Knowledge Generation, Innovation and Space – Exploring the relationship between UK Universities and Business Innovation

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1 Introduction

The innovation process, and our understanding of it, has changed dramatically in recent years. 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). One such actor believed to have a potentially important influence on business innovation is universities (Adams, 2005; Cooke & Leydesdorff, 2006; Etzkowitz and Kloftsen, 2005; Mowery et al. 2004; Poyago-Theotoky et al, 2002). Research demonstrating the potential of universities to contribute to reducing regional economic disparities (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 promoting economic growth through business engagement and knowledge transfer activity.

The evidence-base pertaining to the nature and benefits of university-business engagement has been derived largely from empirical research suggesting a positive relationship between business engagement with Universities and their innovation and business performance. These studies emanate largely from econometric analyses of the relationship between universities and business innovation (largely through CIS data or equivalent) or studies of bibliometric data and patent citations. While some account has been made of differences in impact of liaising with different academic disciplines and the extent of knowledge spillover activity, in general Universities have been examined as homogenous actors with little attention given to institutional variations within the University sector. Yet in almost all countries, heterogeneity exists within the University sector, whether in terms of ownership, size, disciplinary mix, research excellence etc.. This therefore raises questions about the appropriateness of uniform policies to promote (and support) university-business engagement, where significant institutional differentiation exists in the University sector.

In this paper we focus on Universities in the UK and examine if differences exist between Universities in their strategic approach to knowledge transfer, their capability to engage in knowledge transfer activity and current levels of knowledge transfer engagement. In particular we examine three groups of Universities in the UK – Post 1992 Universities, Group 1994 Universities and Russell Group Universities. We also consider if Universities impact on business innovation at the regional level and if differences in knowledge transfer strategy, capability and activity between the University groups is reflected in regional business innovation and performance. In other words, we are concerned with three questions: first, are there differences between Universities in terms of their commitment and engagement with knowledge transfer activities, second, is there evidence that

Universities have a positive effect on business innovation and success at the level of the region and finally, does this effect vary by type of university.

The remainder of this paper is structured as follows. In section 2 we consider the conceptual context of the study along with the policy environment in the UK that is driving greater university-business engagement. Section 3 outlines the data sources and methodological approach adopted in the study. In Section 4 the empirical results are presented and in Section 5 we summarize the key findings from the paper and consider the policy implications arising from the research.

2 Conceptual and Policy Context

It is now widely accepted that the wealth of a country or region is directly linked to levels of R&D and innovation (Pianta, 1995; DTI, 2003a; DTI, 2003b; HM Treasury, 2003). For example, the OECD argues that innovative efforts, and R&D in particular, are the major factor behind technical change and long-term economic performance (OECD, 1998). In other words, low levels of investment in R&D will severely constrain innovation activity and business success at the business-level and economic growth at the regional and national-level. This presents a considerable challenge for the UK, where investment in R&D as a proportion of GDP has been declining steadily relative to other countries in recent years. While cuts in defence spending have contributed to this decline, most of the reduction in R&D spend results from cuts in business sector spend[1].

Governments have responded to underinvestment in R&D through two basic forms of policy response[2]: direct procurement and/or provision in public facilities (including higher education); or incentives for private investment (tax incentives or R&D subsidies). Much research has been undertaken of the impact of incentives on private investment in R&D (see Martin and Scott, 2000; Trajtenberg, 2002) however in this paper we are concerned with the former policy response, and specifically, at a regional level, the provision of research through Universities and the potential impact of this on business innovation. Crucial to the public investment in University research is the expectation of some net positive effect on the (assumed sub-optimal) level of private R&D and innovation activity[3]. This has led to a considerable amount of research on whether and to what extent public (Higher Education) R&D is a complement or a substitute for private R&D (David et. al., 2000).

In general, research suggests that a combination of short-run (static) effects and long-run (dynamic) effects will result from public investment in R&D (Hewitt-Dundas et al 2007). In the short-run the potential for crowding-out effects means that the relationship between higher education research and private R&D is not unambiguously positive. In contrast, in the long-run the potential for knowledge spillovers from universities to business may positively impact on innovation and productivity, and ultimately economic growth. Indeed, much of the public investment in research, and particularly that in Universities, is designed to have a strong public good element; by its very nature it should be disseminated or leak out into the private sector at low or zero marginal cost and be used for economically significant innovations and/or productivity gains (EU, 2004). Research concurs that the short-run relationship between public and private R&D may be positive or negative depending on

[1] Exceptions to this are the pharmaceuticals and aerospace-defence sectors which have comparatively high levels of business sector investment in R&D relative to other countries.

[2] 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 (Arrow 1962; Nelson 1959) first, high risk and sunk costs of conducting R&D discourages firms from engaging in R&D activity and second, the inability of appropriate all of the returns from R&D means that they tend to invest below the socially optimum level.

[3] Strictly, at least a non-negative effect.

the potential for crowding out, while the dynamic effects are likely to be positive, but their strength depends on the characteristics of the individual nation or region.

To date, considerable research has investigated the effect of university R&D on innovation. This research tends to have adopted a straightforward production function approach relating investment in university research to innovative outputs, usually in terms of patents or product announcements. While much of this research is US-based (Mansfield 1995; Jaffe 1989; Adams 1990, 1993; Acs et al 1992, 1994; Feldman, 1994) similar studies in the EU (Kaufmann and Todtling, 2001; Arvanitis et al, 2005; Beise and Stahl, 1999; Becker, 2003; Monjon and Waelbroeck, 2003) all tend to point to a strong positive link between university research (HERD) and innovation activity across different industries.

A related literature suggests that there is a strong geographical dimension to this spillover effect[4], with the impact of university R&D being confined largely to the region in which the research takes place. This empirical research provides support to theoretical contributions on the systemic nature of innovation whether 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), or within clusters etc. (Anselin et al 1997, 2000; Audretsch and Feldman, 1994, 1996; Baptista and Swann, 1998; Malmberg and Maskell, 2002), suggesting a strong role for local university R&D (Fischer and Varga 2003; Verspagen 1999). Bilbao-Osorio and Rodriguez-Pose (2004) however, in analysing the impact of different forms of R&D expenditure on innovation (measured as patent applications per capita) across EU regions find that while private R&D is the sole driver of innovation in non-peripheral regions, in peripheral regions, both private R&D and HERD, but not other public R&D, has a positive effect on innovation. This suggests that Universities have a more significant role to play in contributing to productivity and growth in peripheral regions through undertaking user-driven (applied) research.

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 therefore sensitive to increasing distance (David and Forey, 2003). Indeed, Fritsch (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.

The literature on the impact of universities on business innovation is therefore unambiguous: it has a positive effect, and this effect is probably linked to proximity, suggesting that universities have an important regional role to play in raising the innovative capacity of local firms. However, such a uniform view fails to take into account variations within the University sector and the potential for different types of universities to have quite different impacts on business innovation.

Studies of university-business engagement or spillover effects from university research has tended to adopt an homogenous view of universities with this being reflected in generic government policies to promote greater university-business engagement. In the UK, in 1998, a Government White Paper (DTI, Dec.1998, Cm 4176) on building the knowledge-driven economy emphasised the importance of knowledge generation and exploitation and the intricate link between these activities. 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) from 1999-2000, allocated

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

in response to applications from HEIs in England and Northern Ireland. The purpose of this fund was to 'provide a platform of core funding to help [HEIs] to put into practice organizational and structural arrangements to develop and implement strategic approaches to their relations with business, and to asssit in activity to improve the transfer of knowledge and skills' (HEFCE, 2000, p.4)

A further government White Paper in 2000 (OST, July 2000, Cm 4814) further 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 product and services. In 2002 (DTI, HM Treasury and DfEE, July 2002) proposals were issued to ensure the long-term sustainability of university research and efforts to encourage greater collaboration between universities and the business sector through increased investment in knowledge transfer activities and in particular, through expansion of the Higher Education Innovation Fund (this further developed HEROBC funding)[5]. By the end of 2003 a review of Business-University collaboration (Lambert review) concluded that government funding for knowledge transfer activities had been important in changing the culture among universities towards greater collaboration with business. At the same time, the report also emphasised a lack of demand from the private sector in capitalising on the expertise in the Universities. Despite this, the Government's Science and Innovation Investment Framework 2004-2014 (July 2004) further emphasised its commitment to the development and expansion of third stream funding in UK Universities: 'Over the next ten years, it is critical that the levels of business engagement with the science base increase, to realise fully the economic potential of the outputs of our scientists and engineers to turn basic and strategic research into successful new products and services, and to engage more fully with business. To do this, the UK needs to build the capacity within universities to undertake knowledge transfer activity. Universities will be incentivised to build on the progress made in commercialising their research and working collaboratively with business, through increased funding from the Higher Education Innovation Fund'.

In 2007 a review of Government's science and innovation policies further accentuated the need for a continued emphasis on university-business engagement, however for the first time acknowledged differences between Universities and the activities that they engage in. The report highlighted 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).

This policy approach raises important issues. First of all it suggests a return to the 1960s binary policy towards higher education in the UK which distinguished between universities and technical and/or public sector colleges. In order words, the existence of a two-tier University system. Second, it implies that the geographical scope of positive externalities from universities is likely to be different with business-facing universities more focused on the regional and local economic mission through user-driven research, problem solving and professional teaching. In this paper these two contentious issues relating to institutional disparities between Universities and the geographical impact of Universities on regional business innovation are explored.

UK Universities

[5] The Higher Education Innovation Fund (HEIF) programme provides funding to higher education institutions (HEIs) to build on the activity carried out under 'third stream' funding initiated by the Higher Education Reach-out to Business and the Community (HEROBC) fund. It forms the basis of the Government's commitment for a permanent stream of funding to enhance the contribution of higher education to the economy and society.

In the UK, 1992 represents an important milestone in the provision of Higher Education. From 1966 a 'binary policy' (Pratt, 1997) had existed with 'two separate and distinctive sectors based on the universities and the leading technical and other public sector colleges' (Pratt, 1997, p.1). The Robbins Report (HMSO, 1963) and the subsequent Government White Paper of 1966 (A Plan for Polytechnics) directed the expansion of higher education emphasising the provision of courses aligned to the vocational aims of students[6] and set-out the intention to establish a number of polytechnics in England and Wales[7,8]. Although the Polytechnics delivered both academic and practical subjects their emphasis was on applied work-related education, grounded in engineering and applied science[9]. Furthermore, prior to 1992, Universities were centrally funded while Polytechnics were locally funded.

