PATHWAYS TO IMPACT AND THE STRATEGIC ROLE OF UNIVERSITIES

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Abstract

There has been an increasing focus on the strategic role of universities in stimulating innovation and economic growth, primarily though the transfer of technology. This paper interrogates some of the key aspects of much of the conventional wisdom concerning the transfer of technology and the knowledge exchange process in general. It analyses the results from two unique surveys: a survey of the UK academic community which generated more than 22,000 responses; and stratified survey of businesses which generated more than 2500 responses. The paper shows that there are many knowledge exchange mechanisms used by academics – these include commercialisation processes but also many other 'hidden' connections. It also shows that knowledge exchange involves academics from all disciplines – not just those from science and engineering - and involves partners from the public and third (not for profit) sectors as well as private sector businesses. Furthermore, it shows that the main constraints that hinder or limit the knowledge exchange process include a lack of time, insufficient internal capability to manage relationships; and insufficient information to identify partners. Problems concerning cultural differences between academics and business and disputes concerning intellectual property are not prominent. Overall, the paper suggests that the notion of an academic 'ivory tower' seems to be a myth as far as the UK is concerned. It also suggests that a strategic focus on strengthening connections between academia and the rest of society may generate long-term benefits but it will also face challenges and should not distort or divert from the foundations of scholarship on which the success of universities are built.

Key Words: Universities, Impact, Knowledge Exchange, Technology Transfer

JEL Classifications: 031, 033, 038

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Introduction

The strategic role of universities in stimulating innovation and economic growth has become central theme in innovation and science policy in the UK and elsewhere (Yusuf and Nabeshima, 2007; Sainsbury, 2007). Until the current financial and economic crisis, much of the impetus for this came from discussions on the impact of globalisation and the need to develop 'knowledge driven' economies. More recently, the focus has shifted towards promoting recovery from recession and the need to 'rebalance' national and local economies (Executive Office of the President, 2009; Kitson et al, 2009). Yet, much of the discourse remains narrowly focussed on promoting 'technology transfer' from universities concentrating on the commercialisation of science through such mechanisms as patents, licences and spin outs. Whilst technology transfer is an important element of the knowledge exchange spectrum, it is an incomplete and partial part of the process. And although this has been increasingly recognised in the academic literature (see Salter et al, 2000 and Hughes 2008); according to Perkmann et al (2011, p.5): 'the state of knowledge remains relatively fragmented and tentative'. Furthermore, the extent and breadth of knowledge exchange is not prominently acknowledged in much of the policy discourse.

Public funding for university research in the UK is provided by a dual support system. Universities receive block grant funding allocation linked to their performance in the research excellence framework analysis which is carried out periodically and the latest version of which will relate to performance in the period 2008-13. In parallel, individual academics of universities may apply to the research councils for peer reviewed competitive research awards. In the case of the UK the strategic role of universities has become intimately linked with the need to identify and establish pathways to impact (see RCUK, 2011; HEFCE, 2010). The increasing emphasis in both of these streams on the concept of impact has raised in a direct way the lack of evidence to inform the development and implementation of strategies connected with particular pathways in different disciplines. The development of the research excellence framework methodologies has raised particular issues about the way in which impact may be measured beyond the conventional peer reviewed academic publications and commercialisation metrics of spin-outs, patenting and licensing. It has also led to increasing concern that science, technology, engineering and mathematics (STEM) will be privileged in funding terms, whilst the arts, humanities and social sciences will be marginalised.[1]

This paper interrogates some of the key aspects of the conventional wisdom regarding the knowledge exchange process. First, it evaluates the breadth of the

knowledge exchange mechanisms used by academics – which include commercialisation processes but also many other 'hidden' connections (Hughes, Kitson and Probert, 2011). Second, it considers the connectivity of academics from all disciplines – not just those from science and engineering. Third, it evaluates the extent of connections with a range of partners in the economy and society – not just links to business but also connections with the public and third (not for profit) sectors. Fourth, it considers the constraints that may hinder or limit the knowledge exchange process. Here the conventional wisdom is that there prominent constraints include cultural differences between academics and business and that there are hurdles and disputes concerning the ownership of intellectual property. But it is important to evaluate the extent of these constraints as they are often raised in the context of the commercialisation of science and not the broader notion of knowledge exchange discussed in this paper.

