic Distance Between Universities and Urban KIBS Partners by Region

Region	N	Min	Max	mean	Standard Deviation	Proportion of linkages <25Km	Proportion of Linkages < 50Km
East Midlands	20	1	175	18.96*	40.69	80.0	86.5
East of England	12	1	241	57.23*	67.35	25.0	55.9
London	79	1	258	25.22*	45.70	72.2	80.2
North East	18	1	52	10.64*	14.15	88.9	95.2
North West	54	1	293	24.63*	41.19	63.0	88.5
Scotland	65	1	202	28.12*	45.28	66.2	77.3
South East	67	1	336	53.26*	71.38	50.7	62.5
South West	16	1	217	46.22*	59.75	50.0	68.3
Wales	6	3	316	135.05*	143.19	50.0	69.6
West Midlands	26	1	463	50.08*	96.46	61.5	75.6
Yorkshire and Humberside	31	1	129	27.91*	33.87	61.3	74.3
Total	394	1	463	34.75*	58.79	63.2	74.3

*significant at the 5% level (Kruskall-Wallis Test)

Collaborative linkages less than 25 Km in distance make up the majority of linkages in every region except the East of England. Collaborative linkages where the distance between partners is less than 50 Km account for over two-thirds of linkages in all but two regions. Thus, the evidence suggests that for urban KIBS firms in the UK, local linkages (i.e. those under 50Km and within the same metropolitan/city region) are the dominant type of collaborative linkage with universities. Consequently, it would appear that the firms' own urban innovation acts as the source for collaborative partners when forming these linkages.

The results of the regression analysis are shown in Table 2, which reports the log odds for each variable in the regression. Models 1 and 2 examine the probability that urban KIBS firms engage in collaborations with universities within 25 Km of their location, whereas Models 3 and 4 examine engagement with universities within 50 Km of the firm. Models 1

and 3 test the influence of the characteristics of both the firms and universities while Models 2 and 4 add in location effects. Firstly, the results suggest that firm size has a significant effect on the probability of engaging in collaborations within the immediate metropolitan/city region. Model 1 highlights the fact that both micro (<10 employees) and small firms (<50 employees) are more prone to engaging in collaborative linkages with universities within 25Km than larger firms. While these results suggest that it is the smallest urban KIBS firms (<50 employees) which are most prone to local linkages the magnitude of the coefficients suggests that, of these two groups, micro firms (<10 employees) have a higher propensity to engage with universities within 25Km of their location than the small firms (11-50 employees). Conversely, the result for small firms weakens in Model 2 ($p=0.55$); nevertheless, the results suggest that those urban KIBS firms with fewer network creation resources with which to develop linkages are more prone to engaging in local collaborations within the boundaries of their existing urban innovation system. Contrasting Models 3 and 4 with Models 1 and 2 highlights a number of differences in terms of size effects. Only micro firms are significantly more likely to engage in collaborative linkages under 50 Km than large firms, as opposed to all small firms. Thus, in terms of size, it is micro firms that consistently exhibit the highest propensity to engage in localised collaborative linkages with universities. This suggests that the urban innovation system is most important to the very smallest KIBS firms as those with the fewest resources are most reliant upon these systems for the development of collaborative linkages with universities.

The research intensity of a university partner has a significant and negative effect on collaborating with a university located within both 25 Km and 50 Km of the firm's location. Therefore, developing collaborative linkages with those universities with larger proportions of research active academics attract urban KIBS firms into collaborating outside of their immediate urban innovation system. The table highlights this as the largest of the observed effects on link formation.

There is weak evidence to suggest that a previous collaboration has a negative effect on engaging with a university within 25 Km of the firm's location. In other words, a prior relationship with a university appears to encourage urban KIBS firms to seek partners outside of the immediate vicinity of their immediate urban innovation system. However, this effect is only observed for those engaging in linkages within 25 Km; there is no significant effect on firms collaborating within 50 Km, suggesting that this organisational proximity is only a

factor when examining linkages that develop in very close proximity. This suggests that organisational proximity effects are reinforced by geographic proximity. In terms of location effects, Table 3 highlights the significant and positive effect of the density of KIBS sector employment on engaging in a collaborative linkage with a university within 25 Km. Furthermore, no location effects are observed when looking at the propensity to collaborate over a greater distance, suggesting that locational effects are only important over smaller distances.