This approach in the UK mirrored other countries in the 1960s and 1970s in what the OECD referred to as the 'differentiation of higher education' (OECD 1991, as referred to in Pratt 1997). 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). It is important to note however that in the UK, the 1960s and 1970s was a period of expansion in higher education not only in terms of the establishment of the polytechnics but also in terms of widening access to University education. More specifically, a number of New Universities were formed in the UK, often referred to as the plate glass universities due to their architectural features.

In 1992, the Further and Higher Education Act, (HMSO, 1992) brought changes to the funding arrangements and administration of both further and higher education and a perceived end to the 'binary divide' that had existed between the University and Polytechnic sectors. Polytechnics were now recognised as Universities with degree-awarding status and commonly referred to as Post-92 Universities.

In 1994, within two years of this development two self-selected University groupings were formed: the Russell Group and Group 1994[10]. These groups sought to differentiate themselves within the University system with the Russell Group emphasising their research excellence and the centrality of this to teaching and learning and the Group 1994 universities stressing the importance of 'diverse and high-quality research, while ensuring excellent levels of teaching and student experience'.[11] 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 United Kingdom, and over 30% of all students studying in the United Kingdom from outside the EU. In the 2001 national Research Assessment Exercise, 78% of the staff in 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 were allocated approximately 64% of the total quality-related research funding (QR) allocated by the Funding Councils[12]. While Group 1994 universities also have strong research capabilities, the extent of

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[6] http://www.londonmet.ac.uk/about/150-years.cfm

[7] In Scotland polytechnics were known as Central Institutions. In Northern Ireland the University of Ulster was formed in 1984 through the merger of the New University of Ulster originally established in 1968 and the Ulster Polytechnic as established in 1971. This was the only merger in the UK of a new university with a polytechnic.

[8] Thirty polytechnics were established between 1968 and 1973 with changes in the provision of teacher training leading to the formation of an additional four polytechnics between 1989 and 1991 (Pratt 1997).

[9] http://en.wikipedia.org/wiki/Polytechnic

[10] In 2007, with the addition of Queen's University Belfast, the Russell group now comprises 20 Universities with Group 1994 accounting for 19 Universities. Warwick University is a member of both the Russell Group and Group 1994.

[11] See http://www.1994group.ac.uk/aboutus.php

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

international research contracts and research council funding is significantly below that of the Russell Group. Post 1992 Universities then include 32 universities formerly established as polytechnics and 28 Universities that were established as 'modern' Universities in the 1960s.

3 Data Sources and Methods

Analysis in this paper draws on two UK data sources. In profiling third stream activity strategy, capability and activity across the UK regions the Higher Education Business and Community Interaction Survey (HE-BCI) is used. Analysis of the determinants of innovation activity and innovation success draws on the UK Community Innovation Survey 4 (CIS4) in conjunction with regional HEI measures incorporated into the dataset.

The HE-BCI survey is an annual survey administered by the Higher Education Funding Council for England (HEFCE). Information is collected on a range of 'third stream' activity reflecting the contribution of HEIs to both business and the community[13]. The analysis in this paper draws on the sixth annual survey, examining data from the academic year 2005-06 (HEFCE, 2007/17). This data is publicly available and provides information at the level of the individual HEI[14]. The information collected spans a range of third stream related activity, from the strategic priorities of HEI's activity, their capacity and infrastructure in place to deliver this activity, and levels of income and activity across a range of metrics on the commercialisation of knowledge. The 2007 survey reports data for 158 HEIs across the UK representing a full response rate (100 per cent) for the population of UK HEIs.

Across the UK the profile of HEIs by Government-administered region (GOR) varies significantly (Table X). For example, in some regions of the UK there is a high concentration of HEIs i.e. London with 39, while a lower concentration is found in other regions such as the North East of England with 5 and Northern Ireland with 2. Controlling for resident population by GOR also demonstrates that in some regions there is a significantly higher density of HEIs. This is most evident in London (192,800 resident population per HEI), Scotland (268,100 per HEI) and Wales (268,100 per HEI) with Northern Ireland universities serving the largest resident population per HEI of c.862,000.

Variation is also evident in terms of the composition of the HEIs across the UK regions. For example, Post 1992 Universities as a proportion of all HEIs dominate the profile of HEIs in the North East, North West and East Midlands. In contrast, Russell Group universities, again as a proportion of all HEIs in the region, are relatively more important in Yorkshire and Humberside and the West Midlands, but account for a lower proportion of HEIs in the South West and Wales. In three of the UK GORs no Group 1994 Universities are found i.e. West Midlands, Wales and Northern Ireland however for four GORs Group 1994 Universites account for at least a fifth of the HEIs (North East, East Midlands, Eastern England and South East).

Differences in HEI profile across the regions are exemplified by the North East and other regions such as Northern Ireland and the South East of England. In total, five HEIs are based in the North East of England. Of these, 3 (60 per cent) are Post 1992 universities, 1 (20 per cent) is a Russell Group university and 1 (20 per cent) is a Group 1994 University. Therefore, the profile of HEIs in the North East is clearly dominated by Post 1992's. In other regions a different profile is found, e.g.

[13] 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 organizations and individuals. (see HEFCE, 2007 p.4).

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

NI with 1 Russell group University and 1 University more characteristic of a Post 92 university. While, in the South East, although Post 1992 Universities account for around 40 per cent of the HEIs in the region, group 1994 Universities are much more common than Russell group universities.

In examining business innovation activity and success we use the UK element of the 4th Community Innovation Survey (CIS). This survey provides enterprise level information on innovation across the UK regions over the period 2002-2004. The survey, administered by post, was based on a stratified random sample with stratification based on sector, region and sizeband. In addition the sample selection methodology adopted a Neyman allocation based on firms' innovation active rates in the previous CIS3 (see http://www.berr.gov.uk/files/file11773.doc). Enterprises with 10 or more employees were targeted, with a sample of 28,000 UK-based and a UK-wide response rate of 58 per cent. Response rates were relatively similar across the UK regions (Table 1) with over half of responses from enterprises with between 10 and 49 employees.

The extent of enterprises undertaking innovation between 2002 and 2004 was relatively similar across the UK regions (Table X). The proportion of enterprises reporting the introduction of new or improved products or services ranged from 21 per cent in Northern Ireland and 22 per cent in Scotland, to a high of 28 per cent in SE England. Between half and two-thirds of product/service innovators in each of the UK regions were introducing 'novel' products or services i.e. new to the market innovations. It is likely that these novel innovations in the short term will appropriate higher rent in the market and added value for the enterprise. The extent of process innovation is much lower than product/service innovation activity across the UK (Table X). In particular, there is a lack of correlation between the extent of product/service innovation and process innovation in the Regions. This is evident in SE England with the largest reported gap between product/service innovation activity (28 per cent of enterprises) and process innovation activity (16 per cent). In relation to the sophistication of process innovations, the majority of process innovations, i.e. approximately two-thirds of all process innovations are incremental changes to existing processes as opposed to 'new to the industry' processes.

Enterprises across the UK were more likely to be introducing wider organizational innovations[15] than product or process innovations, with approximately a third of all enterprises reporting organizational innovation between 2002 and 2004. With marked variation in innovation activity between innovation metrics i.e. product, process and organizational innovation, this suggests the importance of disaggregating innovation activity into its component parts.

In assessing the empirical significance of the proposition relating to the regional character of HE and the effect of this on innovation activity at the enterprise level, an innovation or knowledge production function is used (e.g. Geroski, 1990; Harris and Trainor, 1995; Love and Roper, 2001, Jordan and O'Leary, 2007). These models are based on the premise that knowledge sourced by the enterprise (KS) is translated into innovation outputs (e.g. Geroski 1990; Harris and Trainor 1995; Jordan and O'Leary, 2007), and in which the effectiveness of firms' knowledge transformation activity is influenced by the strength of its resource-base (RB), barriers to innovation (BAR) and the receipt of public sector financial support (GOVT). In this model, we also incorporate measures to describe the profile of HEIs in the region in which the enterprise is located. In general terms where I_i is an innovation output indicator we write the innovation production function as:

[15] Wider organizational innovations include, changes to corporate strategy, the implementation of advanced management techniques, changes to organizational structure or the implementation of changes in marketing concepts or strategies.

(1) $$I_i = \Phi_0 RB + \Phi_1 KS + \Phi_2 BAR + \Phi_3 GOVT + \Phi_4 HEI + \epsilon_i$$

Enterprise's internal resource base is proxied through a variety of measures with the expectation that a strong internal resource base will contribute positively to the efficiency of innovation (Crepon et al, 1998; Loof and Heshmati, 2001). These measures include whether the enterprise is part of a larger corporate group, the sales profile of plants in penetrating export markets and whether or not the enterprise is a recent start-up (i.e. established after 1 Jan 2000). Measures of intra- group resources have proved important in previous research on innovation (Love et al., 1996; Love and Roper, 1999, 2001) while research findings suggest the importance of extra-regional links with customers is important in promoting innovation (Love et al 2008). In addition to these variables, with studies suggesting the presence of a quadratic relationship between enterprise size and innovation activity (Love and Roper, 2001) consideration is also made in the models of market position, mainly through enterprise size variables (employment and its square and turnover and its square). It is expected that where firms' internal resources are strong, for example, this would contribute positively to the efficiency with which firms develop new innovations (e.g. Crépon et al., 1998; Lööf and Heshmati, 2001 and 2002).

Knowledge sourcing activity is captured through both internal measures of innovation-related activities that contribute to innovation and external knowledge sourcing. A number of studies have emphasised strong correlation between activities that strengthen enterprise's absorptive capacity and innovation activity/outputs (Griffith et al 2003). Dummy variables are therefore included in the models on enterprise engagement in these activities, e.g. in-house R&D, training activities, design activities etc. as well as intensity measures for these variables through actual spend. External knowledge sourcing is assessed by enterprises co-operation with a range of supply-chain and non-supply chain partners including intra-group knowledge transfers (Howells, 2000), backward linkages to suppliers or external consultants (Horn, 2005), forward linkages to customers (Joshi and Sharma, 2004), linkages to competitors (Hemphill, 2003), to private sector laboratories (Bessand and Rush, 1995) and to universities or other public research centres (Roper, 2004).