To examine these issues, this paper uses the results of two large scale surveys: a survey of UK academics which generated more than 22,000 responses (Hughes et al, 2010b) and survey of UK businesses which generated more than 2500 responses (Hughes et al 2010a). The survey of academics is the largest that has ever been undertaken and provides a detailed and comprehensive picture of the knowledge exchange activity in the UK. This remainder of this paper is organised as follows: section 2 outlines some of the aspects of the conventional wisdom of knowledge exchange; section 3 outlines the data and methods used in this paper; section 4 reports the main findings; and section 5 concludes.

1. Knowledge Exchange: some aspects of the conventional wisdom

There is a growing body of literature on the connections and interactions between universities and the business community (for a review see: Perkmann et al, 2011). Increasingly this literature is unraveling the complexities and dynamics of these connections and how they are influenced by different institutional frameworks, organisational forms and policy initiatives. But despite this rich literature, there are four strong tendencies that inform much of the discussion and in particular the policy discourse (see Sainsbury, 2007). They are: the importance of technology transfer; the importance of connecting to the science base; the connectivity of academia with business; and overcoming barriers such as disputes over intellectual property. Although these issues are important, they need to be interrogated with robust evidence and, if necessary, be considered in the broad context of the knowledge exchange spectrum.

Concentrating on Commercialisation

The is now a well established body of literature that has evaluated the impact of aspects of the technology transfer process, including: academic spin-off activities (Clarysse et al 2005; DiGregorio and Shane, 2003; Krabel and Muller 2009; Landry et al, 2006; O'Shea et al 2005 and 2008); university licensing (Shane, 2002; Thursby et al 2001); patents (Azoulay et al, 2007; Fabrizio and Di Minin, 2008; Owen Smith et al 2001); and science parks (Phan et 2005; Siegel et al, 2003a; 2003b) . This has led to critical evaluations of the institutions that have developed to promote the transfer of technology (Goktepe-Hulten, 2010; Owen-Smith and Powell, 2001; Siegel et al 2003a) and the impact of policy regimes and changes such as the Bayh Dole Act in the USA (Mowery and Sampet 2005; Sampet et al 2003).

Although commercialisation mechanisms are an important part of the knowledge exchange spectrum they are an incomplete representation of the wide process of knowledge exchange which encompasses multiple mechanisms (D'Este and Patel, 2007; Salter and Martin, 2001). The UK-US Innovation Benchmarking Survey (IBS) reveals the importance of investigating a broad variety of channels through which knowledge exchange activity affects business performance (Cosh et al, 2006). The IBS survey shows that those informal contacts are the most frequently cited interaction, followed by what more conventional interactions involving recruiting graduates, using publications, and attending conferences. Licensing and patenting are among the least frequently cited interactions. It also emphasises the 'public space' role that universities may play in providing opportunities for a variety of interpersonal and organisational exchanges that can inform and feed back into teaching, research and problem solving interactions. A number of studies have shown that the patterns of interactions, and their importance, vary by sector, the size and life cycle of the business, and its form of production process. Moreover, their impact on businesses depends on where they impact on the value chain and the location of business activities (Mowery and Sampet 2005; Asheim and Gertler; 2005; Brown and Ternouth 2006). Many businesses consider that the impact of these broader forms of knowledge exchange have a more valuable impact than the more formal methods of technology transfer (Abreu et al 2008; Cohen et al, 2002).

Beyond Science and Engineering

Although a range of recent studies have considered the broader spectrum of knowledge exchange activities, almost all have focused on science and engineering disciplines. This is consistent with the usual and powerful narrative about how knowledge from academia impacts on economic growth. The focus tends to be narrowly concerned with how science and engineering can improve the innovative performance of businesses through technological developments which will lead to new products and processes. The research reported in D'Este and Patel (2007) and D'Este and Parkman (2010) is based on a survey of 4337 researchers who received grants from the UK Engineering and Physical Science Research Council (EPSRC). Given the remit of the EPSRC, the vast majority of the researchers are from science and engineering. Similarly, the national survey of academic researchers in the US, conducted from 2003 to 2004 by the Research Value Mapping (RVM) Program at Georgia Tech included academics from engineering, biology, computer science, mathematics, physics, earth and atmospheric science, chemistry, and agriculture (see Boardman, 2008 and 2009; Boardman and Coley, 2008; Boardman and Ponomariov; Bozeman and Gaughan, 2007). Of course, sometimes respondents to a survey may not be those that are desired so Boardman (2009) removed sociologists and faculty employed at universities not categorized as 'research extensive' from his analysis of the RVM data. Other studies of the engagement mechanisms have considered the activities of: scientists from Germany (Grimpe and Fier, 2010); academics from the life sciences in Germany and the UK (Haeussler and Colyass, 2011); and scientists, engineers and medics from Ireland and Sweden (Klofsten and Jones-Evans, 2000). What is apparent is that the majority of studies of knowledge exchange have focussed on science and engineering-based disciplines (for review of the evidence see Perkmann et al, 2011) and have not considered the engagement activities of academics from the social sciences and the arts and humanities (exceptions include Abreu et al 2009 and Hughes, Kitson and Probert, 2011).

