Research Policy 41 (2012) 262–275

Contents lists available at SciVerse ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Research intensity and knowledge transfer activity in UK universities

Nola Hewitt-Dundas*

Queen's University Management School (QUMS), Queen's University Belfast, Belfast, Northern Ireland, United Kingdom

ARTICLE INFO

Article history:
Received 27 February 2009
Received in revised form 14 October 2011
Accepted 26 October 2011
Available online 4 January 2012

Keywords:
University–industry
Knowledge transfer
Research intensive universities
Innovation policy

ABSTRACT

As the innovation process has become more open and networked, Government policy in the UK has sought to promote both research excellence in the university sector and the translation of this into economic benefit through university–business engagement. However, this policy approach has tended to be applied uniformly with little account for organisational differences within the sector. In this paper we consider if differences between universities in their research performance is reflected in their knowledge transfer activity. Specifically, as universities develop a commercialization agenda are the strategic priorities for knowledge transfer, the organisational supports in place to facilitate knowledge transfer and the scale and scope of knowledge transfer activity different for high research intensive (HRI) and low research intensive (LRI) universities? The findings demonstrate that universities' approach to knowledge transfer is shaped by institutional and organisational resources, in particular their ethos and research quality, rather than the capability to undertake knowledge transfer through a Technology Transfer Office (TTO). Strategic priorities for knowledge transfer are reflected in activity, in terms of the dominance of specific knowledge transfer channels, the partners with which universities engage and the geography of business engagement.

1. Introduction

Traditional conceptions of a linear innovation process are now limited in their relevance and instead innovation is perceived to occur as a multidirectional and iterative process involving multiple actors (Kline and Rosenberg, 1986; Malecki, 1997; Evangelista, 2000; Tether, 2005). Research demonstrating the potential of universities to contribute to regional economic growth (Potts, 2002) and to be instrumental in the formation of new industries (biotechnology – Bagchi-Sen et al., 2001; nanotechnology – Martinez-Fernandez and Leevers, 2004) has led to a greater policy focus on the role of universities in engaging with businesses and undertaking knowledge transfer activities.

Although the positive effect of universities on business innovation has been widely investigated through the use of firm-level innovation data, bibliometric data or patent citation studies (e.g. Griliches, 1979; Jaffe, 1989; Blind and Grupp, 1999) what is less well-known is how these benefits are affected by organisational and institutional differences between universities. Indeed Fritsch and Slavtchev state that 'our knowledge about the factors that determine the impact of universities in innovation systems and the different functions they may accomplish is rather incomplete' (2006, p. 2). This is surprising given that in almost all countries, heterogeneity exists within the university sector, whether in terms of ownership, size, disciplinary mix, research excellence etc. If this heterogeneity is reflected in disparities in knowledge transfer activity, then this raises questions about the appropriateness of uniform policies targeted at the university sector to promote (and support) university-business engagement.

In this paper we are concerned with diversity in the university sector and how this is reflected in knowledge transfer activity. Specifically, we are interested in the relationships between the research intensity of universities and their strategic priorities for knowledge transfer, their capability to deliver this and the scale and scope of knowledge transfer activity. In other words, to what extent is universities research performance, or intensity, reflected in knowledge transfer activity? Do high research intensive (HRI) universities differ from low research intensive (LRI) universities in the ways they seek to contribute to the wider economy, the organisational supports that they have in place to facilitate knowledge transfer activity and the scale and scope of their external engagement. Following D'Este and Patel (2007) we consider universities' engagement across a range of knowledge transfer channels, including intellectual property (IP) dependent channels such as patents, licenses and spin out activities but this is extended to include other channels such as collaborative research, contract research, consultancy, training activities and the use by external organisations of universities' facilities and equipment. From a policy perspective, if knowledge transfer activity reflects organisational specificities then uniform policies across the sector to stimulate university-industry collaboration may be inappropriate. Further, if differentiation in knowledge transfer activity exists between

* Tel.: +44 0 2890974670.
E-mail address: nm.hewitt@qub.ac.uk

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doi:10.1016/j.respol.2011.10.010

universities, then the mix of universities in a region may have significant implications for private sector innovation outputs in that region. In such circumstances regional policy to promote knowledge transfer may need to be tailored according to the research intensity of universities located within the region.

The remainder of the paper is structured as follows. In Section 2, focusing specifically on the UK, we consider how policy is promoting research excellence in universities and also seeking to maximize the economic contribution from this. Alongside this policy context we also consider how universities are responding to this changing policy environment and how this might be expected to vary for HRI as compared to LRI universities. In Section 3 we describe the data sources and methodological approach adopted in the study. In Section 4 the empirical results are presented looking at differences in the strategic priorities, capability and knowledge transfer activity. Section 5 then summarizes the key findings from the paper and considers the policy implications arising from the research.

2. Policy context and organisational response

2.1. Policy context

The relationship between investment in R&D and national and regional economic growth has been well documented (Pianta, 1995; DTI, 2003a,b; HM Treasury, 2003). Responding to this, governments have prioritized R&D investment, typically through two main policy channels[1]: direct procurement and/or provision in public facilities (including higher education); or incentives for private investment (tax incentives or R&D subsidies). Our concern in this paper is with the former policy response, specifically the provision of research through universities and how this spills-over to the private sector through formal knowledge transfer channels.[2]

As governments have increased their investment in university research[3] there has been a growing expectation of a net positive effect from this investment on the (assumed sub-optimal) level of private R&D and innovation activity (Henderson et al., 1998). In some countries this has been reflected in the introduction of performance-based or competitive funding mechanisms often replacing trust-based funding regimes where universities automatically received a grant allocation from government with little account of their output and outcomes (Geuna and Martin, 2001; Conraths and Smidt, 2005; Orr et al., 2007; Sorlin, 2007). Sorlin (2007) argues that performance-based funding acts as an important policy instrument in the allocation of resources to universities. Specifically, through the use of metrics to measure deliverables and outputs, it allows governments to invest more efficiently in R&D while also creating diversity in the university sector.

Geuna and Martin (2001) suggest that one of the advantages of performance-based funding of research is that it is 'meritocratic', rewarding successful research departments and universities and therefore acting as an incentive for improved performance. In other words, it leads 'to increased efficiency in how research resources are used in the short term' (Geuna and Martin, 2001; 26). At the same time they suggest that such a funding regime may lead to 'homogenisation' as all universities have the same goals, i.e. research publications in international peer-reviewed journals.

The UK was one of the first countries to introduce performance-based funding in the early 1980s when 'growing constraints on public funding and the prevailing political ideology in the UK resulted in policies aimed at greater accountability and selectivity' (Geuna and Martin, 2001, 26). An ex post evaluation of research performance was introduced in the UK in 1986 – the Research Assessment Exercise (RAE). Based on peer review of research activity the RAE evaluates the quality of research based largely, on publications at national or international levels of excellence. These rating are then used in the allocation of public funds for research thereby providing the best performing institutions with the largest grants and ensuring that 'the infrastructure of the top level of research in the UK is protected and developed' (RAE 2001).[4,5] Following the first RAE in 1986, subsequent exercises were performed in 1989, 1992, 1996, 2001 and 2008. Despite over 20 years of this funding regime in the UK, evidence suggests that homogenisation has not occurred and strong internal differentiation remains (Lepori et al., 2005).

Towards the end of the 1990s in the UK, not only was a performance-based funding regime in place to nurture high quality academic research, but government policy was also emphasising the inter-relatedness of research and economic benefit. For example the 1998 Government White Paper (DTI, December 1998, Cm 4176) on building the knowledge-driven economy emphasised the importance of strengthening research capability, the exploitation of this research and the intricate link between these activities. A further Government White Paper in 2000 (OST, July 2000, Cm 4814) outlined proposals for investing in the science base and stimulating strong links with universities to ensure that excellence in science and engineering was translated into innovative products and services. While high quality research was being nurtured through the RAE and research funding mechanisms, government was also directly supporting capability building for knowledge and technology transfer in the universities. In 1999, the Higher Education Funding Council for England (HEFCE) outlined the establishment of a Higher Education Reach-out to Business and the Community Fund (HEROBC). The purpose of this fund was to 'provide a platform of core funding to help [universities] to put into practice organisational and structural arrangements to develop and implement strategic approaches to their relations with business, and to assist in activity to improve the transfer of knowledge and skills' (HEFCE, 2000, p. 4). This funding was available throughout the university sector.