We would also expect firms' innovation outputs to be negatively related to barriers to innovation (Hewitt-Dundas 2006) and positively related to the receipt of government assistance (e.g. Roper and Hewitt-Dundas, 2005; Link et al., 2005). Finally, measures are included in the models to capture the regional profile of HEIs. This is measured as the concentration of different university forms in each government office region (GOR) in the UK. In other words, for each enterprise in the UK CIS4, the appropriate Government-administered region is identified and regional indicators of the concentration of post-92, Group 1994 and Russell group universities in that region included.

The appropriate estimation method for the innovation production function depends primarily on the nature of the dependent variable. For examining enterprises' engagement in product innovation, process innovation and wider organisational innovation bivariate probit models are appropriate, while for innovation success i.e. the percentage of sales from new to the market products, (which is a percentage), a bounded Tobit estimator[16] is used.

[16] A range of econometric issues arise in estimating this type of innovation production function and we discuss these extensively elsewhere (Roper et al., 2006).

4 Empirical Findings

Knowledge Transfer Strategy

As the UK Government has committed to a permanent stream of funding for knowledge transfer or 'third stream' activity, HEIs have formulated and refined their knowledge transfer strategies. Across the different HEI groups, differences in strategic priorities are identified (Table 2). For Post 1992 HEIs, providing access to education, retaining graduates in the region, contributing to the regions skills needs and supporting the activities of SMEs are the most commonly cited aspects of their KT strategy, and these issues are significantly more important than for Group 1994 and Russell Group Universities. This emphasis on the provision of education and skills within the region as well as working with SMEs reflects the previous ethos of the Polytechnics in being embedded in the regional economy and offering skills and education closely aligned to this.

In contrast to the Post 1992 HEIs, for the Russell Group of HEIs while providing access to education was also cited as important (40 per cent), graduate retention was not cited by any of these HEIs with national skills needs as opposed to regional skills needs being identified as an important element of their contribution to economic development. The activities identified as central to knowledge transfer strategy among Russell Group HEIs were the importance of transferring technology and in undertaking research collaboration with industry. In addition, although only a small proportion of Russell Group HEIs identified spin-off activities as an important contribution to economic development (15 per cent), this was cited by significantly fewer Group 1994 HEIs and none of the Post 1992 HEIs.

In relation to the Group 1994 HEIs their emphasis on the various means of contributing to economic development is found to typically fall somewhere between the Post 1992 and Russell Group HEIs (Table 2). As found for the Russell Group HEIs, the most commonly cited means of contributing to economic development by Group 1994 HEIs was through research collaboration with industry, followed by providing access to education (50 per cent). For only 3 of the 13 means of contributing to economic development did Group 1994 HEIs place greater emphasis than that by the Post 1992 or Russell Group HEIs. These factors related to their role in attracting inward investment, in attracting non-local students and in management development. This suggests that Group 1994 perceive themselves as representing an important link between external knowledge and regional economic development. Their contribution to economic development is collaborative with the regional economy not only in attracting external knowledge (people and businesses) but in the development of management skills and collaborative research.

Drawing on HEFCE (2007) data we can identify the geographical area in which the HEIs perceive their role to be defined (Table 3). In general, Post 1992 HEIs are significantly more likely to define the immediate HEI area as the priority area for their institutional mission. For Group 1994 HEIs again the immediate area surrounding the HEI is the most important area, however the City area is more frequently cited by these HEIs, being identified by 11 per cent of Group 1994 HEIs as compared to 1.7 per cent of Post 1992 and none of the Russell Group HEIs. For Russell Group HEIs the majority stated that the area of greatest priority was either the RDA (45 per cent) or that no specific area defined their institutional mission (20 per cent). This data suggests therefore that for all HEIs, the government administered region is important in shaping the institutional mission. However at the same time, Post 1992s and Group 1994 more likely to identify the area as defined by the HEI. Russell Group HEIs are more likely to operate independent of a specific area which may reflect the internationalisation of their activities.

Capability to undertake knowledge transfer activity

As highlighted in the HEFCE (2007) HE-BCI report, in establishing government funding to support third stream activity in HEIs, a fundamental aim of this was to assist HEIs to establish and/or enhance their capacity to respond to both business and the wider community. For many HEIs 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. Examining the number of staff HEIs have recruited in their KT units is a useful proxy for the capability of HEIs to engage in KT activity.

The HE-BCI survey collects information on the number of full-time equivalent staff employed in dedicated KT units that engage with different types of partners. As was evident in terms of the KT strategy, again differences between HEI forms is found in the capacity to engage with business and the community (Table 4). For all HEI groups, i.e. Post 1992, Group 1994 and Russell Group HEIs, the majority of KT staff are focused on liaising with commercial partners followed by Public sector partners and then social, community and cultural partners. Despite this similarity, the average number of staff dedicated to liaising with commercial partners differs markedly between Russell Group HEIs (45.2 staff) and the Post 1992 (26.5 staff) and Group 1994 HEIs (16.6 staff). In all cases of liaising with external partners, the Group 1994 HEIs have on average fewer staff dedicated to KT activity than either the Post 1992 or Russell Group Universities. Indeed the Group 1994 HEIs have on average, just over a third of the staff dedicated to liaising with commercial partners (36.7 per cent) as that in Russell Group HEIs.

Differences in staffing between HEI forms are further accentuated in terms of the capability of HEIs to exploit IP, whether through the filing of patent applications or the identification of licensing opportunities (Table 4). Russell group HEIs almost without exception (95 per cent) have the in-house capability to source licensing opportunities. While this is higher than for Post 1992 and Group 1994 HEIs, Russell Group and Group 1994 HEIs are equally as likely to seek licensing opportunities, whether in-house or through external sourcing. Further, Group 1994 and Russell Group HEIs display a similar capability in terms of filing of patents with Group 1994 having slightly greater capability to file patents in-house. Post 1992 HEIs have significantly lower capability to file patents in-house, being much more dependent on the outsourcing to non-HEI organisations.

Focusing on the services offered through the KT unit in HEIs, a similar pattern of capability is found across the HEI forms. For example, almost all HEIs state that they provide an enquiry point for SMEs as well as providing indemnity insurance for staff which is particularly important in the undertaking of consultancy and contract research. While over 90 per cent of Post 1992 and Russell Group HEIs provide assistance to SMEs in specifying their needs, this is less common among Group 1994 HEIs. It is possible that this relates back to lower staff resourcing of KT Units in Group 1994 HEIs, in that while they can provide a focal point for SME enquiries, the capability to explore these enquiries and identify a suitable fit between SME needs and HEI capability (demand and supply) is restricted.

Further evidence of lower capability among Group 1994 HEIs is also found in relation to the presence of a commercialisation company in the HEIs to manage consultancy and other external interactions. While all Group 1994 HEIs have the capability to manage consultancy and external interactions, either through a company or department, they are less likely than Post 1992 or Russell Group HEIs to undertake this through a commercialisation company, being more dependent instead on a department. In other words, Group 1994 HEIs manage consultancy and other external interactions more informally than among Russell Group and Post 1992 HEIs.

Activity

In assessing KT-related activity across the HEIs, income is used as a proxy for the scale of activity. Data collected by HEFCE (2007) also enables analysis of the different types of external partners with which HEIs are liaising as well as their location and in particular the extent of engagement with regional partners.

Scale of KT Activity

Looking first at the scale of KT activities as measured by collaborative income, contract research income, consultancy income, facilities and equipment related services income as well as income from courses (Table 5) significant differences are apparent between the HEI forms. For each form of income the median income to Russell Group HEIs far exceeds that for either Group 1994 or Post 1992 HEIs. In other words, the average (median) Post 1992 HEI acquires only 7.0 per cent of the collaborative income, 3.6 per cent of contract research income, 6.5 per cent of income from facilities and equipment services and 18.9 per cent of the consultancy income as recorded by Russell Group HEIs. Post 1992 HEIs do perform slightly better in terms of relative income from providing courses for businesses and the community, with average (median) income being 96.4 per cent that of Group 1994 HEIs and 66.1 per cent that of Russell Group HEIs.

As for Post 1992 HEIs, the average Group 1994 HEI also report significantly lower levels of income across each of the measures as compared to Russell Group HEIs (Table X), however the disparity is less marked than that for the Post 1992s. The largest average difference between Group 1994 and Russell Group HEIs is for income from facilities and equipment services (4.7 per cent of the median Russell Group HEI income). Similarly, average consultancy income, contract research income and collaborative research income are also significantly lower among Group 1994 HEIs, relative to average Russell Group figures, at 10.2 per cent, 15.4 per cent and 25.3 per cent respectively. As with Post 1992 HEIs, similar levels of activity/income from courses for businesses and the community are recorded by Group 1994 HEIs relative to Russell Group HEIs.

External Partners

It is clear that significant differences exist in the scale of KT-related activities, as measured through KT-related income, with Russell Group HEIs reporting significantly higher income levels across all of the measures, with the exception of income from courses where the income gap is less marked. Another important aspect relating to the income generated relates to its source, both in terms of the partners involved and the geographical area in which the activity takes place.

Looking at each source of income provides an insight into the nature of KT activity being performed by the HEIs and differences between the HEI forms. In terms of collaborative income we find that OST Research councils account for the largest share of income among Group 1994 HEIs (41.8 per cent of total collaborative income), this compares to 30.1 per cent of total collaborative income among Russell Group HEIs. Russell Group HEIs also appear to be less dependent on UK Govt departments as co-funder of research, but more dependent on EU Government funding. 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 HEI-business engagement occurs on a European or international level. Indeed, this is where the largest gap (based on median income levels – Table X) are found between the Group 1994 and Russell Group HEIs, suggesting that while Group 1994 HEIs have similar ability in attracting OST research council funding for collaborative research, they are significantly less likely to attract EU Government funding, which if this is being acquired through EU Framework programmes, may reflect lower international presence amongst Group 1994 HEIs.