In relation to differences between the three KIBS sub-sectors, technology-based, research-based and professional service-based firms, the results show no significant differences between in terms of the geographic proximity of their collaborative links with universities. This suggests that while the types of knowledge used by the firms in the course of providing their service may differ according to sub-sector (Doloreux & Shearmur 2010; Tether et al. 2012), this does not influence the localisation of collaborative links with universities.

Table 2: Factors Influencing the Geographic Distance Between Universities and Urban KIBS Partners

	Model 1	Model 2	Model 3	Model 4
Independent Variable	Dependent: <25 Km	Dependent: <25 Km	Dependent: <50 KM	Dependent: <50 KM
Firm Size: < 10 employees	1.275*** (0.479)	1.326*** (0.487)	1.537*** (0.535)	1.550*** (0.537)
Firm Size: 10-49 employees	0.884** (0.447)	0.868* (0.453)	0.739 (0.467)	0.727 (0.468)
Firm Size: 50-249 employees	0.227 (0.477)	0.091 (0.486)	0.226 (0.491)	0.203 (0.494)
Sub sector: T-KIBS	-0.286 (0.250)	-0.279 (0.256)	-0.330 (0.297)	-0.323 (0.298)
Sub sector: R-KIBS	-0.382 (0.316)	-0.304 (0.324)	-0.438 (0.354)	-0.400 (0.361)
Previous Collaboration	-0.601* (0.309)	-0.584* (0.314)	-0.412 (0.339)	-0.402 (0.340)
Commercial Focus of University	0.002 (0.027)	0.006 (0.027)	0.055 (0.066)	0.054 (0.068)
Research Intensity (Ln)	-2.604*** (0.744)	-2.641*** (0.774)	-2.849*** (0.862)	-2.804*** (0.900)
% Regional Knowledge Workers		-0.027 (0.017)		-0.001 (0.019)
KIBS Employment Density (Ln)		0.155** (0.077)		-0.097 (0.086)
Regional Firm Growth (Ln)		-0.259* (0.133)		-0.148 (0.152)
Intercept	0.776 (0.484)	1.288 (1.076)	1.592 (0.527)	2.375* (1.227)
n	394	394	394	394
Log Likelihood:	479.755	465.922	378.059	375.643
R ²	0.128	0.168	0.124	0.131
*p<0.10, **p<0.05, ***p<0.01				

Overall, the results indicate a positive relationship between engaging with more proximate partners and firm size in the case of micro firms (those with fewer than 10 employees), suggesting their collaborative links are more localised than for large firms. This evidence suggests that the KIBS are subject to similar patterns with respect to firm size as other sectors, in that geographic proximity appears to be more important for small firms (Lawton Smith & Bagchi-Sen 2006; Hewitt-Dundas 2011; Laursen et al. 2011).

In terms of magnitude, researcher density has the largest influence, with a higher proportion of research active academics within an institution having a negative effect on probability that an urban KIBS firm will be engaging with actors within a local knowledge network. The fact that the research intensity of a university clearly influences the scope of collaboration with urban KIBS firms parallels evidence from other sectors suggesting the same type of effects are prevalent (Laursen et al. 2011; Hewitt-Dundas 2012).

The effect of the socio-economic characteristics of the firms' location on engaging with proximate universities appears to be spatially bounded. The results observed show that significant effects are only observed for collaborations of less than 25 Km. These factors have no effect on the propensity to engage with partners within 50 Km. It is observed that higher densities of KIBS employment has a positive effect on the localisation of collaboration, indicating that agglomeration or clustering of employment is associated with more localised collaboration and collective learning (Maskell & Malmberg 1999; Capello & Faggian 2005).

In contrast, a higher firm growth rate within the region has a negative influence on the localisation of collaboration, i.e. where the regional growth rate of firms is higher, the geographic proximity of the partners is lower. More dynamic regional environments generally exhibit higher levels of performance on accepted performance metrics such as growth, innovation, R&D and firm start-ups, which is usually ascribed to greater 'untraded interdependencies' between firms, facilitating interaction between actors within these regions (Storper 1997; Huggins 2003; Rutten & Boekema 2007). However, in the case of KIBS it appears that greater regional dynamism in terms of firm start-ups is associated with more global linkages, suggesting that these firms are seeking the most appropriate partner rather than the most convenient.