It was not until 2007 in the review of Government's science and innovation policy in the UK that differentiation in the university sector and knowledge transfer activity was acknowledged (HM Treasury, 2007). The report stressed the importance of having a 'diversity of excellence' in the research base, distinguishing between 'research universities focusing on curiosity-driven research, teaching and knowledge transfer, and business-facing universities focusing on the equally important economic mission of professional teaching, user-driven research and problem-solving with local and regional companies' (HM Treasury, 2007, p. 5). In other words, research quality was a key differentiating feature of heterogeneity in knowledge transfer strategies and activities in the university sector. In the context of the UK it also suggested

[1] Traditionally, governments have supported R&D in some form principally because of a desire to correct market failures in the private provision of new scientific knowledge. These market failures arise from two sources first, high risk and sunk costs of conducting R&D discourages firms from engaging in R&D activity and second, the inability to appropriate all of the returns from R&D means that they tend to invest below the socially optimum level.

[2] Considerable research has been undertaken of the impact of incentives on private investment in R&D (see Martin and Scott, 2000; Trajtenberg, 2002; Harris et al., 2008).

[3] The UK government science budget more than doubled from 1997 to 2007/8, to £3.4 bn (NESTA, 2007).

[4] Further information on the Research Assessment Exercise in the UK is available at www.hero.ac.uk.

[5] A similar performance based approach to university funding has also been used in countries such as Hong Kong, Australia and Poland, while in other countries such as Canada and the USA research assessment and funding decisions tend to be separate (see von Tunzelmann and Mbula, 2003; Geuna and Martin, 2001).

a return to the pre-1992 two-tier, binary approach to higher education, distinguishing between research intensive universities and those universities more focused on vocational teaching.

This differentiation in the university sector reinforces the finding that performance-based funding regimes ensure that the 'existing research elite is further reinforced and the status quo is maintained' (Geuna and Martin 2001, p. 28) through vertical differentiation with the potential for functional specialization (Sorlin, 2007). In the remainder of the paper we consider how universities in a performance (research)-based funding regime, are responding to the growing expectation for them to demonstrate a positive effect on private R&D and innovation activity. In particular we focus on knowledge transfer activity and consider whether differences would be anticipated between the organisational response of HRI and LRI universities. Following Caldera and Debande (2010) we examine this along three dimensions: university characteristics, whereby research quality is used as the differentiating characteristic; university policies to promote knowledge transfer activity; and the presence of technology intermediaries to facilitate knowledge transfer.

2.2. Organisational response

2.2.1. Strategic priorities in knowledge transfer activity

Buckland (2009, p. 3) defines strategy as, 'a process whereby organisational activity is managed such that it is aligned, more or less, with the expression of the organization's goals and objectives, enabling the organisation to deliver value to its various stakeholders'. Siegel et al. (2003) emphasises that it is the strategic approach at the institutional level in universities that strongly influences how research is 'valorised'. In the UK, universities' strategic objectives have been shaped by the performance (research) based funding regime, with research being prioritized and valorized through publication in peer-reviewed international journals. Alongside this it is argued that the growing expectation of wider economic benefit from public investment in university research, alongside reduced public sector funding for universities is leading to 'academic capitalism': 'the institutional and professorial market or market-like efforts to secure external moneys' (Slaughter and Leslie, 1997; 8). Some suggest that this has changed the basis of competition in the university sector with a greater focus on commercial-oriented metrics and outcomes (Owen-Smith, 2003). In other words, the 'open science' approach to knowledge is being superseded by a 'licensing' or 'innovation model' as universities focus more on the private ownership of Intellectual Property (IP) and a more proactive IP development and exploitation strategy (Siegel et al., 2003; Lockett and Wright, 2005; EU, 2004).[6]

Clearly difficulties arise for universities in reconciling the various missions of a growing number of stakeholders, particularly that of being an 'engine of growth in knowledge-based economies' alongside the role of being 'an independent knowledge-seeking institution' (Sorlin, 2007; 414). The pursuit of high quality research (and teaching) as well as managing the tensions between open science and the privatization of research through IP protection, has created organisational tensions or strategic ambiguity (Jarzabkowski et al., 2010). Yet, evidence suggests that these activities are interrelated (DiGregorio and Shane, 2003; Powers and McDougall, 2005; O'Shea et al., 2005), with the strategic priorities for knowledge transfer of HRI universities being more likely to focus on areas where there is a comparative advantage, i.e. research quality and the protection and commercialization of this IP (Antonelli, 2008). In contrast, the knowledge transfer strategy of LRI universities would be more likely to reflect their history and capabilities as teaching and vocational universities. The protection and exploitation of IP through patents, licenses and spin-offs may therefore not be as important for these universities. This differentiation in knowledge transfer activity between HRI and LRI universities reflects how strategic priorities are formulated, being evolutionary and processual, context specific and path dependent (Buckland, 2009). In other words, universities' strategic priorities for knowledge transfer will reflect heterogeneity as measured by resources, competencies, capabilities and histories of each university.

2.2.2. Organisational supports

In addition to strategy, the presence of organisational supports (Chang et al., 2009) may significantly effect knowledge transfer performance. These organisational supports may include the presence of an entrepreneurial culture, reward and incentive structures to encourage academics to engage with industry (Siegel et al., 2003) and the presence of intermediaries (Caldera and Debande, 2010) to facilitate partnerships, knowledge and technology transfer. The presence and capabilities of intermediaries are of particular interest in trying to understand heterogeneity in knowledge transfer activity across the university sector. Intermediaries reflect organisational structures that are put in place to manage the various demands of research, teaching and commercialization (March 1991 as referred to in Chang et al., 2009).

A considerable amount of research has examined the role of Technology Transfer Offices in knowledge transfer performance. For example, evidence suggests that as the size of TTOs increase (Siegel et al., 2003) or the age of TTOs increase (Friedman and Silberman, 2003; Lach and Schankerman, 2004) then this raises the volume of technology transfer activity. Similarly, as universities increase their investment in TTO staff, this contributes positively to spinoff activity (O'Shea et al., 2005). This occurs because first, TTO staff have experience in building networks and acting as intermediaries between research and commercialisation. Second, staff typically have experience of setting-up businesses, identifying market opportunities and in protecting proprietary knowledge (O'Shea et al., 2005). These capabilities and the accompanying commercialization practices means that 'Universities that develop effective patenting and licensing practices, then, will have an advantage relative to those that do not' (Owen-Smith, 2003, p. 1083).

Our interest in this paper is the extent to which this capability in terms of the presence of a TTO, its size and the services that it offers, varies across the university sector – particularly between HRI and LRI universities. TTOs provide support to the university in commercializing research and engaging with business. As such, they facilitate the implementation of universities' knowledge transfer strategy. In HRI universities it would be reasonable to expect that the TTOs would have greater capability to protect and commercialize IP through patenting and licensing than would be found for LRI universities. For LRI universities, business engagement is more likely to reflect the teaching and in many instances a vocational ethos of these universities. Our question is, to what extent are differences in strategic priorities for knowledge transfer reflected in the organisational supports in place to support this activity?