For Post 1992 HEIs, their most significant source of Collaborative income is from UK Government Departments (excluding OST research councils). Indeed, these HEIs have the lowest proportion of their income from OST Research Councils as well as EU Government sources.

In terms of contract research and consultancy income, again differences are found between HEI forms in the relative importance of different external partners. For Post 1992 HEIs three-quarters of all contract research income comes from non-commercial contracts, a value significantly higher than for Group 1994 and Russell Group HEIs where approximately half of contract research income is from this source. Group 1994 and Russell Group HEIs display similar levels of contract research activity with non-SME commercial partners, accounting for, on average, c.40 per cent of total contract research income. Although the contribution to the average total research income is small, the data suggests that for Group 1994 HEIs contract research with SMEs accounts for almost double the share of contract research income (8.4 per cent) than for Russell Group HEIs (4.6 per cent).

Income from consultancy contracts in Post 1992 and Group 1994 HEIs is dominated by the non-commercial sector, accounting for around two-thirds of total consultancy income. This proportion is considerably lower among Russell Group HEIs, at 39 per cent of total consultancy income. In contrast, Russell Group HEIs acquire a larger share of their consultancy income from the private sector, with SMEs and large businesses accounting for 21.3 and 39.7 per cent of income respectively. It should be noted however that for both Group 1994 and Russell Group HEIs, average income from consultancy is markedly lower than for contract research. This is not the case with Post 1992 HEIs where average (median) income from contract research and consultancy are roughly equal (around £700,000).

Approximately half of income from facilities and equipment (F&E) related services in Post 1992 and Russell Group HEIs comes from the non-commercial sector. This differs considerably from Group 1994, where private sector use of equipment and facilities dominates income from this source. In particular, income from SMEs is particularly important accounting for, on average, 46.2 per cent of F&E services income. Although this suggests that the private sector is more likely to use facilities and equipment in Group 1994 HEIs, the scale of this activity is considerably below that in either Post 1992 or Russell Group HEIs.

The provision of courses is one important mechanism through which knowledge can be transferred from the University. As found previously, although Russell Group HEIs are again acquiring a larger share of income from courses, the gap between them and both the Post 92 and Group 1994 HEIs is not as large as for other KT-related activities. For Russell Group HEIs, income from courses is dominated by large businesses and individuals whereas for Group 1994 and Post 1992 HEIs non-commercial partners dominate income from this activity. While for the Group 1994 HEIs individuals also act as an important source of income (32.5 per cent), large businesses are much less important than among Russell Group HEIs.

The final measure of KT related activity relates to income from licenses. Clearly across the HEI types, income from software licenses was extremely low with no significant differences found between the HEI forms. For non-software licenses both Group 1994 and Russell Group HEIs are obtaining revenue from this and while this remains relatively low, non software license income is significantly higher in Russell Group HEIs than in Group 1994 or Post 92 HEIs. In sum, IP Income is significantly higher among Russell Group HEIs than Group 1994 or Post 1992s with this accentuated when income from the sale of shares from Spin-off companies are included with this increasing median IP revenue in Russell Group HEIs by £16000, to £424,000 in 2005-06.

Regional 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.

Contract Research Income
Looking first at the proportion of contract research conducted by the different types of HEIs in their regional economy – both in terms of number and value of contracts –a number of significant differences are found. In general we find that Russell Group HEIs are undertaking c. one fifth of the research contracts in the region as compared to approximately a quarter of contracts for Group 1994 HEIs and a third of contracts for Post 1992 HEIs. Across the HEI groups, close correspondence is found between the number of research contracts and their value suggesting that the quality of contract research undertaken with partners in the region is similar to that with external partners.

In comparing the HEI groups a number of significant differences are apparent. First, Post 1992 HEIs are significantly more likely than Russell Group HEIs to undertake their contract research in the GOR. This difference between Post 92 and Group 1994 HEIs is not however found, with the only significant differences being the relative value of contract research with non-SME commercial firms as well as the overall total proportion of research contract income, with the regional value for both measures being significantly higher among Post 1992 HEIs.

In terms of differences between Group 1994 and Russell Group HEIs, overall Group 1994 HEIs were undertaking a significantly larger proportion of their research contracts in the GOR. Reflecting this, the relative value of contract research income undertaken within the GOR was also higher among Group 1994 HEIs.

Consultancy Income
The proportion of consultancy activity and income undertaken by HEIs in the GOR is similar to that for Contract Research Income, with the majority of consultancy contracts and associated value being performed outside of the GOR. This is particularly the case for Russell Group and Group 1994 HEIs with 73.8 per cent and 90.3 per cent respectively, of consultancy contracts conducted *outside* the GOR of the HEIs. Of particular interest however is the apparent scale of these regional consultancy contracts. While Group 1994 HEIs are the least likely to have regional consultancy contracts, where they do exist they are significantly larger than external contracts i.e. 9.7 per cent of contracts account for 33.5 per cent of income. In contrast among Russell Group HEIs, regional consultancy contracts are comparatively smaller, with 26.2 per cent of all consultancy contracts (i.e. those conducted in the GOR) accounting for only 17.4 per cent of consultancy income. Looking at the profile of consultancy contracts across the different actors suggests however that this regional concentration of value is dominated by consultancy contracts between Group 1994 and Non commercial partners where 4.3 per cent of all consultancy contracts by Group 1994 HEIs accounts for 40.5 per cent of their consultancy income.

Facilities and Equipment
In relation to regional partners using facilities and equipment in Regional HEIs, Post 1992 HEIs have the highest proportion of partners from within the region and Russell Group with the lowest proportion. In terms of value however it is Group 1994 HEIs that have the greatest regional presence, with 70.8 per cent of income from facilities and equipment coming from partners in the region (compared to 65.4 per cent of income for Post 1992 HEIs and 37 per cent for Russell Group HEIs). In general, for Group 1994 and Russell Group HEIs, the average income per contract for the use of facilities and equipment by partners in the region is larger than for non-regional partners. This

suggests more intense relationships between Regional partners and the use of Group 1994 and Russell Group facilities and equipment than that for Post 1992 HEIs.

CPD/CE Course Income
The profile of regional income from CPD/CE courses is markedly similar for Post 1992 and Group 1994 HEIs with between 40.0 and 50.0 per cent of all course income from regional partners. In contrast only 13.1 per cent of CPD/CE Course income generated by Russell Group HEIs is from the region with 90.7 per cent of income from large firms being derived from outside the region.

IP Income
IP income from software licenses is very low across all HEIs and therefore it is difficult to interpret regional activity for the issue of these licenses. For non-software licenses, Group 1994 and Russell Group HEIs were the main actors with both HEI groups having a similar proportion of this activity in the region. Overall, the vast majority (between 85 and 90 per cent) of IP income generated in 2005-06 by each of the HEI groups, originated from outside the regional economy.

5 Determinants of Innovation Activity and Success

Having identified a number of significant differences between HEI groups, this raises the following question: is there evidence of a relationship between the profile of HEIs in a region and business innovation? For example, in a region with a high concentration of Russell Group HEIs, does this have a significant effect on business innovation?

The results of estimating the innovation production function for different measures of innovation (i.e. equation 1) are shown in Tables 6 to 9. In Tables 6, 7 and 8 probit models are estimated in which the dependent variables are dummy variables for the different types of innovation: product, process and organisational innovation respectively. These models reflect the factors which influence the extent of each type of innovation across the population of UK businesses between 2002 and 2005. In each model estimation is also presented for manufacturing and service businesses separately. In Table 9 a tobit model is estimated for the proportion of businesses' sales derived from new to the market innovative products/services i.e. novel innovations. This model reflects the factors which influence the success of businesses' innovation activity. A broadly-based modeling strategy is adopted reflecting the exploratory nature of the models. The models are clearly significant overall, however, and the measures of fit (Pseudo R^2) are favorable to that obtained in other cross-sectional studies.

Across the estimation for innovation activity and innovation success, marginal effects on measures of firm's resource base, their knowledge sourcing activities, the barriers to innovation and government financial support for innovation are consistent with other research. For example, our results support other research demonstrating the importance of a strong internal resource base in contributing to the efficiency with which firms develop new innovations (Crepon et al 1998; Loof and Heshmati, 2001, 2002; Griffith, Redding and Van Reenan 2003). In particular, investment in R&D, the acquisition of machinery equipment and software, undertaking employee training, investing in design etc. are all found to positively affect the likelihood of firms undertaking innovation[17].

[17] It is interesting to note the importance of businesses investing in in-house R&D in contributing not only to product/service innovation but also to process innovation – indeed where a stronger affect is found. Further, investing in R&D is not only important for manufacturing businesses but also in the service sector. This confirms research by Zhara and George (2002) that business R&D may play an important part in shaping service firms' absorptive capacity. In addition, investing in R&D may mean that businesses are better able to capture the benefits from external knowledge sources (Veugelers and Cassiman, 1999; Roper et al, 2000).

Our main interest in the models relates to the profile of Universities in the region in which the businesses are located and whether or not this configuration of universities has an impact on innovation activity and success. The remainder of this discussion therefore focuses on the marginal effects for the Regional HEI profile variables in each of the estimations.

In terms of the probability of businesses engaging in product or service innovation we find that the higher the concentration of Group 1994 universities in a region, the greater the likelihood of businesses introducing new products or services (Table 6). In contrast, the concentration of Russell group or post 1992 Universities in a region has no significant effect on product/service innovation activity by businesses in that region. Re-estimating these models for the production and services sectors separately (Table 6) refines the significant marginal effect result for Group 1994 universities and highlights that this effect is significant only in the services sector.

The inclusion of business-level variables measuring whether or not businesses had formal innovation links with universities (at various spatial levels) or the access of useful information from Universities were not significant and excluded from the models. This suggests therefore that it is not formal innovation links that are positively contributing to product/service innovation activity, but more informal mechanisms of knowledge exchange, with this being much more important from Group 1994 universities than Russell Group or Post 1992 universities.

Estimation of the probability of businesses engaging in process innovation activities (Table 7) suggest that the concentration of Russell Group universities in a region has a positive and significant effect on the introduction of new processes. Similar evidence is not found however, for the concentration of Group 1994 or Post 1992 Universities in a region. However, re-estimation of the equations for the production sector and then the services sector suggests that as with the product innovation estimations, the positive effect on process innovation activities of a higher concentration of Russell group universities is capturing their effect on service sector businesses. Further, for manufacturing businesses we now find a positive and significant effect between the concentration of Group 1994 universities in a region and process innovation.