There are important reasons to broaden the research agenda and consider and analyse the engagement academics from all disciplines and not just those from science and engineering. First, even if the realm of study is narrowly confined to how knowledge exchange influences innovation, it should be recognised that innovation is a fuzzy concept which frequently breaches the borders of technology to embrace, design, marketing and business practices. Second, many businesses may engage with academia for reasons that are not concerned with innovation but are concerned with other aspects of business performance such as the management

of human relations. Third, many academics may be engaging with external partners that are not private sector business but are from the public or third sectors.

Beyond Business Performance

The focus of much of both the academic literature and the policy discourse has been how, and through which mechanisms, academics engage with business (sometimes referred to as 'industry'). For instance D'Este and Perkmann (2010) and Lee (2000) consider the motivations for academics to engage with industry and Giuliani et al (2010) analyse the characteristics of academics who engage with business. The channels through which academics interact with business are analysed by Klofsten and Jones-Evans (2000) and Perkmann and Patel (2007). And the role of university-business interactions has been increasingly emphasised by policymakers as important contributions to innovation and economic growth (Lambert, 2003; Sainsbury, 2007; BIS, 2009).

What tends to be lacking from the academic and policy discourses is significant analysis of how academics engage with the public and third (which includes charities, voluntary organisations and social enterprises) sectors. This is an important omission for a number of reasons. First, the public and (to a lesser extent) the third sectors are important contributors to the economy in all advanced economies. Second, the public sector is major part of the innovation system in most advanced economies - it is no coincidence that two of the most innovative sectors in the UK are pharmaceuticals and aerospace; both of which have had significant support and custom from the UK state. Third, when we step out of the narrow confines of economic policy and economic metrics and indicators, the knowledge exchange process can contribute to range of other aspects of society. It can contribute to the quality of life and well being - indicators that are not adequately captured by GDP or associated metrics. And the importance of the not for profit sector in contributing to local communities has been highlighted by the concept of the 'Big Society' – despite the fact that many find the concept based on empty rhetoric rather than robust content.

Constraints: are they the usual suspects?

The focus on university-business interactions has also led to number of studies which have evaluated the barriers or constraints to such interactions (Baldini et al, 2007; Tartari et al, 2011). It is commonly argued that there are cultural barriers that limit interactions because universities are different to business. For instance the Lambert Report stated that: 'companies and universities are not natural partners: their cultures and their missions are different' (Lambert, 2003, p.15). It is also argued that disputes over intellectual property (IP) are an important barrier that has been becoming increasingly problematic (Bruneel et al, 2009).

A limitation of many of the discussions of barriers is that they are based on assertion or perceived wisdom. Only a few studies are based on the perceptions of academics and even fewer are based on the perceptions of business or other partners. The study by Tartari et al (2011), which is based on a survey of academics shows that the barriers to engagement are complex and multifaceted and that conflicts over IP affect a modest share of academics. Although this study is insightful, it is primarily limited to scientists and engineers and their engagement with industry – and therefore cannot shed light on the barriers and constraints that may inhibit academics from other disciplines and engagement with other partners.

2. Data and Methodology

This paper used two unique national surveys to examine the pattern and extent of knowledge exchange in the United Kingdom. First, a web-based survey of the academic community to address the supply side issues; and second a postal survey of a stratified sample of businesses to evaluate the demand pull side of knowledge exchange.

The Academic Survey

The sampling frame for the survey was all academics active in teaching and/or research in all disciplines in all UK higher education institutions in 2008. There is no publicly available database which provides contact details for this sampling frame. A list of all UK higher education institutions was compiled from data prepared by the Higher Education Statistical Agency (HESA), Universities UK, the Higher Education Funding Councils of England, Wales, Scotland and the Northern Ireland Department for Employment and Learning. A list was manually compiled

of all academics listed on the websites in all departments and faculties of their institutions. This email directory was the sampling frame for a web based questionnaire (Hughes et al, 2010b).