2.2.3. Knowledge transfer channels

Innovation and knowledge transfer has moved from a corporate model of knowledge production towards a new distributed, inter-organisational, innovation model (Tether, 2005). In this distributed model the type of businesses and other organisations forming links with universities have changed along with the channels through which knowledge is accessed and transferred (Cohen et al., 2002). While scientific publication and patenting was an effective means of knowledge dissemination in the past (Antonelli, 2008),

[6] Perkmann and Walsh (2007) also discuss 'open science' however they use the term to refer to the transfer of knowledge through relationships which are socially embedded within the context of 'open innovation' (Chesbrough, 2003, 2006).

social interactions and the transfer of tacit knowledge now means that tailored knowledge transfer channels, including collaborative research and information contacts have become more important (Etzkowitz and Leydesdorf, 2000; Antonelli, 2008; Bekkers and Bodas Freitas, 2008; Perkmann and Walsh, 2007).[7] This suggests that studies of universities' knowledge transfer performance need to extend beyond single indicators such as patenting, licenses or spin-outs (Caldera and Debande, 2010) and incorporate a wider range of knowledge transfer channels (Agrawal, 2001; Cohen et al., 2002; D'Este and Patel, 2007).

Where business innovation occurs in a more distributed and inter-organisational way, Perkmann and Walsh (2007) argue that relationships between organisations become more important in the creation and exchange of knowledge. Some knowledge transfer channels such as collaborative research between organisations are characterised by 'high relational involvement' while other channels including contract research or consultancy are associated with 'low relational involvement' (Perkmann and Walsh, 2007; Cohen et al., 2002). In addition, for some knowledge transfer channels such as the provision of education and training, relational involvement is 'intermediate' with knowledge not only being transferred from academics to business professionals, but at the same time interaction provides academics with an insight into business-specific issues. Alongside these relational knowledge channels, transactional or dis-embedded knowledge transfer[8] may still occur through publications, patents and to a lesser extent licenses.

Our interest in this paper is in determining if there are differences between HRI and LRI universities in their use of different knowledge transfer channels. While other research has illustrated that higher research quality is associated with a greater amount of patents licenses and licensing income (Chukumba and Jensen, 2005) the effect of research quality (particularly at the orgnaisational level) on the use of other knowledge transfer channels is less well understood.

For example, where knowledge creation focuses on blue-skies or generic research as with collaborative research partnerships (Agrawal and Henderson, 2002; Polt et al., 2001), then this may be more common among HRI universities. In contrast, contract research and consulting activities, tend to focus more on the acquisition of specialist expertise and the application of knowledge in development activities, activities that are more aligned with LRI universities. In other words: 'research partnerships are designed to generate outputs that are of high academic relevance and can therefore be used and adapted for academic publications by the researchers involved. . . Research services, by contrast are provided by academic researchers under the direction of industrial clients and tend to be less exploitable for academic publications' (Perkmann and Walsh, 2010, p. 271). The research orientation of the university may therefore affect the use of certain knowledge transfer channels. HRI universities may be more likely to engage in both dis-embedded transfer through patents and licenses along with high relational collaborative research partnerships where the co-production of knowledge has high quality academic outputs. In contrast, LRI universities may use low and intermediate relational knowledge transfer channels in solving technical problems and providing further education and training.

2.2.4. Proximity of knowledge transfer

The final aspect of interest in exploring heterogeneity of knowledge transfer activity within the university sector is the geography of university-business engagement. Research evidence suggests that the spillover effect[9] of research is spatially confined – largely to the region in which the research takes place. For example, in the US, while University research was found to have a significant effect on innovation output, this was limited to a 75 mile radius (Anselin et al., 1997, 2000; Acs et al., 2002). Similar results have been identified elsewhere: Germany, where over half of all business innovations arising from university research were located within 100 km of the respective university (Beise and Stahl, 1999); and France (Autant-Bernard, 2001) where analysis of scientific publications highlighted that it was regionally based knowledge sources that significantly effected innovation output.

The explanation for this strong proximity effect in university-business knowledge spillovers relates to the generation of informational advantages from agglomeration (Boschma, 2005). The creation of new knowledge results not only from the transfer of codified knowledge but also tacit knowledge (Nonaka and Takeuchi, 1995) which is facilitated by personal interactions (Lundvall, 1992) and is sensitive to increasing distance (David and Forey, 2003). Indeed, Fristch (2001) suggests that where businesses seek to acquire knowledge from public research organisations, then spatial proximity becomes even more important in facilitating the transfer of tacit knowledge. Yet, it is likely that the importance of distance between knowledge transfer partners will depend on the knowledge transfer channels (Perkmann and Walsh, 2007). For example, those channels with high relational involvement between partners are likely to be more constrained by distance than low relational channels such as contract research, consultancy or licenses. It follows that if research performance influences the use of different knowledge transfer channels, i.e. with HRI universities favouring collaborative research arrangements with academic benefit, then this will subsequently impact on the geography of knowledge spillovers from HRI and LRI universities.

3. Data sources

Analysis in this paper draws on the Higher Education Business and Community Interaction Survey (HE-BCI). The HE-BCI survey is an annual survey administered throughout the UK by the Higher Education Funding Council for England (HEFCE). The 2007 survey reports data for 158 universities across the UK representing a full response rate for the population of UK universities. The analysis in this paper draws on the sixth annual survey, examining data for the academic year 2005–06 (HEFCE, 2007/17). This data is publicly available and provides information at the level of the individual university.[10] Information is collected on a range of 'third stream' activity reflecting the contribution of universities to both business and the community.[11] The information includes the strategic priorities of universities third stream activity, their capacity and infrastructure in place to deliver this activity, and levels of income

[7] This mirrors the reasons already discussed as to why businesses access university research and knowledge, being motivated less by commercial innovation outcomes and more by obtaining knowledge of scientific and technological advances, getting access to students and faculty and solving specific problems (D'Este and Patel, 2007).

[8] Perkmann and Walsh (2007, p. 261) describe transactional market links and disembedded knowledge transfer as 'the use of knowledge codified within research papers, patents or prototypes'.

[9] A related literature looks at the geographical bounds of knowledge spillovers more generally, regardless of their source. This literature is summarized in Roper (2004).

[10] The Report and Data can be accessed at: http://www.hefce.ac.uk/pubs/hefce/2007/07_17/.

[11] The HE-BCI survey defines 'businesses' as both public and private sector partners of all sizes and sectors and 'Community' as society as a whole outside the HEI, including all social, civic and cultural organisations and individuals (see HEFCE, 2007 p. 4).

and activity across a range of metrics on the commercialisation of knowledge. It is this information that is used in the analysis, however before examining the data, the core of our argument has to be established concerning heterogeneity in the university sector. The following discusses this in more detail.

In the UK the population of universities can be sub-divided into 4 groups, the 'Russell Group', 'Group 1994', 'Post 1992' universities and the remaining universities which are predominantly (although not exclusively) specialist universities focusing on research and education such as teacher training, agriculture, art and design, nursing and theology etc. This grouping reflects the evolution of the Higher Education sector with the move from a 'binary policy' (Pratt, 1997) comprising 'two separate and distinctive sectors based on the universities and the leading technical and other public sector colleges' (Pratt, 1997, p. 1) to one higher education sector as a result of changes to funding arrangements and administration following the 1992 Further and Higher Education Act (HMSO, 1992).

'Technical and other public sector colleges' were formed mainly during the late 1960s and 1970s as Governments in the UK and other European countries[12] brought a differentiation to higher education by establishing new or 'modern' universities and vocation-oriented colleges,[13] referred to as polytechnics. Although the polytechnics delivered both academic and practical subjects their emphasis was on applied work-related education, grounded in engineering and applied science. Their funding was from local government sources as opposed to the central funds used to support universities. However after 1992, polytechnics were recognized as universities with degree-awarding status, accounting for approximately 32 universities in the UK. Together with a further 28 universities established as 'modern' Universities in the 1960s this group of universities is commonly referred to as the Post 1992 universities.[14]

The Russell Group was formed in 1994 as a self-selecting group of universities, seeking to differentiate themselves (currently 20 or 12 per cent of the University sector) from other universities in the sector. Priorities for the Russell Group include leading the UK's research effort internationally, ensuring that research is resourced appropriately, that leading academics and students are attracted to these universities and that the highest quality teaching is delivered in nurturing the next generation of innovators and leaders. The research excellence of the Russell Group is reflected in the following statistics: In 2004/5, Russell Group Universities accounted for 65% (over £1.8billion) of UK Universities' research grant and contract income, 56% of all doctorates awarded in the UK, and over 30% of all students studying in the UK from outside the EU. In the 2001 national Research Assessment Exercise (RAE), 78% of the staff in the highest rated (Grade 5*) departments and 57% of the staff in Grade 5 departments were located in Russell Group Universities, and in 2004/5 Russell Group Universities received approximately 64% of the total quality-related research funding (QR) allocated by the Funding Councils[15].