Direct measures of interaction between businesses and Universities suggest that links with universities in other EU countries (outside the UK) has a positive effect on process innovation activity, however again the coefficients are capturing a service sector effect.

In an attempt to capture innovation as a broader organizational activity and the potential impact of regional university profile on this, the equations were estimated for organizational innovation (Table 8). Again the concentration of Group 1994 Universities in a region is found to have a positive and significant effect on organizational innovation activity in businesses in that region. On re-estimating these equations for product and service sectors no independent effect was found however. In addition to the Group 1994 Universities, some evidence is found of a positive effect of the concentration of Post 1992 Universities in a region and organizational innovation in service sector businesses in that region.

Significant effects are also found in this model on Business-level measures from CIS data on businesses accessing information from Universities and formal innovation links with universities. Where businesses state that they have accessed useful information from Universities then this has a positive effect on organizational innovation. However, where businesses have a formal innovation link with local universities this has a significantly negative effect on organizational innovation in the business. One possible reason for this result is that where formal innovation links with local universities occur these tend to be for product or process-related activities and therefore businesses

engaging in these may be less likely to undertake organizational innovation. It is not possible however to verify this from the CIS data.

The final model is concerned with innovation success and those factors contributing to a higher proportion of businesses sales from new and/or modified products or services (Table 9). In this model only the concentration of Group 1994 universities is found to have a significant effect on innovation success, with again this result largely arising from the service sector. Other variables on external knowledge sourcing from universities were not found to be significant in this model and therefore excluded.

6 Discussion and Conclusions

In this paper we have explored two main issues concerning the role of universities in the knowledge economy. First, we have examined the approach to knowledge transfer of UK universities and attempted to identify if heterogeneity exists reflecting diversity in institutional forms: specifically between Post 1992, Group 1994 and Russell group universities. Second, with research pointing to the importance of proximity in capturing the benefits from universities – and in particular from university research – we have considered the extent of regional engagement by UK universities and the effect of this on business innovation and success. In relation to this we have considered not only formal channels of regional engagement by the universities as measured by income streams, but also attempted to capture more informal effects on business innovation through the regression analysis.

In relation to the strategic priorities of UK universities in contributing to economic development differences within the university system are identified. Post 1992 universities are much more likely to stress their contribution as providing access to education, retaining graduates in the region, contributing to the regional skills base and supporting SMEs. Group 1994 universities, like Post 1992 universities also emphasise their role in contributing to regional skills and graduate retention, however these universities also perceive themselves as having a role in attracting to the region, non-local students and inward investment. Russell group universities are much less likely to consider their economic contribution at a regional level, but instead are more likely to emphasise their role in developing national skills, in transferring technology and in undertaking research collaboration with industry. There is clearly a marked difference between the University groups in terms of the geographical area at which they perceive their economic contribution to be greatest. This area is the most limited for Post 1992 universities in terms of their immediate HEI area, extending to the City area for Group 1994 universities and further, to the Region and beyond for Russell Group universities. Indeed, for a fifth of Russell group universities no geographical area is identified, most likely reflecting the internationalization of research, teaching and knowledge networks.

UK government policy to promote greater university-business engagement led to initial public sector funding for third steam activity through HEROBC (1999/2000). This and subsequent funding was directed towards establishing the capacity in HEIs to liaise with business and the community and to commercialise knowledge generated in the HEIs. In general we find that most knowledge transfer resources are directed at the commercial sector across the universities. However, Group 1994 universities tend to have fewer staff committed to third stream activity, equating to only a third of the staff in Russell group universities liaising with commercial partners. At the same time, no significant differences are found between university groups in the services that they offer, their ability to file patent applications and their capability to identify licensing opportunities. The only area where variation in capability between the university groups is found relates to the organisational structures for managing consultancy and other external interactions. Here we find that Russell group universities manage these activities more formally through a company whereas Post 1992 and Group

1994 universities are more likely to perform this informally as part of a broader knowledge transfer unit.

Despite the similarity in capability across the University groups, significant differences are found in the extent to which universities undertake knowledge transfer activities, with whom they perform this activity and the proportion of activity captured within the region. In relation to scale of activity, across all of the forms of knowledge transfer, Russell group universities far exceed the level of income obtained by Group 1994 or Post 1992 universities. This disparity is however less marked for income from courses where average Post 1992 income is only marginally below that in Group 1994 universities and around two-third that in Russell Group universities. What is clear however is that consultancy is relatively less important to Group 1994 and Russell group universities than contract and collaborative research income. In contrast, for Post 1992 universities a similar level of income is obtained from each of these sources with income from courses providing the most significant funding stream. This suggests the focus of Post 1992 universities on teaching and associated income generation while for Group 1994 and Russell Group universities the priority of the university on research is reflected in the disproportionate share of knowledge transfer income from research related activity i.e. collaborative and contract research.

Looking at the partners with which the universities engage, in general we consistently find significant differences between Post 1992 and Russell Group universities. First of all, in terms of collaborative research income, Post1992 universities are most likely to receive funding from UK Government sources, for Group 1994 universities research council funding is the dominant source followed by other Government sources while for Russell group universities EU programmes account for the largest share of funding followed by research council grants. It could be argued that this pattern of funding reflects two trends: first, research capability in the universities with higher quality research ability in Group 1994 and Russell Group universities leading to a larger share of research council funding; second, this reflects the area in which the universities feel they make the greatest contribution with Post 1992 universities most likely to look to the local area where government funding is available while Russell group universities pursue a much wider national and international agenda.

Russell group and Group 1994 universities display a similar profile of contract research between SMEs, large firms and non-commercial partners. In contrast, Post 1992 universities are much less likely to engage with large firms but more likely to undertake contact research with non-commercial partners. Again this may be indicative of research quality in the respective university groups with small firms and non-commercial organizations requiring less challenging expertise from the Universities as compared to large firms. The implication is that large firms wishing to pursue contract research with a university will be much more likely to approach Group 1994 or Russell group universities than Post 1992 universities. Further, as reflected in the actual value of research contracts, the majority of these occur with research intensive universities, and in particular the Russell Group Universities.

In relation to consultancy activity, again the majority of these contracts – by value - are with Russell Group universities, however consultancy income is relatively more important in Post1992 and Group 1994 universities. Income from the hire/use of facilities and equipment is relatively more important in Group 1994 and Russell Group universities. This may suggest a leveraging effect whereby the purchase of advanced equipment through research grants later generates income through external use. Further, this income level may also reflect the reputational or ‘halo’ effect of Russell Group and Group 1994 universities in attracting private and non-private organizations to hire facilities. Similarly, it is likely that reputational effects are also important in generating income from courses

among the University groups. In particular, Group 1994 and Russell Group universities attract a significant share of income from individuals with Russell Group accounting for a disproportionate share of income from large businesses.

Regional Activity -
In capturing the extent of knowledge transfer activity at the level of the region, consideration must be given not only to the relative share of activity undertaken in the region, but also to the total level of activity. For example, for Russell group universities, on average only 18.5 per cent of the value of contract research in 2005-06 was performed with regional organizations. However, taking this as a proportion of total contract research income which is significantly greater among Russell Group universities, means that these universities accounted for c. 62 per cent of all regional contract research income.

In general we find, almost without exception, that the *share* of knowledge transfer activity undertaken in the region, is larger in Post 1992 and Group 1994 universities than among Russell Group universities. However, due to significantly larger investment in activity among Russell Group universities, for contract research and income from facilities and equipment, Russell group universities account for 62 and 47 per cent of all regional activity, respectively.

Having established significant differences in knowledge transfer activity within the university sector, in the estimations we considered if the profile of universities in a region has any effect on business innovation and success. Across the models we find evidence that the profile of universities in a region has an effect on business innovation, but that this effect varies by type of university and type of innovation being considered. For example, Group 1994 universities have a positive effect on firms in a region undertaking product/service innovation, process innovation and organizational innovation. Russell Group universities are found to have a positive effect on innovation only in relation to process innovation while a significant effect of Post 1992 Universities is found only for Service sector businesses undertaking organizational innovation. These findings support other research identifying a positive relationship between the knowledge and technology transfer activities of research institutions and firms' innovation performance (Arvanitis et al 2005). At the same time the positive findings contrast with that of Becker in Germany (2003) and Hall et al in the US (2003) where university knowledge as an external knowledge source was not found to have a significant effect on product innovation. One important distinction to make is that between formal and informal links (knowledge sourcing) between businesses and universities. In the estimations in this paper variables for formal interaction are included in the models, and only found to be significant in terms of the probability of businesses performing process or organizational innovation. For example, formal innovation links with Universities are found to have a positive effect on process innovation, however these links are with universities in EU countries outside the UK. Indeed, formal innovation links with local universities are found to have a significant negative effect on the probability of businesses undertaking organizational innovation. By including measures of the profile of universities in a region we are therefore capturing a more indirect effect of universities on business innovation than that from normal CIS type indicators.

In relation to whether the proximity of universities to businesses effect innovation, research such as that by Beise and Stahl (1999) in Germany and Monjon and Waelbroeck (2003) in France suggest that proximity between public research and business innovation does not have a significant effect on innovation activity and success. In contrast, Kaufmann and Todtling (2001) not only point to a positive effect of university cooperation on innovation activity but that proximity is important in these relationships. Furthermore, they also found that it was pure science as opposed to applied research focusing on commercialization that drove innovation activity. This confirms the findings in

the models, suggesting that it is predominantly the more research intensive universities that have a positive effect on innovation as opposed to the Post 1992 universities.

Perhaps most surprising aspect in the models is the lack of significance in the production sector, with the University effect instead being most apparent in the service sector. This supports other research by Fritsch and Frank (2004) who also found a positive effect of service sector collaborations with public sector research organisations. The rationale behind this bias towards the service sector may reflect the greater importance of inter-organisational connectivity and the associated geographical proximity of this (Ref) however, this is not obvious from the data and is certainly an issue that warrants further investigation. This is particularly the case as much knowledge transfer activity in universities is directed towards technology transfer activity, which tends to be exploited and commercialised in the production rather than the service sectors.