The survey instrument was designed in the light of previous research in this area and in parallel with a survey conducted as part of an evaluation commissioned by the Higher Education Funding Council of England (HEFCE) on the impact of third stream funding on university, culture and practice (HEFCE, 2009). This process allowed a significant amount of piloting before the conduct of the survey described here. It also drew on the findings of a suite of detailed case studies of university-industry interactions completed at an earlier stage of the project (Abreu et al., 2008).

The survey involved an initial web mailing followed by a follow-up prompt sent two or three weeks later. The first wave began in September 2008 and the final wave was completed in June 2009. The 22,129 useable responses represent an overall response rate of 17.6%. Table 1 shows the distribution of responses by four broad disciplinary groupings by gender and by 3 broad levels of seniority. Of the total sample 60% are male and 40% are female.

Table 1. The Academic Survey: Characteristics of Respondents

Discipline	Sample Size	Gender (%)		Seniority (%)		
		Male	Female	Professor	Reader/ Senior Lecturer/ Lecturer	Other
Health Sciences	3,623	44.7	55.3	18.6	53.8	27.5
STEM	7,590	72.8	27.2	20.0	44.8	35.2
Arts & Humanities	3,680	55.1	44.9	19.8	61.0	19.3
Social Sciences	7,236	56.6	43.4	20.4	60.1	19.5
All	22,129	60.0	40.0	19.8	54.0	26.2

Health Sciences includes: Health Sciences
STEM includes: Physics, Astronomy, Earth Sciences, Chemistry, Mathematics, Computing, Engineering, Materials Science, Biological Sciences and Veterinary Science
Arts & Humanities includes: Languages, Other Humanities and Creative Arts and Media
Social Sciences includes: Architecture, Building and Planning, Law, Social Sciences and Economics, Business and Financial Studies and Education

Source: Authors' calculation from Hughes et al (2010b)

Just under 20% of the sample are professors and 54% are readers, senior lecturers or lecturers. A comparison of the distribution by gender and seniority with the higher education statistical authority (HESA) data reveals that the pattern of our respondents by gender is broadly comparable with the HESA data (see Annex). The sample is, however, somewhat more heavily represented by senior members of the profession rather than by more junior members; whereas the HESA statistics suggest that 8% of male academics are professors, in our sample the proportion is 15% and similarly, whereas 2% of the female academic profession are professors,

in our sample the number is 4%. To the extent that more senior members of the profession are more likely to participate in a range of activities with external organisations, our results will tend to overestimate the degree of interactions. A comparison of our data by discipline and gender with the HESA statistics reveals no significant differences in pattern across disciplines and we may be confident that variations across the disciplines that we discuss in this paper are not due to differences arising from our survey response characteristics in relation to gender (see Annex for a fuller discussion of the survey process and response bias analysis).

The size of the sample means that for virtually all comparisons in this paper, differences between categories of academics by discipline, gender or seniority are statistically significant. We therefore focus most of our discussion on the quantitative significance of the differences which are revealed.

The Business Survey

The business survey was carried out contemporaneously with the academic survey and took place between July 2008 and February 2009. The sampling frame was the Dun & Bradstreet Marketing Database, supplemented by the FAME Financial Accounts Database for the largest firms. A size, sector and regions stratified sample was drawn from this database and a total of 25,015 firms were drawn for this purpose of whom 2,530 provided usable responses representing a response rate of 11.3%.

We report the business survey results grossed up to population levels. The grossing up process was implemented using a rim weighted procedure based on the population count data for the number of firms in each size class, sector and region. We use four employment size categories (5-9, 10-45, 50-249, and 250+) and six broad sectors along with 13 regions/devolved nationalities to produce the population estimates reported in this paper (a more detailed account of the survey process and a response bias analysis is contained in the Annex).

Table 2 shows the distribution of the unweighted respondents by size group and four broad sectors. Of the 2,530 responses around 10% were in the medium and large groups respectively, 42.8% in the small group and 37.9% in the micro group. The sample sizes for manufacturing (514), construction (360), wholesale & retail (721) and other services (935) enable us to draw robust conclusions and form a reliable basis for the grossing up process. The coverage of the enterprise survey in

terms of size and sectoral provides a wide range of business experience of university-industry relationships on which to base our analysis.