The 'Group 1994' universities were also formed in 1994 following the 1992 Further and Higher Education Act and like the Russell Group sought to differentiate themselves from the wider sector. Currently with 19 members, Group 1994 universities also emphasize the importance of 'diverse and high-quality research, while ensuring excellent levels of teaching and student experience'. Yet, these universities tend to have lower income and staff and the extent of international research contracts and research council funding is significantly below that of the Russell Group (Table A1).

On average, Russell Group universities are substantially larger than each of the other university groups (Table A1). This scale effect is evident for income and employees, with the average income in Russell Group universities being £394,036 m as compared to £94,393 m for Post 1992 universities. Similarly, income per academic member of staff is highest in Russell Group Universities (£151,381) compared to Group 1994 universities (£73,876) Post 1992 Universities (£135,922), and Other (typically specialist universities – £149,606). This suggests that Russell Group universities have higher resourcing (as measured by income per academic staff FTE) than other university groups.

Our main interest in this paper is how the research quality of universities is reflected in their knowledge transfer strategy and activity. Using data from the UK Research Assessment Exercise 2001, and controlling for differences in size across the university sector, three measures of research quality were calculated for each University in the UK: the percentage of research units rated at 4 or above on the RAE research quality scale[16] reflecting the breadth of research excellence across each university; second, the percentage of academic staff rated at 4 or above on the RAE research quality scale reflecting the depth of research excellence in terms of academic staff; and the percentage of income from research council grants and contracts reflecting the research focus of the university.

Using a *K*-means cluster analysis with 2 clusters, produces one cluster with 70 universities and a second cluster with 71 universities (Table 1). Research performance is significantly higher for universities in Cluster 2 as measured by each of the performance variables. Values for each of the university groups are also presented in Table 1 for comparison. By mapping cluster membership onto the university groups of Post 1992, Group 1994, Russell Group and other/specialist universities (Table 2) we see a clear split between the Post 1992 universities which are almost entirely in Cluster 1 and the Group 1994 and Russell Group universities which are all in Cluster 2.

This empirically supports the notion of heterogeneity in the university sector reflecting the origin and evolution of universities – e.g. historical research focused universities as compared to polytechnics – but also differences in their relative size and resourcing, their breadth (academic units) and depth (academic staff) of high quality research and their focus on research activity (research grants). Given these differences, the remainder of the paper focuses on the Russell Group as representing the high research intensive (HRI) universities on the Post 1992 universities representing low research intensive (LRI) universities and Russell group universities as high research intensive (HRI) universities, located in Clusters 1 and 2 respectively, to explore how organisational differences are evident in knowledge transfer strategy, the capability to engage with organisations and individuals outside the university and the levels of knowledge transfer activity, particularly that performed within the region.

[12] For example in Germany and France non-university sectors similar to the Polytechnics in the UK were also established during this period (the Fachhochschulen in Germany and the Instituts Universitaires de Technologie in France).

[13] The Robbins Report (HMSO, 1963) and the subsequent Government White Paper of 1966 (A Plan for Polytechnics) were instrumental in directing the expansion of higher education in the UK during this period.

[14] Since 1992 this number has reduced slightly largely due to the merger of some universities. In this analysis data is derived from 57 Post 1992 universities.

[15] Source: http://www.russellgroup.ac.uk/home.html.

[16] Research quality in the RAE2001 was expressed on a standard scale from 1 to 5*. A rating of 1 related to no national excellence, 2 to national excellence in up to half of research activity submitted, 3 to national excellence in up to two-thirds of research activity submitted, 4 to all research at national excellence standards with some international excellence, 5 to up to half of research at international levels and 5* with more than half of research at internationally excellent levels (see http://www.rae.ac.uk/2001/pubs/5_99/section1.htm accessed 12 December 2009).

Table 1
Cluster analysis of UK universities by research performance indicators.

	Percent of academic units at 4, 5 or 5* (RAE 2001)		Percent of academic staff at 4, 5 or 5* (RAE 2001)		Percent of Income from Research grants and contracts (2000/1)	
	Mean	Std deviation	Mean	Std deviation	Mean	Std deviation
Cluster 1 (n = 70)	15.24	13.83	18.26	16.85	39.30	27.35
Cluster 2 (n = 71)	83.26	15.76	89.07	12.19	78.91	17.93
F mean square (Sig)	741.345 (.000)		819.479 (.000)		103.669 (.000)	
Post 1992	20.74	18.29	23.48	19.31	42.88	23.46
Group 1994	87.40	9.03	92.00	7.28	82.35	14.39
Russell	93.63	5.46	96.13	4.06	83.42	5.77
Other/specialist universities	51.41	37.59	58.20	39.68	59.98	35.85

Notes: Research income calculated from Resources of Higher Education Institutions 2000/2001, HESA Ltd 2002. F test is presented for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

4. Empirical findings

4.1. Knowledge transfer strategy

As the UK Government has committed to a permanent stream of funding for knowledge transfer or 'third stream' activity, universities have refined their knowledge transfer strategies with differences in strategic priorities apparent between LRI and HRI universities (Table 3). In general, LRI universities are more likely to perceive their economic contribution in the development of human capital. Specifically, providing access to education, retaining graduates in the region and contributing to the regions skills needs are cited by a significantly higher proportion of LRI than HRI universities. Alongside this, LRI universities are also more likely to identify providing support to SMEs as a key economic contribution. This strategic emphasis on the provision of education and skills within the region and an orientation towards SMEs reflects the 'polytechnic' ethos in being embedded in the regional economy, providing education and training in vocational subjects for which typically there is strong local and regional demand.

For the HRI universities, while providing access to education was also cited as important (40 per cent), graduate retention was not emphasised and it was national skills needs rather than regional skills needs that were identified in their strategic priorities. Much more important to HRI universities was economic contribution through technology transfer and research collaboration with industry. Supporting SMEs was less frequently cited than by LRI universities, suggesting that where technology transfer and research collaboration occurred it was more likely to be with those businesses with high absorptive capacity and leading-edge technologies, irrespective of size. Given the emphasis on technology development and innovation, a higher emphasis might have been expected in terms of the potential contribution to economic development from spin-off activity. This was identified by only 15 per cent of the HRI universities, supporting the argument that studies of technology and knowledge transfer activity should extend beyond a narrow focus on spin-off activity (Kitson, 2009).

Table 2
Mapping of research quality cluster membership to University groups.

	Cluster 1 low research intensive universities	Cluster 2 high research intensive universities
Post 1992	54	3
Group 1994		18
Russell Group		20
Other/specialist universities	16	30
Total	70	71

In terms of the geographical area identified by the universities as of greatest priority in their organisational mission, for both university groups little emphasis is placed on the locality e.g. city or town, or the local authority area e.g. county (Table 4). Instead, the organisational mission is either focused on the regional government area (29.3 per cent and 40 per cent of LRI and HRI universities respectively) or more commonly, on an area defined by the individual universities. Indeed, for one-fifth of the HRI universities, 'no specific area' defined their organisational mission suggesting that the way they contribute to economic development, predominantly through technology transfer, was not constrained by distance but reflected a technology development agenda independent of space.

4.2. Capability to undertake knowledge transfer activity

As outlined in the HEFCE (2007) HE-BCI report, a separate stream of funding for universities' 'third stream' activity and distinct from teaching and research funding, was established in 1999 in the UK. This funding was aimed at increasing the capability of universities to respond to both businesses and the wider community in building wealth. For most universities one of the first activities they undertook with this funding was to establish a dedicated unit as a link between the university and the wider community and in resourcing this unit with staff. As a consequence of this government funding, almost all universities have the capability to manage external interaction, whether through a formal exploitation company and/or a department. Furthermore, most universities, irrespective of research intensity have established facilities to provide an enquiry point for SMEs and assistance in specifying their needs, a contracting system for staff-business and community interaction and the provision of indemnity insurance for staff (Table 5). In other words, not only has funding provided the infrastructure for engagement between the universities and external organisations, but organisational practices such as indemnity insurance have also been established to facilitate engagement.