In conclusion, this paper has demonstrated that there are significant disparities in the university sector as assessed through the knowledge transfer strategy of universities and the scale of activity that they engage in. This therefore supports a rising consciousness in UK policy making of the heterogeneity of the University sector and differential contribution to economic development, particularly at a local and regional level. The findings also suggest that proximity is important between universities and businesses, although this tends not to be in terms of formal innovation links. Instead as reflected in the models in this paper the effect of universities on business innovation and success is better captured by more indirect measures. Other research (Young et al 2008) suggests that where businesses require specialist expertise or technology accessible from a university, then this be with the appropriate university, irrespective of proximity. However, the findings in this paper also suggest that in a much broader sense, local or regional universities do have an effect on business innovation. However, this effect is not even across the university sector, with more research intensive universities having a stronger regional effect on business innovation than more business-facing universities i.e. Post 1992 universities.

This last finding is critical to current policy making in the UK. From a policy perspective, if HERD is perceived as complementing private R&D then in those regions where private R&D is weak then knowledge transfer from the HE sector will become increasingly important in stimulating regional productivity and growth. The danger of such an approach is that where a two-track university system is perceived with different institutional missions (i.e. curiosity-driven research and teaching as compared to user-driven research, problem solving and professional teaching) then there is a danger that 'business-facing' universities will be encouraged in regions with weak R&D capability and research universities encouraged in more successful regions. The problem with such an approach is that the research findings presented in this paper suggests that it is not the universities undertaking Government sponsored applied research that make the greatest contribution to business innovation, but rather the more research intensive universities. These universities are undertaking basic research funded typically through the Government's research councils and EU funding. The research may not be directly exploitable by businesses in the short-term (through direct formal innovation links) but rather it is through the transfer of knowledge in more indirect ways for example through the training of graduates, university procurement, use of facilities and equipment, spin-out companies etc. that contributes positively to business innovation and success.

Table 1 Regional profile of higher education institutions in the UK

GOR	Russell Group		Post 1992		Group 1994		Other		Total HEI	GOR Pop (000's)	Pop per HEI
	n	%	n	%	n	%	n	%	n		
North East	1	20.0	3	60.0	1	20.0	0	0.0	5	2558.3	511.7
North West	2	14.3	8	57.1	1	7.1	3	21.4	14	6846.3	489.0
York. & Humber.	2	20.0	4	40.0	1	10.0	3	30.0	10	5063.9	506.4
East Midlands	1	11.1	5	55.6	2	22.2	1	11.1	9	4306.3	478.5
West Midlands	2	16.7	5	41.7	0	0.0	5	41.7	12	5365.4	447.1
Eastern England	1	11.1	3	33.3	2	22.2	3	33.3	9	5541.6	615.7
London	4	10.3	10	25.6	4	10.3	21	53.8	39	7517.7	192.8
South East	2	11.8	7	41.2	4	23.5	4	23.5	17	8164.2	480.2
South West	1	7.7	4	30.8	2	15.4	6	46.2	13	5067.8	389.8
Wales	1	9.1	2	18.2	0	0.0	8	72.7	11	2958.6	269.0
Scotland	2	10.5	6	31.6	1	5.3	10	52.6	19	5094.8	268.1
Northern Ireland	1	50.0	1	50.0	0	0.0	0	0.0	2	1724.4	862.2

Source: GOR Population Values based on Mid-2005 Population Estimates, ONS (2005) Key Population and Vital Statistics, Local and Health Authority Areas, VS No. 32, PPI No. 28, Table 1, p.10 ISSN 1469-2732

Table 2 Universities perceived contribution to economic development

	(1) Other Universities (%)	(1)(2)(3)(4)	(2) Post 92 (%)	(2) (3) (4)	(3) Group1994 (%)	(3) (4)	(4) Russell Group (%)
Access to Education	53.1	***	81.0	***	50.0		40.0
Graduate Retention	15.6	**	31.0	**	16.7	*	0.0
Technology Transfer	31.3	***	25.9	***	33.3	***	80.0
Supporting SMEs	29.7	*	36.2	**	16.7		10.0
Attracting Inward Inv	3.1		1.7		11.1		10.0
Research Collab with Ind	32.8	***	15.5	***	61.1		80.0
Attracting non-local students	15.6	**	5.2	***	33.3		15.0
Support Comm Dev	18.8	*	10.3		5.6		0.0
Develop Local Partnerships	17.2	*	25.9	**	5.6		5.0
Mgt Development	3.1		1.7	*	11.1		0.0
Regional Skills Needs	32.8	***	53.4	***	27.8	***	0.0
National Skills Needs	39.1	***	12.1	***	22.2		45.0
Spin Off Activity	3.1	**	0.0	**	5.6		15.0
Strategic Analysis of Reg Economy	1.6		0.0		0.0		0.0

Table 3 Area of greatest priority in universities institutional mission

	(1) Other Universities (%)	(1)(2)(3)(4)	(2) Post 92 (%)	(2) (3) (4)	(3) Group1994 (%)	(3) (4)	(4) Russell Group (%)
No Specific Area	17.2	**	1.7	**	5.6		20.0
RDA area e.g. West Midlands, South West etc.	31.3		29.3		27.8		45.0
Local Authority Area e.g. County	1.6		0.0		0.0		0.0
Locality – City or Town	6.3		1.7	*	11.1		0.0
Defined by HEI*	43.8	**	67.2	*	55.6		35.0

Source: HEFCE (2007) Annex 1, Qu 6

* The area as defined by the HEI may include surrounding counties especially where the HEI crosses regional boundaries or is multi-county (HEFCE, (2007) Annex A, Qu.6)

Table 4 Capability of UK HEIs to deliver knowledge transfer activity, 2005-06

	Other Universities (1)	(1) (2) (3) (4)	Post 92 (2)	(2) (3) (4)	Group 1994 (3)	(3) (4)	Russell Group (4)
Staff Employed in Dedicated Bus & Community Function (Full-time equivalent)							
Staff with Commercial Partners	11.2	***	26.5		16.6		45.2
Staff with Public Sector Partners	6.5	***	16.2		10.4		14.1
Staff with Social Community and Cultural partners	6.5		10.0		5.3		14.3
Dedicated Unit providing the following (% of HEIs)							
Enquiry point for SMEs	89.8		96.6		100.0		95.0
Assistance to SMEs in specifying their needs	84.7		91.4		77.8		90.0
Contracting system for staff-business and community interaction	67.8		81.0		83.3		75.0
Indemnity insurance for Staff	81.4	*	91.4		100.0		95.0
Filing of Patents (% of HEIs)							
In-house filing	36.4	**	17.6	***	52.9		45.0
Outsourcing of filing (to non-HEI org)	47.7	***	80.4		70.6		60.0
Other IP Protection action	59.1		49.0		41.2		40.0
Identification of licensing opportunities for IP (% of HEIs)							
In-house capability	53.1	***	75.9		88.9		95.0
External sourcing	12.5		13.8		5.6		0.0
No capability (internal or external)	34.4	***	10.3		5.6		5.0
HEI has commercialization company to manage consultancy & other external interactions (% of HEIs)							
No	18.8	***	1.7		0.0		5.0
Yes – Exploitation Company	6.3	**	1.7	**	5.6		20.0
Yes – Exploitation Dept	60.9	**	50.0	**	55.6	**	20.0
Yes – Both Company & Dept	14.1	***	46.6		38.9		55.0

Source: HEFCE, HE-BCI (2007), Annex A

Table 5 Income from Knowledge Transfer-related activity in UK HEIs, 2005-06

	Other Universities (1)		Post 92 (2)		(2) and (3)	(2) and (4)	Group1994 (3)		(3) and (4)	Russell Group (4)	
	£000s	%	£000s	%			£000s	%		£000s	%
Collaborative Income* 2005-06 (£000s median)											
OST Research Councils	0.0	37.1	113.0	20.7	***	***	824.0	41.8		1174.0	30.1
Other UK Govt Depts	0.0	39.1	365.0	47.3	**	***	881.0	27.0		1692.5	17.8
EU Government	0.0	14.5	67.0	19.5	***	***	737.5	22.8	***	3627.0	34.7
Other	0.0	9.4	25.0	12.4	*	***	60.0	8.3		133.0	17.4
Total Collaborative Income	137.0	100.0	696.0	100.0	***	***	2490.5	100.0	**	9840.0	100.0
Contract Research Income 2005-06 (£000s median)											
SMEs	0.0	8.2	6.0	6.9	***	***	136.0	8.4	***	758.5	4.6
Non SME Commercial	0.0	44.7	114.0	17.8	***	***	741.5	41.0	***	6695.0	42.1
Non Commercial	0.0	47.13	347.0	75.2	**	***	1124.5	50.6	***	9743.0	53.3
Total Contract Research Income	133.0	100.0	697.0	100.0	***	***	2977.0	100.0	***	19320.5	100.0
Consultancy Income 2005-06 (£000s median)											
SMEs	5.0	15.3	75.0	16.4		***	26.5	6.9	*	443.5	21.3
Non SME Commercial	0.0	34.5	92.0	24.4		***	159.5	28.0		1218.0	39.7
Non Commercial	41.0	50.1	345.0	59.2	**	***	204.5	65.0		1080.0	39.0
Total Consultancy Income	105.0	100.0	703.0	100.0	**	***	378.5	100.0		3705.0	100.0
Facilities and Equipment Related Services Income 2005-06 (£000 median)											
SMEs	0.0	16.7	6.0	33.2	**	***	21.0	46.2		155.0	22.7
Non SME Commercial	0.0	21.1	0.0	18.3	***	***	2.0	36.4		179.0	27.0
Non Commercial	0.0	62.2	7.0	48.5		***	17.0	17.3	*	264.0	50.3
Total F&E Income	17.0	100.0	72.0	100.0	**	***	52.5	100.0		1103.0	100.0
Income from Courses for Business and Community (£000 median)											
SMEs	0.0	5.4	29.0	9.2			24.5	10.5		50.5	2.9
Non SME Commercial	0.0	44.7	97.0	17.3		**	43.0	17.9	*	424.5	27.5
Non Commercial	1.0	26.7	816.0	47.9	*		435.0	39.1		578.5	21.8
Individuals	21.0	23.2	73.1	25.6		**	341.0	32.5	**	323.0	47.8
Total Income from Courses	242.0	100.0	1806.0	100.0		**	1873.5	100.0		2733.5	100.0
Total Learner Days of CPD/CE courses delivered (median)	600.0	n/a	9658.0	n/a			9595.0	n/a		10342.0	n/a
IP Income (median)											
Software Licenses	0.0	n/a	0.0	n/a			1.0	n/a		1.5	n/a
Non Software Licenses	0.0	n/a	0.0	n/a		***	4.5	n/a	***	17.0	n/a
IP Income Sub Total	0.0	n/a	0.0	n/a		***	49.5	n/a	**	408.0	n/a
IP Income Total	0.0	n/a	0.0	n/a		***	49.5	n/a	***	424.0	n/a