6. Discussion and Conclusion

This study has examined the organisational, locational and relational factors that influence the spatial reach of the knowledge networks established by KIBS in urban areas with universities. In particular, the study has sought to better identify the spatio-relational nature of the knowledge spaces and urban innovation systems for which both sets of organisations are often key components (Muller & Zenker 2001; Doloreux & Shearmur 2012; Corrocher & Cusmano 2014; Huggins et al. 2008; Lawton Smith 2007), as means of contributing to heightened understanding of such networks, spaces and systems contribute to the

phenomenon of knowledge-based urban development (Yigitcanlar 2009; Carrillo et al. 2014; Knight 2008; Knight 1995). The key results of the study can be summarised as follows: (1) the size of urban KIBS firms further determines the reach and localisation of their university links; (2) the characteristics of the urban areas in which the KIBS firms are located plays an important role in determining the spatial reach and localisation of their university links (3) the level of research undertaken within a university influences the spatial reach of their links with urban KIBS firms.

The results highlight the fact that engaging in geographically proximate collaborative links with universities is the domain of smaller urban KIBS firms, particularly micro firms. These firms are more likely to be engaged with partners within both 25 Km and 50 Km of their location than their larger counterparts. Whilst some networks will be formed on the basis of the urban social capital (Lorenzen 2007) of both KIBS and the academic community, these are likely to be limited to smaller KIBS firms that lack the resources to search, screen and select partners from outside their interpersonal interactions. Larger firms are likely to be more richly endowed with the forms of network capital (Huggins 2010; Huggins & Johnston 2010) – both urban/local and more global – that allow the more strategic formalisation of networks with universities and other relevant actors. As such, for relatively small urban KIBS firms the results suggest that the urban innovation system within which they are located is of the greatest importance in terms of developing collaborative linkages with universities as it is these firms which have the highest propensity to develop linkages with institutions in close geographic proximity. In contrast, it appears that larger KIBS firms are less dependent upon their own urban innovation system for the development of collaborative linkages with universities.

The socio-economic characteristics of the firms' location influence their propensity to engage in very proximate (<25 Km) collaborations with universities. The evidence from this model suggests that higher densities of employment in the KIBS sector have a positive influence on the formation of localised links with universities. Therefore, higher levels of specialisation within an urban innovation system with respect to KIBS employment promotes more localised collaborative linkages between these firms and universities. As Porter notes in his work on clusters, 'drawing cluster boundaries is often a matter of degree, and involves a creative process informed by understanding the most important linkages and complementarities across industries and institutions to competition. The strength of these

“spillovers” and their importance to productivity and innovation determine the ultimate boundaries’ (Porter 1998, pg. 202). Transferring this message to the discourse on urban innovation systems, the results suggest that the more an urban innovation system resembles a cluster, i.e. the more specialised it is in terms of employment in a given economic sector (in this case KIBS), the more localised the collaborative network linkages with universities will be. Given this, it can be argued that it is as much the nature of the networks and connections existing between knowledge actors that will define their ‘space’ as the profile of the particular area in which they are physically located.

Furthermore, the research intensity of an institution allows the development of links with a greater spatial reach. Thus, where an institution is responsible for a greater level of research activity then this will encourage KIBS firms to establish links outside their immediate urban environment. This finding would suggest that the prospect of collaborating with a more research intensive university increases the propensity for KIBS firms to develop links outside their own urban innovation systems. As such, the results suggest that the extent of the resources available to firms and the knowledge creation capabilities of firms are the key factors determining the development of collaborative network linkages of firms outside of their urban innovation system. The caveat here is that this data set is focussed on collaborative network linkages that are designed to transfer codified knowledge, i.e. the KTP programme is focussed on the completion of a discrete project. Therefore, these results must be interpreted in these terms; while there is undoubtedly a tacit dimension to these projects this has not been examined here, suggesting an avenue for future research.