Some significant differences are however found between the HRI and LRI universities (Table 5). HRI universities have a larger number of staff liaising with commercial partners than LRI universities. In contrast, LRI universities commit, on average just under a third of their staff to working with public sector partners, as compared to around a fifth of HRI staff. This may reflect the greater importance of industry or funding bodies directly associated with vocational subjects such as art, design, engineering etc. and the focus of LRI universities in working with these organisations.

Table 3
Proportion of universities stating that their main contribution to economic development was in the following areas.

	Low research intensive universities (%, $N = 57$)	High research intensive universities (%, $N = 20$)	Significance
Human capital development			
Access to education	81.0	40.0	***
Graduate retention	31.0	0.0	***
Attracting non-local students	5.2	15.0	
Regional skills needs	53.4	0.0	***
National skills needs	12.1	45.0	***
Mgt development	1.7	0.0	
Technology development and innovation			
Technology transfer	25.9	80.0	***
Supporting SMEs	36.2	10.0	**
Research collaboration with industry	15.5	80.0	***
Spin off activity	0.0	15.0	**
Local environment development			
Support community dev	10.3	0.0	
Develop local partnerships	25.9	5.0	**
Attracting Inward Inv	1.7	10.0	

Source: HEFCE (2007), Higher education business and community interaction survey 2005–06, Annex 1, Qu. 1.
Notes: 1. Fishers exact test used to test for independent samples. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$; 2. Universities responded to the following question: in which areas do you see the HEI as a whole making the greatest contribution to economic development? Each university was permitted to select the three most important areas.

Table 4
Area of greatest priority in universities institutional mission.

	Low research intensive universities (%, $N = 57$)	High research intensive universities (%, $N = 20$)	Significance
No specific area	1.7	20.0	**
Regional Government Area, e.g. West Midlands, South West, etc.	29.3	40.0	
Local Authority Area, e.g. County	0.0	0.0	
Locality – e.g. City or Town	1.7	0.0	
Area as defined by University*	67.2	40.0	**
Total	100.0	100.0	

Source: HEFCE (2007) Higher education business and community interaction survey 2005–06, Annex 1, Qu. 6.
Notes: 1. Each university was asked to identify the 'area' of greatest priority in their university's institutional mission? (HEFCE (2007) Annex A, Qu. 6); 2. * Where the area is 'Defined by University' this may include surrounding counties especially where the university crosses regional boundaries or it could be multi-county; 3. Fishers exact test used to test for independent samples. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 5
Capability of UK universities to deliver knowledge transfer activity, 2005–06.

	Low research intensive universities $N = 57$	High research intensive universities $N = 20$	Significance
Number of staff employed in dedicated bus & community function (full-time equivalent)			
Staff with commercial partners – mean (Std. dev)	26.5 (31.6)	45.2 (32.4)	**
Staff with public sector partners – mean (Std. dev)	16.2 (21.8)	14.1 (17.1)	
Staff with social community and cultural partners – mean (Std. dev)	10.0 (11.2)	14.3 (17.8)	
Dedicated unit providing the following (% of universities)			
Enquiry point for SMEs (%)	96.6	95.0	
Assistance to SMEs in specifying their needs (%)	91.4	90.0	
Contracting system for staff-business and community interaction (%)	81.0	75.0	
Indemnity insurance for staff (%)	91.4	95.0	
Filing of patents (% of universities)			
In-house filing (%)	17.6	50.0	**
Outsourcing of filing (to non-university org) (%)	80.4	55.0	**
Other IP protection action (%)	49.0	40.0	
Identification of licensing opportunities for IP (% of universities)			
In-house capability (%)	75.9	100.0	**
External sourcing (%)	13.8	0.0	
No capability (internal or external) (%)	10.3	0.0	
University has commercialization company to manage consultancy & other external interactions (% of universities)			
No formal organisation (%)	1.7	5.0	
Exploitation company established (%)	1.7	20.0	
Exploitation department used (%)	50.0	20.0	
Both commercialization company & department used (%)	46.6	55.0	

Source: HEFCE, HE-BCI (2007), Annex A.
Notes: 1. Mann–Whitney test was used to test whether the two samples were independent in the number of staff employed in dedicated business and community functions. For all other variables in the table, Fishers exact test was used to test for independent samples. For all tests, *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

More significant differences between the universities relate to their capability to exploit IP, whether through the filing of patent applications or the identification of licensing opportunities (Table 5). HRI universities without exception have the in-house capability to source licensing opportunities as compared to only three-quarters of LRI universities. This capability is closely related to universities' internal capability to file patent applications which is much more common among HRI universities; LRI universities being more likely to outsource this. It is likely that where the internal capability to file patent applications and seek licensing opportunities exist, this reflects both the strategic mission of the university to pursue patent applications as well as the presence of leading-edge technology for which there is a need to gain IP protection. In other words, for many LRI universities, the quality of research may mean that IP protection through patent applications is both less relevant and frequent, therefore making internal provision of these services less important.

4.3. Knowledge transfer activity

In assessing knowledge transfer-related activity across the universities, income is used as a proxy for the scale of activity. Given the substantially larger average scale of HRI universities (Table A1), an accurate comparison of knowledge transfer activity between HRI and LRI universities requires that account is taken of university size, specifically the number of academic staff. It is also important to consider the type of external partners with which universities are cooperating and again this is considered, controlling for differences in size between the HRI and LRI universities.

4.4. Scale of knowledge transfer activity

The scale of knowledge transfer activity is assessed through collaborative income, contract research income, consultancy income, facilities and equipment related services income as well as income from professional courses and the sale of licenses and shares of spin-off companies (Table 6).

On average, with the exception of income from courses, LRI universities generate significantly lower income per academic, for each of the knowledge transfer channels than academics in HRI universities. More specifically, the average (median) academic in LRI universities generates only 10 per cent of contract research income, 28 per cent of the collaborative income, 34 per cent of income from facilities and equipment services and 69 per cent of the consultancy income as recorded by academics in HRI universities. In contrast, academics in LRI universities generate almost twice (189 per cent) the average income from delivering courses to businesses and the community, compared to academics in HRI universities.

If the unit of analysis for measuring the amount of knowledge transfer activity is changed from the individual academic to the organisational level of the university, then for each of the knowledge transfer channels, differences in scale of activity between the LRI and HRI universities are exacerbated[17] due to the much larger size of HRI universities. For example, in comparing the scale of collaborative research income, LRI universities drop from 28 per cent of the level in HRI universities to only 6 per cent at a university level. Similarly for contract research income, LRI universities decline from 10 per cent of income at the individual level to 4 per cent at a university level. Further, comparative income from facilities and equipment declines from 34 per cent to 7 per cent and consultancy income declines from 69 per cent to 19 per cent the average amount generated by HRI universities.[18] Even for income generated from providing courses to businesses and the community, the greater level of activity per academic in LRI universities (189 per cent that of academics in HRI universities) is reversed at the organisational level, with the average LRI university generating only 52 per cent of the income in HRI universities.

Perhaps, the most striking difference between the HRI and LRI universities is for income from licenses. Undoubtedly there is variation among the HRI universities with some having more license income than others[19] however, on average although license revenue is quite low across the UK university sector, it is significantly higher for HRI universities. For example, including income from the sale of shares of spin-off companies, the average[20] HRI university generated £1.72 m in 2005/06 compared to £0.06 m for LRI universities. Obviously part of this difference in income reflects the significantly larger size of HRI universities, however after controlling for this, differences are still evident as seen in the IP income per academic (Table 6).