Source: HEFCE, HEBCI (2007) Annex B

Notes: Collaborative Income defined as income from collaborative research involving both public funding and funding from business (£000s). IP Income Total is the sum of IP Income Sub Total plus income from the Sale of Share of Spin-off companies

Table 6 Regional Concentration of Knowledge Transfer-related activity and income in the UK, 2005-06

	Other Universities (1)		Post 92 (2)			Post 92 (2)			Group1994 (3)				Russell Group (4)	
	No. %	**Value %**	**No. %**	(2) and (3)	(2) and (4)	**Value %**	(2) and (3)	(2) and (4)	**No. %**	**(3) and (4)**	**Value %**	(3) and (4)	**No. %**	**Value %**
Contract Research Income 2005-06 (mean proportion)														
SMEs % in Region	**29.1**	**20.1**	**56.3**		***	**53.6**		***	**37.8**	**	**31.2**	***	**42.4**	**46.6**
Non SME Commercial % in Region	**6.3**	**5.1**	**23.8**		***	**19.8**	**	***	**10.3**	***	**7.1**	**	**11.1**	**12.5**
Non Commercial % in Region	**26.7**	**22.5**	**30.3**		***	**26.0**		***	**30.2**	*	**31.8**		**22.1**	**20.8**
Total Contract Research Income % in Region	**`8.7**	**14.6**	**32.2**		***	**26.8**	**	***	**23.8**	**	**21.6**	**	**19.5**	**18.5**
Consultancy Income 2005-06 % in RDA														
SMEs (%)	**78.5**	**51.6**	**45.7**			**59.2**		**	**73.1**		**63.2**		**51.2**	**32.0**
Non SME Commercial (%)	**51.6**	**27.6**	**30.5**			**31.6**		**	**21.9**		**9.8**		**14.1**	**10.1**
Non Commercial (%)	**34.4**	**29.9**	**43.8**			**33.2**	*		**4.3**		**40.5**		**17.5**	**16.9**
Total Consultancy Income (%)	**58.1**	**32.4**	**43.2**			**37.1**	*	***	**9.7**		**33.5**		**26.2**	**17.4**
Income from Facilities and Equipment 2005-06 % in RDA														
SMEs (%)	**53.7**	**28.4**	**72.3**			**75.5**	**	**	**61.3**		**94.6**		**58.5**	**74.6**
Non SME Commercial (%)	**39.1**	**30.9**	**53.9**			**31.1**	*	***	**39.0**		**46.2**		**13.6**	**12.2**
Non Commercial (%)	**57.3**	**15.0**	**67.0**			**71.4**		**	**50.9**		**59.1**		**24.9**	**33.3**
Total F&E Income (%)	**53.3**	**20.6**	**66.8**			**65.4**	*	***	**52.4**		**70.8**		**32.7**	**37.0**
Income from CPD/CE Courses 2005-06 % in RDA														
SMEs (%)		**17.2**	n/a			**74.0**			n/a		**72.6**		n/a	**57.3**
Non SME Commercial (%)		**5.7**	n/a			**25.9**			n/a		**22.5**		n/a	**9.3**
Non Commercial (%)		**32.5**	n/a			**46.6**		**	n/a		**46.1**		n/a	**16.8**
Individuals (%)		**25.1**	n/a			**49.0**			n/a		**41.1**		n/a	**11.0**
Total CPD/CE Income (%)		**18.0**	n/a			**46.1**		**	n/a		**43.0**		n/a	**13.1**
IP Income % in RDA														
Software Licenses		**7.7**	n/a			**52.5**			n/a		**5.9**		n/a	**11.4**
Non Software Licenses		**4.4**	n/a			**31.8**		***	n/a		**26.7**	**	n/a	**26.6**
Sub-Total IP Income		**2.3**	n/a			**14.7**		***	n/a		**12.3**	**	n/a	**10.9**
Notes: t-tests														

Notes: Figures refer to the proportion of activity undertaken in the Government Office Region and based on mean values.
Source: Data from HEFCE, HEBCI (2007) Annex B

Table 7 Determinants of Product/Service Innovation in the UK: marginal effects from Probit Model

Product/Service Innovator	All Businesses			Production			Services		
	dy/dx	Std. Err.		dy/dx	Std. Err.		dy/dx	Std. Err.	
Enterprise Characteristics									
Part of Group	0.0330	.01015	***	0.0165	.01717		0.0446	0.0125	***
Large Plants	-0.0493	0.0110	***	-0.0461	0.2020	**	-0.0561	0.0131	***
Employment Growth (2002-04) Ln	0.06618	0.0122	***	0.1135	0.0239	***	0.0504	0.0140	***
Wider Organisational Innovation	0.1004	0.0099	***	0.08683	0.0163	***	0.1109	0.0126	***
Sales UK	0.0518	0.0107	***	0.0638	0.0196	***	0.0453	0.0128	***
Sales Other EU	0.0666	0.0109	***	0.0825	0.0180	***	0.0425	0.0141	***
Main Customer – Public Sector	0.0528	0.0161	***	0.7362	0.0276	***	0.0391	0.0194	**
Sector – Primary	-0.161	0.0270	***	-0.1929	0.0321	***			
Sector - Construction	-0.0887	0.0157	***	-0.0919	0.0216	***			
Innovation Activity									
Process Innovator	0.2360	0.0122	***	0.3464	0.1899	***	0.1881	0.0158	***
In-house R&D	0.2080	0.0110	***	0.2552	0.1681	***	0.1684	0.0147	***
Acq mach, equ & software	0.03123	0.0107	***	0.0428	0.0179	**	0.0210	0.0133	
Training	0.05615	0.0106	***	0.4250	0.0174	**	0.0719	0.0137	***
Design	0.1101	0.0127	***	0.1381	0.0187	***	0.0725	0.0174	***
In-house R&D (£'000)	0.00001	0.0000	***	0.0556	0.0000	***	0.00001	0.0000	**
Acq Ext Knowledge (£'000)	0.0000	0.0000	***	0.7300	0.0000	**	0.00006	0.0000	**
Training (£'000)	0.0000	0.0000	***	-0.012	0.0000	***	-0.0001	0.0000	***
Innovation Links									
Innov Link – Suppliers	0.06943	0.0218	***	0.0674	0.0361	*	0.0706	0.0273	***
Innov Link – Client/Customer	0.1302	0.0232	***	0.1737	0.0379	***	0.1007	0.0290	***
Barriers to Innovation									
Barrier to Innov – Perceived Risk	0.0463	0.0148	***	0.0494	0.0259		0.0686	0.0179	***
Barrier to Innov – Costs	0.0364	0.0155	**	0.0487	0.0266	*	0.0351	0.0188	*
Barrier to Innov – Info on Tech	-0.0498	0.0157	***	-0.2717	0.0264		-0.0655	0.0192	***
Barrier to Innov – Info on Mkts	0.04509	0.0159	***	0.2444	0.0271		0.0582	0.0197	***
Barrier to Innov – Uncertain Demand	0.11270	0.0130	***	0.1261	0.0220	***	0.1039	0.0161	***
Barrier to Innov – EU regulations	-0.02971	0.0111	***	-0.2505	0.1867		-0.0341	0.0136	**
Regional HEI Profile									
Post 92 Universities in Region (%)	0.00009	0.0005		0.0109	0.0009		-0.0002	0.0006	
Group 1994 Universities (% in Region)	0.0016	0.0005	***	0.0646	0.0009		0.0024	0.0007	***
Russell Group Universities (% in Region)	-0.0003	0.0005		0.0244	0.0008		-0.0006	0.0007	
Number of obs	13093			5741			7352		
LR chi 2 (26)	5211.06			2798.9			2428.8		
Prob > chi2	0			0			0		
Pseudo R2	0.3131			0.3693			0.2701		
Log likelihood	-5716.98			-2389.8			-3282.08		

Table 8 Determinants of Process Innovation in the UK: marginal effects from Probit Model