As Benneworth and Rathino (2014) make clear, the most effective innovation spaces and systems will be those based on a dynamic interaction between proximity and networks. In other words, both spatial and relational factors matter for development, but it is the combination and evolution of these factors that will impact most on urban development trajectories. In essence, it would seem that urban innovation spaces should be conceptualised as ‘spaces of knowledge flow’ (Huggins, 2011) rather than necessarily fixed places of knowledge assets and stocks. The results have shown that there is a clear propensity for inter-innovation system linkages to develop through larger urban KIBS firms and more research intensive universities, resulting in the cross-fertilisation of knowledge across space. As such, the most effective urban innovation systems will be those that act as hubs and nodes of knowledge networks, be it local or extra-local and more global. Consequently, successful

urban innovation systems may be those that are more porous and open in that they allow firms to access knowledge from within and, where appropriate, from outside. As Antonelli (2008) states, the structure of networks affects the flow and availability of knowledge, which in turn affects the value generated by networks. Despite the recognised importance of urban places to network development, there is an increasing emphasis on the importance of understanding networks and knowledge flows in an environment that is simultaneously local and global (Anderson & Karlsson 2007; Lorentzen 2008; van Geenhuizen 2008; Maggioni & Uberti 2008; Broekel & Boschma 2012). As this study has shown, firms do not always acquire their knowledge from within geographically proximate areas, particularly those firms based upon innovation-driven growth (Davenport 2005). Even in the world's most acknowledged innovation spaces, such as Silicon Valley and Cambridge in the UK, there is evidence of a greater role being played by non-localised networks (Athreye 2004; Doloreux 2004; Garnsey & Heffernan 2005; Saxenian 2005).

With regard to policy implications, it is clear that the dual role of factors both internal and external to collaborative network partners in determining the spatiality of such collaboration suggests that one size fits all models are unlikely to best promote knowledge-based urban development. Urban development policymakers must instead be aware of the need to accommodate the differing influences on the development of collaborative linkages and act accordingly. For example, our results suggest that the very smallest KIBS firms tend towards developing the most localised linkages when it comes to collaborating with universities and policies should be designed to reflect this. As micro firms account for around 96% of KIBS firms in the UK (author's calculations from ONS-ABI data) then a locally focussed approach to the development of links between this sector and universities will indeed be of benefit to the majority of the sector provided local universities have the appropriate knowledge creation capabilities. The promotion, therefore, of the urban innovation system as a means of seeking a collaborative linkage with a university appears to be a sensible first step.

The remaining question is whether more should be done by policymakers to foster a wider cohort of firms to establish knowledge networks within emerging urban innovation 'places' or should policymakers seek to promote networks with a wider geographic reach? The answer is probably that a context specific balance is required, i.e. a focus on 'place-based' economic development with policies tailored towards specific locales rather than a one-size-fits-all approach (Bolton 1992; Barca et al. 2012). In general, KIBS firms in urban areas tend

to be quite specialised, resulting in policymakers needing to consider local and regional socio-economic characteristics, and the extent to which these characteristics may influence the geographic scope of KIBS firms collaborative linkages with universities. Fundamentally, knowledge-based urban development focused on stimulating and fostering network activity must increasingly recognise that firms, and universities for that matter, will require assistance in finding the most appropriate network partner rather than just the nearest geographically. Therefore, it may be that a matching process can be utilised in order to engage firms with suitable partners. These policy implications echo those of Warren et al (2008) who propose that, with respect to universities, policymakers should develop 'supportive innovation systems' for their locales, appropriate to the need of the firms within them. For instance, smart online services to match potential partners may be tailored towards the needs of particular types of firm, with smaller KIBS firms being perhaps best directed towards local universities. Larger KIBS firms, on the other hand, may require resources from outside the immediate innovation system, requiring policymakers to collaborate across spatial boundaries in order to match potential partners.

Clearly, the main limitations of this study is that it is restricted to particular cohort of firms based in Britain and only analyses a segment of the networks that are likely to comprise particular innovation systems. In the future, more will be required to assess whether or not the nature of KIBS linkages with universities follows a similar pattern in other nations. Furthermore, future studies should seek to map a broader range of networks and linkages constituting knowledge-based urban innovation spaces, particularly those that go under the radar of the more formal types of knowledge transfer partnership analysed here (Hughes & Kitson 2012). Finally, a further area of future analysis that would facilitate an improved understanding of knowledge-based urban development is to open the 'black box' on these types of networks in order to examine the partner selection process and the operational functioning of such networks (Bodas Freitas et al. 2013; Bruneel et al. 2010).

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