In general, analysis of the scale of knowledge transfer activity performed by HRI as compared to LRI UK universities suggests that this is dominated by the top-tier, HRI universities. Three observations emerge from the data as discussed. First, significant differences are found in the level of income generated per academic in HRI and LRI universities across the range of knowledge transfer channels. With the exception of income from providing courses, academics in HRI universities are generating significantly higher levels of income from knowledge transfer activity. Second, this higher level of activity among HRI academics is more pronounced for contract research, collaborative research and license income than for some of the other knowledge transfer channels, such as consultancy and income from courses. Third, when account is made for relative scale of HRI and LRI universities, then the differences in knowledge transfer activity are accentuated. In other words, not only are academics in HRI universities undertaking more knowledge transfer activity – specifically in collaborative research, contract research and patenting but at an organisational level this difference is magnified.

Relating these findings back to the strategic priorities and capability to undertake knowledge transfer the findings suggest that capability is less important in shaping knowledge transfer activity than the strategic priorities. For example, the focus of LRI universities on teaching and the concentration of academic effort on this type of knowledge transfer activity is reflected in the comparative levels of income generated from this knowledge transfer channel. In contrast, academic staff in HRI universities generate a significantly greater amount of income across all of the other knowledge transfer channels. However, this apparent strength in LRI universities is eroded at the organisational level, as substantially greater numbers of academic staff in HRI universities means that overall income generated from courses for business and the community is larger than among LRI universities.

[17] Average (median) income 2005/06 across each of the knowledge transfer channels per HRI and LRI respectively, is as follows: Collaborative Research income £11.16 m and £0.69 m; Contract Research income £19.32 m and £0.67 m; Consultancy income £3.79 m and £0.70 m; Facilities and Equipment income £1.10 m and £0.07 m; income from courses £3.47 m and £1.80 m; IP income £0.56 m and £0.00 m.

[18] For the average Russell group university, consultancy income is markedly lower than contract research income. This is not the case with Post 1992 universities where average (median) income from contract research and consultancy are roughly equal (around £700,000). These figures may however mask institutional differences in the freedom given to academic staff to undertake private consultancy and therefore underestimate consultancy performed by academics in HRI universities.

[19] For example, for 2005/06, income from the commercial sector for non-software and software licenses was comparatively high for University of Birmingham (£3.86 m) the University of Oxford (£3.66 m) and Cambridge University (£2.79 m) while being low for the University of Edinburgh (£1.41 m). At the same time, some other Russell Group universities such as University of Glasgow did not record any license income from the commercial sector in 2005/06.

[20] This figure relates to mean income per HRI and LRI university in 2005/06 and does not control for differences in size between the university groups.

Table 6
Income from knowledge transfer-related activity in UK Universities, per academic FTE[d], 2005–06.

	Low research intensive universities $N = 57$		High research intensive universities $N = 20$		Test for independent samples[c]
	Mean	Median	Mean	Median	
Collaborative income[a] 2005–06 (£000 s median)					
OST research councils	0.30	0.18	1.59	0.79	***
Other UK Govt Depts	0.83	0.54	1.09	0.83	
EU government	0.29	0.10	1.94	1.55	***
Other	0.23	0.05	0.76	0.16	
Total collaborative income	1.66	1.19	5.37	4.21	***
Contract research income 2005–06 (£000 s median)					
SMEs	0.11	0.01	0.41	0.32	***
Non-SME commercial	0.27	0.15	3.23	2.56	***
Non-commercial	1.09	0.57	4.79	4.58	***
Total contract research income	1.47	0.79	8.42	7.93	***
Consultancy income 2005–06 (£000 s median)					
SMEs	0.22	0.12	0.46	0.15	
Non-SME commercial	0.29	0.14	0.72	0.62	***
Non-commercial	0.86	0.51	0.83	0.42	
Total consultancy income	1.37	1.06	2.02	1.54	*
Facilities and equipment related services income 2005–06 (£000 median)					
SMEs	0.08	0.01	0.25	0.08	**
Non-SME commercial	0.04	0.00	0.26	0.06	***
Non-commercial	0.11	0.01	0.51	0.14	***
Total F&E income	0.24	0.11	1.02	0.32	**
Income from courses for business and community (£000 median)					
SMEs	0.25	0.05	0.07	0.03	
Non-SME commercial	0.57	0.15	0.46	0.19	
Non-commercial	1.91	1.29	0.79	0.30	***
Individuals	0.82	0.14	0.61	0.17	
Total income from courses	3.55	2.88	1.94	1.52	**
Total learner days of CPD/CE courses delivered (median)					
Total days per academic FTE	64.45	12.76	6.41	4.02	**
IP income (£000 median)					
Software licenses	0.01	0.00	0.01	0.00	***
Non-software licenses	0.05	0.00	0.02	0.01	***
IP income total[b]	0.07	0.00	0.58	0.29	***

Source: HEFCE, HEBCI (2007) Annex B; Number of academic staff – HESA.

[a] Collaborative income defined as income from collaborative research involving both public funding and funding from business (£000 s).

[b] IP income includes income from the sale of software licenses, non-software licenses and the sale of shares of spin-off companies.

[c] Mann–Whitney test was used to test whether the two samples were independent for each variable. *$p < 0.00$, **$p < 0.05$, ***$p < 0.01$.

[d] Number of employees calculated as the sum of full-time equivalent staff on teaching only contracts, research only contracts and teaching and research contracts.

4.5. Knowledge transfer partners

The variety of external organisations with which universities are undertaking knowledge transfer activity is also of interest in profiling knowledge transfer activity. This provides an insight to the demand-side and whether differences exist in the type of partners with which HRI and LRI universities engage. Specifically, we are interested in the extent to which HRI and LRI universities engage with small and medium sized businesses (SMEs), large private sector businesses (non SME commercial) and non-commercial partners (Table 6).

Looking first at the source of funding for collaborative research, on average, academics in HRI universities derive a proportionately greater share of this income from UK (Office of Science and Technology – OST) Research councils and EU Government sources than academics in LRI universities. Although further detailed information on the nature of this EU funding is not available, it is likely that this represents support through Framework programmes where university–business engagement occurs on a European or international level. For academics in LRI universities, the most significant source of collaborative research income is from UK Government Departments (excluding OST research councils) accounting for 50 per cent of total collaborative research income in 2005/06. This pattern suggests that funding for collaborative research may be closely aligned to research quality with research councils and European funding targeted at high quality research. This is not to imply that funding from Government departments does not account for research quality, but rather that it may be more accessible for undertaking low research intensive collaborative activities.[21]

For both contract research activity and income from facilities and equipment related services, academics in HRI universities generate significantly more income from all external partners than academics in LRI universities. This means that SMEs, large businesses and non-commercial organisations are spending more per academic in HRI universities than in LRI universities in commissioning contract research and in accessing facilities and equipment related services. A somewhat different profile of spend on knowledge transfer activity is found for consultancy income, where academics in HRI universities are generating significantly more income from large businesses but the difference in income from SMEs or non-commercial organisations is insignificant. In other words, for consultancy activity, SMEs and non-commercial organisations are spending as much per academic in LRI universities as in HRI universities. Similarly, for income generated per academic from courses, academics in HRI and LRI universities are generating a similar amount of income from SMEs, large businesses and individuals, however income from non-commercial partners is significantly higher for academics in LRI universities.

[21] One example of this is the Knowledge Transfer Programme (KTP) which is offered across the UK to enable partnerships between academic institutions and businesses of all sizes as well as community or public sector organisations. These partnerships are project based ranging from 10 to 40 weeks for short KTPs to 1–3 years for classic KTPs enabling new skills and expertise to be offered and typically new business-capabilities to be developed.

4.6. Regional knowledge transfer activity

In contributing to economic growth it is helpful if the information on scale and type of partner can be contextualised in terms of regional economic development (Table 7). On average, HRI universities undertake approximately one sixth (16.5 per cent) of their contract research in the region as compared to a third (30.3 per cent) of research contracts for LRI universities. Similarly, for consultancy activity, on average HRI universities performed around a fifth of consultancy in the region (21.0 per cent) as compared to approximately two-fifths for LRI universities (41.0 per cent). In other words, both LRI and HRI universities undertake the majority of contract research and consultancy outside the immediate government office region with this ex-regional focus being proportionately higher for HRI universities. This is not to underestimate the contribution of these universities in the region, with for example the average HRI university performing approximately £3758k of contract research and £769k of consultancy in the regional economy (2005/06).