Process Innovator	All Businesses			Production			Services		
	dy/dx	Std. Err.		dy/dx	Std. Err.		dy/dx	Std. Err.	
Enterprise Characteristics									
Small Plants (1/0)	-0.06291	0.0086	***	-0.04790	0.0141	***	-0.07518	0.0109	***
Medium Plants (1/0)	-0.04297	0.0084	***	-0.03618	0.0137	***	-0.04770	0.0105	***
Turnover Growth Ln	0.02166	0.0060	***	0.02603	0.0117	**	0.01790	0.0068	***
Construction	-0.1016	0.0086	***	-0.09853	0.0122	***			
Retail and Distibution	-0.0555	0.0084	***				-0.07998	0.0097	***
Other Services	-0.04477	0.0079	***				-0.06780	0.0096	***
Innovation Activities									
Product Innovator	0.12975	0.0121	***	0.17611	0.0188	***	0.09572	0.0155	***
Wider Organisational Innovation	0.05857	0.0096	***	0.06124	0.0145	***	0.05322	0.0126	***
Corporate Strategy	0.02397	0.0095	**	0.03402	0.0151	**	0.01457	0.0120	
Advanced Man Techniques	0.03363	0.0098	***	0.03323	0.0155	**	0.03515	0.0126	***
New to Market Innov	0.03285	0.0108	***	0.01561	0.0153		0.04809	0.0154	***
Innov Sales - New to Enterprise (%)	0.00095	0.0002	***	0.00063	0.0004		0.00114	0.0003	***
Innov Sales – Improved Prod/Serv (%)	0.00065	0.0002	***	0.00114	0.0003	***	0.00034	0.0002	
In-house R&D	0.02713	0.0081	***	0.03038	0.0126	**	0.02649	0.0105	**
Acq mach, equ & software	0.14714	0.0077	***	0.17970	0.01166	***	0.12704	0.0103	***
Training	0.07374	0.0079	***	0.05386	0.0120	***	0.08352	0.0105	***
Innovation Links									
Innov Link – Group	0.03115	0.0152	**	0.01929	0.0224		0.03937	0.0204	**
Innov Link - Suppliers	0.09786	0.0162	***	0.09656	0.0247	***	0.10284	0.0217	***
Innov Links - Consult, Comm Lab, Private R&D	-0.03445	0.0127	***	-0.01832	0.0209		-0.04695	0.0154	***
Innov Links - HEI other EU	0.09842	0.0489	**	0.05072	0.0652		0.13879	0.07181	**
Barriers to Innovation									
Barrier to Innov - Costs	0.04768	0.0102	***	0.04329	0.1617	***	0.05261	0.0130	***
Barrier to Innov - cost of finance	-0.04081	0.0135	***	-0.02735	0.0219		-0.04814	0.0168	***
Barrier to Innov - available finance	0.02826	0.0116	**	0.02589	0.0186		0.03331	0.0148	**
Barrier to Innov - Established enterprises	-0.02289	0.0088	***	-0.01904	0.0140		-0.02443	0.0111	**
Public Support									
Govt support for Innovation	0.06314	0.0140	***	0.05813	0.0192	***	0.06445	0.0204	***
HEI Regional Profile									
Group 1994 Universities (% in Region)	0.0003	0.0004		0.00155	0.0006	**	-0.00074	0.0005	
Russell Group Universities (% in Region)	0.0014	0.0003	***	0.00006	0.0006		0.00237	0.0005	***
Post 92 Universities in Region (%)	0.0004	0.0004		0.00016	0.0006		0.0004	0.0005	
Number of obs	13293			5731			7562		
LR chi 2 (26)	4099.59			2079.23			2081.9		
Prob > chi2	0			0.00			0.00		
Pseudo R2	0.2875			0.3229			0.2671		
Log likelihood	-5080.67			-2180.10			-2856.13		

Table 9 Determinants of Organisational Innovation in the UK: marginal effects from Probit Model

Dependent Variable = Wider Organisational Innovation	All Businesses dy/dx	Std. Err.		Production dy/dx	Std. Err.		Services dy/dx	Std. Err.	
Enterprise Characteristics									
Employment Growth ln	0.03752	0.0130	***	0.10102	0.0219		0.04904	0.0164	***
Small Enterprise	-0.12107	0.0113	***	-0.11315	0.0172	***	-0.12755	0.0151	***
Large Enterprise	0.07672	0.0140	***	0.06549	0.222	***	0.07777	0.0184	***
Sales UK	0.09652	0.0103	***	0.08057	0.0173	***	0.11077	0.0133	***
Ent. Est. after 1 Jan 2000	0.04150	0.0150	***	0.05754	0.0244	**	0.02994	0.0191	
Sector									
Primary	0.11758	0.0392	***	0.11950	0.0410	***			
Other Manufacturing	-0.03152	0.0127	***	-0.01431	0.0167				
Construction	0.04941	0.0175	***	0.05061	0.0222	**			
Knowledge intensive services	0.12546	0.0134	****				0.11478	0.0148	***
Innovation Activity									
Process Innovator	0.16610	0.0123	***	0.16745	0.0184	***	0.16962	0.0168	***
Product Innovator	0.14339	0.0126	***	0.12129	0.0192	***	0.16435	0.0168	***
Innov Sales - New to Enterprise (%)	0.00112	0.0004	**	0.00163	0.0006	**	0.00075	0.0006	
Training (£'000)	0.00032	0.0000	***	0.00040	0.0000	***	0.00028	0.0000	***
Innov Activities (2002-04) on-going or abandoned	0.10262	0.0155	***	0.10857	0.0214	***	0.10318	0.0229	***
Innovation Links									
Innovation Links (0/1)	0.12242	0.0158	***	0.10651	0.0236	***	0.13736	0.0215	***
Useful Info from HEIs (0/1)	0.04880	0.0117	***	0.07335	0.0170	***	0.03052	0.0162	*
Innov Links - HEIs Local (0/1)	-0.07217	0.0312	***	-0.07940	0.0439	*	-0.05864	0.0455	
Innov Links - Local Consult, Comm Lab, Private R&D (0/1)	0.10804	0.0345	**	0.16046	0.0512	***	0.05905	0.0467	
Barriers to Innovation									
Barrier to Innov - Perceived Risk	0.05334	0.0142	***	0.04283	0.0220	**	0.05960	0.0188	***
Barrier to Innov - cost of finance	0.05099	0.0138	***	0.05643	0.0210	***	0.04583	0.0183	***
Barrier to Innov - lack qualified personnel	0.03202	0.0134	**	0.03275	0.0205		0.03050	0.0178	**
Barrier to Innov - Established enterprises	0.04284	0.0149	***	0.02235	0.0229		0.05830	0.0197	***
Barrier to Innov - Uncertain Demand	0.06885	0.0152	***	0.06727	0.0237	***	0.07283	0.0199	***
Public Support									
Public Support - local/regional	0.14091	0.0206	***	0.14043	0.0271	***	0.14389	0.0321	***
HEI Regional Profile									
Group 1994 Universities (% in Region)	0.00107	0.0005	**	0.00109	0.000		0.00094	0.0007	
Post 92 Universities in Region (%)	0.00073	0.0005		0.00012	0.0007		0.00106	0.0006	*
Number of obs	13210			5763			7447		
LR chi 2 (26)	3738.57			1532.11			2231.17		
Prob > chi2	0.00			0.00			0.00		
Pseudo R2	0.2077			0.1947			0.2201		
Log likelihood	-7132.75			-3168.13			-3951.92		

Table 10 Determinants of Organisational Innovation in the UK: marginal effects, Tobit Model

Dependent Variable = Sales of New to Market Innovations	All Businesses dy/dx	Std. Err.		Production dy/dx	Std. Err.		Services dy/dx	Std. Err.	
Enterprise Characteristics									
Small Enterprise	1.83408	0.2262	***	1.28446	0.3284	***	1.99099	0.3103	***
Medium Enterprise	0.84988	0.2530	***	0.78750	0.3560	**	0.65243	0.3499	*
Sales Local or Regional in UK	-0.59156	0.2236	***	-0.29756	0.3039		-0.97147	0.3149	***
Ent. Est. after 1 Jan 2000	1.35349	0.2557	***	0.68829	0.3689	*	1.61175	0.3465	***
Innovation Activity									
Process Innovator	-3.71016	0.3413	***	-3.0617	0.4887	***	-4.21714	0.3465	***
Process Innovation - New to Industry (0/1)	6.01388	0.3917	***	5.02092	0.5056	***	6.6966	0.5742	***
Advanced Mgt Techniques	-0.58397	0.2360	**	-0.38575	0.3145		-0.84397	0.3374	***
Innovation Effect - Increase range of goods/services	0.49332	0.2557	**	0.38788	0.3534		0.56704	0.3568	
Innovation Effect - Enter new markets or increase mkt shr	0.69864	0.2603	***	0.776204	0.3602	**	0.71973	0.3621	**
In-house R&D	0.77757	0.2290	***	1.54872	0.2987	***	0.29328	0.3367	
Training	-0.37885	0.2066	*	-0.28498	0.2666		-0.62575	0.3032	**
Market penetration activities	1.99693	0.2321	***	1.91649	0.3126	***	2.14461	0.3306	***
Inv in Design (£000)	0.00025	0.0001	**	0.00013	0.0001		0.00043	0.0002	**
Abandoned Innov Activities 2002-04	1.63655	0.2861	***	1.18830	0.3522	***	2.22877	0.4423	***
IP - Copyright	1.05273	0.2545	***	0.93571	0.3193	***	1.0183	0.3833	***
IP - Design Complexity	0.70260	0.2528	***	0.33926	0.3237		1.14390	0.3812	***
Employment Growth	0.00367	0.0010	***	0.00707	0.0017	***	0.00226	0.0012	*
Graduates (% of emp)	0.04383	0.0037	***	0.02946	0.0063	***	0.03828	0.0048	***
Product and Process Innovator	6.39737	0.3954	***	4.90960	0.5478	***	7.88433	0.5584	***
External Knowledge Sourcing									
Useful Source Info – Enterprise or group	-0.6485	0.2079	***	-0.63050	0.2753	**	-0.66457	0.2983	**
Innov Links – Ent or Ent Group	-0.84443	0.4303	**	-0.48054	0.5595		-1.11365	0.6280	*
Innov Link – Client/Customer	2.87084	0.4095	***	1.83869	0.5189	***	3.94811	0.6126	***
Innov Links – Competitors	-1.42814	0.4638	***	-0.33756	0.6342		-2.55111	0.6567	***
Innov Links – Consult, Comm Lab, Private R&D	0.84890	0.4498	**	-0.54318	0.5882		2.11806	0.6551	***
Barriers to Innovation									
Availability of Finance	0.66055	0.2193	***	-0.08145	0.2904		1.13380	0.3147	***
Information on Technology	-0.68206	0.2278	***	0.138817	0.3013		-1.20929	0.3273	***
Public Support for Innovation									
R&D Tax Credit	5.08899	0.4558	***	2.71388	0.5394	***	8.19231	0.7330	***
EU Support	3.88568	0.9951	***	4.23711	1.1569	***	3.05252	1.6376	*
Participate in EU's 5th or 6th FP	-4.95208	1.3283	***	-6.41927	1.6411	***	-4.22222	2.0621	**
Group 1994 Universities (% in Region)	0.01642	0.0096	*	-0.00414	0.0125		0.02688	0.0139	**
Number of obs	13951			5999			7952		
LR chi 2 (26)	2752.57			1067.66			1823.76		
Prob > chi2	0.00			0.00			0.00		
Pseudo R2	0.0259			0.0242			0.0294		
Log likelihood	-51782.8			-21479.8			-30064.1		

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