The geographical concentration of knowledge transfer activity is slightly higher for the use of facilities and equipment (F&E). For LRI universities, on average, just over half of the total hire of facilities and equipment is from regional actors (54.4 per cent). Indeed, even for HRI universities, the share of income generated from F&E services with regional actors is markedly higher (37.3 per cent) than for contract research and consultancy. SMEs have a greater propensity to collaborate with regional universities for the hire of F&E than large businesses which appear to be constrained less by geographical distance. Although data is unavailable to support our proposition, it is likely that large firms tend to source specialist equipment which is often only available in specialist research labs outside the region. Further, large firms as well as non-commercial partners may wish to host events in HRI universities because of their research expertise or reputation. Indeed as many of the HRI universities are centrally located in major UK cities or towns, this may also contribute to their attractiveness in the hosting of conference type events. These factors may also help to explain the significant difference in the profile of income from courses for LRI and HRI universities. While almost half of income generated from courses by LRI universities comes from the region, the equivalent share for HRI universities is less than a quarter. IP income from licenses is very low across all universities and therefore it is difficult to interpret regional activity for this. However, on average the vast majority of IP income generated in 2005–06 by the university groups, originated from outside the regional economy.

In general, the data suggests that the importance of the region for knowledge transfer activity does vary markedly by university group. The HRI universities tend to perform a smaller *proportion* of their knowledge transfer activity in the region compared to LRI universities. At the same time, some knowledge transfer channels appear to be more sensitive to distance than others. For example, in the use of university F&E, SMEs and non-commercial organisations are more likely to access local and regional universities for this. Similarly, where SMEs require consultancy services then this is most likely to be undertaken with local and regional universities. Activities such as contract research and the exploitation of IP through license agreements are less sensitive to distance and therefore the economic benefits are more likely to be realized outside the region where the knowledge (IP) has been generated.

5. Discussion and conclusions

In recent years the role of the university sector has changed markedly. The move from a linear to a distributed model of innovation has meant that the generation, application and exploitation of knowledge extends beyond the confines of large corporations and industrial labs with universities playing an important role in economic development.[22] At the same time, there has also been changes in universities' model of knowledge management from 'open science', where new knowledge is viewed as a public good and universities place little priority on IP ownership, to a 'licensing model' or 'innovation model' where the identification, protection and exploitation of IP is central (EU, 2004). Yet, it is argued that publications and citations remain important in the licensing or innovation models in acting as market signals of research quality (Dasgupta and David, 1994). The implication being that research quality performance will be closely aligned to knowledge transfer activity. In other words, those universities with highest research quality will be most likely to engage in knowledge transfer.

This raises questions about institutional differences in the University sector and the potential effect that this has on knowledge transfer behavior. Although much research has examined the relationship between universities and business innovation little account has been taken of heterogeneity in the university sector (Fristch and Slavtchev, 2006). However if, as is argued in this paper, significant differences in knowledge transfer behavior exist within the university sector – particularly between HRI and LRI universities – then 'as we increase our understanding of the actors involved and the potential outcomes, it might be possible to craft policy that selects for the outcomes the public deems most attractive' (Welsh et al., 2008, p. 1863). For this reason, analysis in this paper has considered how institutional differences in the university sector, specifically research quality, are reflected in the knowledge transfer strategy and perceived geography of economic impact, the capability to deliver knowledge transfer activity, and the scale and scope of knowledge transfer engagement, with reference to activity performed with other organisations in the geographical region.

Looking first at knowledge transfer ***strategy***, our findings support the proposition that university's knowledge transfer strategy is aligned to their organization's goals and objectives (Buckland, 2009). In particular, HRI universities are more likely to emphasize knowledge transfer activities related to the development and exploitation of IP and maximizing the return on research while LRI universities stress their potential contribution to human capital development[23] (Table 3). This suggests a strong relationship between organisational goals and objectives, the translation of this into strategic academic priorities, and the valorization of this both academically and commercially (Siegel et al., 2003). For example, the Russell Group of universities' prioritization on leading the UK's research effort internationally is valorized academically through high quality research publications and the funding that this secures from Government, and valorized commercially through the exploitation of research by technology development and innovation. Similarly, for LRI universities when established in the 1960s and 1970s, the original objective of being vocation oriented colleges with an emphasis on teaching, is still evident today with this prioritization on education being valorized academically, less through high quality research and more through the provision of vocation-oriented courses and valorized commercially by a greater focus on human capital development (Table 3).

[22] This is evident in theoretical contributions on the systemic nature of innovation at national (Lundvall, 1992; Nelson, 1993; Edquist, 1997, 2005; Edquist and Hommen, 2008), regional (Cooke et al., 2000, 2004; Doloreux, 2002; Asheim and Gertler, 2005) and sector or cluster-levels (Anselin et al., 1997, 2000; Audretsch and Feldman, 1994, 1996; Baptista and Swann, 1998; Malmberg and Maskell, 2002).

[23] This does not imply that HRI universities fail to contribute through human capital development, indeed one of the aims of the 'Russell Group' of universities – the HRI universities in our analysis – is to attract the best students with 80 per cent of doctors and dentists and 30% of the UK's science and engineering graduates graduating from these universities. http://www.russellgroup.ac.uk/Benefits-to-the-UK/ (accessed 10.01.10).

Table 7
Regional concentration of knowledge transfer-related activity and income in the UK, 2005–06.

	Low research intensive universities $N=57$			High research intensive universities $N=20$			Test for independent samples
	Average income from region, £000 s (mean)	Std. dev.	Percentage of total activity income from region (%)	Average income from region, £000 s (mean)	Std. dev.	Percentage of total activity income from region (%)	
Contract research income 2005–06							
SMEs	44.2	112.8	44.2	434.8	479.0	42.1	***
Non-SME commercial	42.0	79.9	21.9	1066.2	1902.9	10.4	***
Non-commercial	232.5	426.6	31.8	2257.8	4804.4	17.7	*
Total contract research Income	318.6	500.5	30.3	3758.7	6249.6	16.5	***
Consultancy income 2005–06							
SMEs	91.6	179.5	53.5	301.1	677.8	37.5	
Non-SME commercial	72.6	159.9	29.7	177.0	258.0	14.3	**
Non-commercial	185.1	288.1	38.6	291.3	474.0	26.2	
Total consultancy income	349.3	451.9	41.0	769.4	934.9	21.0	**
Facilities and equipment related services income 2005–06							
SMEs	37.9	126.1	52.5	418.5	1109.3	51.1	*
Non-SME commercial	8.6	23.8	35.2	81.1	141.5	28.2	***
Non-commercial	52.4	134.2	58.5	413.3	1207.7	18.3	
Total F&E income	98.9	194.3	54.4	912.8	1711.0	37.3	
Income from courses for business and community							
SMEs	172.1	887.1	53.6	64.7	135.9	45.7	
Non-SME commercial	113.2	225.7	40.7	100.5	222.8	21.2	
Non-commercial	564.2	768.1	51.4	144.9	228.7	25.3	**
Individuals	317.2	908.3	53.9	2074	655.8	32.7	
Total income from courses	1166.6	1593.0	49.1	517.5	895.0	23.7	**
IP income							
Software licenses	2.6	18.0	35.7	0.7	1.6	18.5	**
Non-software licenses	1.9	8.6	–	9.6	14.1	–	***
IP income sub total	8.4	35.5	25.7	123.0	203.3	9.6	***

Source: Data from HEFCE, HEBCI (2007) Annex B.
Notes: 1. Figures refer to the proportion of activity undertaken in the government office region and based on mean values. 2. Mann–Whitney test was used to test whether the two samples were independent for each variable.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

For UK universities, the pressure from government has been increasing to produce both leading academic research and to exploit this commercially. Such a scenario has led to suggestions that organisational tensions or strategic ambiguity may be increasing among universities (Sorlin, 2007; Jarzabkowski et al., 2010). Yet, the findings in this paper are consistent with the proposition by Antonelli (2008) that universities will focus on areas where they have a comparative advantage and therefore alignment will occur between how strategic priorities of the organisation are valorized academically and commercially.

In relation to the ***capability*** of UK universities to engage in knowledge transfer activities we find that government policy to promote greater university–business engagement through public sector funding for third steam activity has been relatively successful. Only very minor differences are found between the HRI and LRI universities in the services that they offer, notably their capability to file patent applications and to identify licensing opportunities. Therefore, limited support is found for the proposition by March (1991 and later developed by Chang et al., 2009) that intermediary organisations are formed to reflect the demands of teaching, research and commercialisation activity. Instead, the findings suggest that government assistance for universities to establish TTOs may explain the similarity of services that university TTOs are offering across the higher education sector, irrespective of their research intensity. In other words, the relationship between strategic priorities for knowledge transfer and organisational supports is relatively weak.

Further, Chang et al. (2009) suggested that the organisational supports for knowledge transfer activity may significantly affect the performance of this activity. Again, limited support is found for this and instead despite similarity in the presence, staffing and capability of TTOs between HRI and LRI universities, significant differences are found in the scale and scope of knowledge transfer activities. This is contrary to the findings that an increase in technology transfer staff leads to higher levels of spinoff activity (O'Shea et al., 2005, see also Caldera and Debande, 2010). Instead it is more likely that capability is most effective where it is aligned to strategic priorities. In other words, even where capability is established, this will not directly generate activity if there is a 'disconnect' between the organisational supports and strategic priorities.

In relation to the extent of knowledge transfer activity, little support is found for arguments that university's profile of knowledge transfer activity will be influenced by the degree of relational involvement (Perkmann and Walsh, 2007; Cohen et al., 2002). Instead the findings suggest that academic staff in HRI universities are performing significantly more high relational (e.g. collaborative research), medium relational (e.g. contract research and consultancy) and low relational knowledge transfer activities (e.g. licensing and spin-outs) than staff in LRI universities. The only exception to this is in providing courses to businesses and the community which could be defined as a medium to high relational activity, and performed much more in LRI universities. The implication of this is that HRI universities are not confining knowledge transfer to high relational channels where the co-production of knowledge has both direct academic and commercial outputs.

Although the knowledge transfer indicators examined in this paper are restricted to those that can be measured financially, the findings support the argument that studies of universities' knowledge transfer performance should extend beyond single indicators such as patents, licenses or spin-outs (Caldera and Debande, 2010;

Agrawal, 2001; Cohen et al., 2002; D'Este and Patel, 2007). Indeed, HRI universities have higher *direct* technology-oriented outputs i.e. patent and licensing income (see also Chukumba and Jensen, 2005) as well as indirect knowledge-oriented outputs i.e. collaborative, contract research and consultancy activity. This supports the notion of a signaling process whereby research quality acts as a market signal to businesses as they form links to universities for innovation (Dasgupta and David, 1994).

In considering economic contribution and the stickiness of knowledge transfer activities to the regional economy, LRI universities undertake a larger *proportion* of knowledge transfer activity in the region, than HRI universities. It could be argued that this reflects universities' strategic priorities for knowledge transfer with HRI universities performing the majority of their knowledge transfer activity outside the region. Yet, due to the significantly greater size of HRI universities, regional knowledge transfer activity (as measured by total income) is substantially higher than for LRI universities. From the demand-side, it suggests that the research quality and reputation of HRI universities means that knowledge transfer partners will travel to acquire their expertise. However, this is less likely for SMEs, which are more likely to form links with local (regional) universities. For larger businesses as cognitive proximity increases then this reduces the dependency on co-location in knowledge transfer activities (see Hewitt-Dundas, 2011).

In conclusion, a number of national and regional policy implications are suggested from the research. Nationally, UK policy to develop a knowledge based economy has stressed investing in the science base and building stronger links between universities and businesses to exploit this expertise. High quality research performance by the university sector underlies this approach with research-based funding models for higher education being introduced by government. The challenge for national policy is managing the diversity in the university sector, particularly between HRI and LRI universities, and in introducing appropriate policy programs and supports to maximize the economic contribution of universities. For example, technology transfer activities are much more likely to occur with HRI universities whereas LRI universities may be more effective in human capital development through courses for business and the community. This implies that the approach in the UK to nurture a 'diversity of excellence' may be appropriate. Yet, it also raises questions about why academic staff in HRI universities undertake significantly lower levels of teaching on courses for external organisations. From the perspective of knowledge transfer, it might be preferable to target funding to research oriented universities and provide greater support for increased executive and continuous professional development teaching to complement technological expertise.

Nationally, our findings suggest that UK policy to build capability for knowledge transfer activities has been effective. However, in the UK there is a misalignment between the capability to undertake knowledge transfer, the strategic priorities attached by universities to knowledge transfer and the scale and scope of knowledge transfer activity. In other words, organisational supports poorly explain the knowledge transfer activity that universities engage in. Instead, differences between HRI and LRI universities in their strategic priorities for knowledge transfer (and indeed who this is with and where it occurs) reflects differences in ethos and in particular, research quality. This suggests that policy support for infrastructure and staffing to support knowledge transfer activity needs to consider the institutional and organisational resources of universities as reflected in their ethos and research performance.

Regionally, with 'research universities focusing on curiosity-driven research, teaching and knowledge transfer and business-facing universities focusing on... professional teaching, user-driven research and problem-solving with local and regional companies' (HM Treasury, 2007, p. 5), this presents challenges where there is an uneven spatial 'diversity of excellence'. This may be particularly relevant for peripheral regions dominated by small businesses, with typically lower absorptive capacity. These businesses are less mobile in their search for knowledge transfer partners, and the type of university knowledge they seek tends to be consultancy, training and courses and access to F&E. In such a region, a higher concentration of LRI universities with a strong commitment to local and regional economic development largely through an education and regional skills development agenda would result in strong synergies between the university and business sectors. However, if there is a dominance of HRI universities, a possible mismatch may occur between the technology transfer agenda of the universities and the human capital development and problem-solving requirements of businesses. While it is possible for regional government to attempt to align the interests of both parties, this is difficult as the majority of funding for HRI universities comes from national and international sources and the strategic priorities for knowledge transfer of these universities lies outside the region. Further, for the HRI university, pressure to contribute to the regional economy may require the development of knowledge transfer priorities more characteristic of LRI universities i.e. 'professional teaching, user-driven research and problem solving with local and regional companies' (HM Treasury, 2007). In other words, regional economic policy may mediate the relationship between strategic priorities for knowledge transfer and the activity undertaken, however this will be minimized where income from regional sources remains low. What is less clear is how HRI universities can manage these strategic tensions in defining their priorities for knowledge transfer, the constraints they face in undertaking less research intensive knowledge transfer activities and the longer-term effect of this on research quality.

Appendix A.

Table A1.

Table A1
Income and academic staffing of UK universities, 2005–06.

	Total	Mean	Median	Std dev	Min	Max
Income (£000 s)						
Post 1992	5,663,623.0	94,393.7	93,842.0	44,918.3	24,975.0	188,037.0
Group 1994	1,228,860.5	128,860.5	137,785.0	44,761.9	45,137.0	191,676.0
Russell	7,880,735.0	394,036.7	345,167.0	167,003.5	149,444.0	890,748.0
Other/specialist universities	3,512,463.0	57,581.4	27,307.0	62,266.4	5,507.0	352,700.0
Academic staff FTE						
Post 1992	41,668	718	735	338	206	1430
Group 1994	16,634	924	923	299	411	1373
Russell	51,380	2569	2500	866	828	4113
Other/specialist universities	23,478	385	168	473	31	2811

Source: Higher education information database for institutions (HEIDI), 2005–06 tables.

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