Table 2. The Business Survey: Sector and Firm Size

Sector	Sample Size	Size Group (%)			
		Micro	Small	Medium	Large
Manufacturing	514	30.4	48.1	12.8	8.8
Construction	360	36.1	52.8	8.1	3.1
Wholesale & Retail	721	47.9	38.7	7.4	6.1
Other Services	935	35.1	39.4	11.3	14.2
All	2,530	37.9	42.8	10.0	9.2

Micro: <10 employees
Small: 10<50 employees
Medium: 50<250 employees
Large: 250+ employees

Source: Authors' calculation from Hughes et al (2010a)

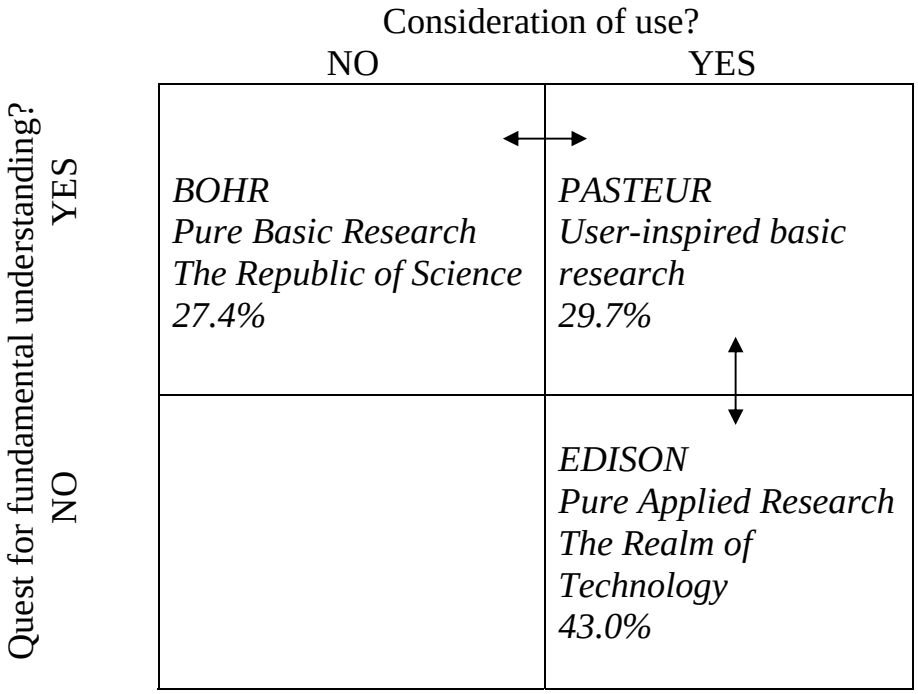
3. Findings and Discussion

One of the most persistent themes in discussion of the strategic role that universities play in either economic growth or rebalancing the economy has been the need to encourage a shift away from basic research to more applied research - or the need to facilitate interactions between the two realms of research. This is reflected in the insistence in the UK upon the identification of pathways to impact in research grant applications and the need of individual researchers to demonstrate impact upon the completion of their projects and by the research councils themselves in making their case for funding (see, for example, HEFCE, 2010 and RCUK, 2011). It is, therefore, important to ask academics whether they consider that their work is relevant to commercial practice and to the commercialisation agenda.

Research: Basic, Applied or Both?

It is of course well-known that the distinction between basic and applied research may be too easily and simplistically drawn and that it ignores the many ways in which there is a positive feedback between basic and applied research. We therefore asked our academic respondents to characterise their research activities in terms of the extent to which it was primarily concerned with basic, user-inspired or applied research using the definitions developed in the OECD (2003) and OECD (2005) manuals to characterise the nature of research. The categories of basic, user-inspired and applied research with which the respondents were asked to identify were defined as follows. Basic research comprises theoretical, empirical or experimental work, undertaken primarily to acquire new knowledge about the underlying foundation of phenomena or observable facts, without any particular application or use in view. User-inspired basic research comprises theoretical, empirical or experimental work, undertaken primarily to acquire new knowledge about the underlying foundation of phenomena or observable facts, but also inspired by considerations of use. Applied research comprises original investigation undertaken in order to acquire new knowledge directed towards an individual, group or societal need or use. [2] Following Stokes (1997) we mapped our respondents into a quadrant diagram which asks whether research was motivated by a quest for fundamental understanding (pure basic research), or solely with application (pure applied research), or with both (user-inspired research), or with neither. The first three are referred to by Stokes (1997) as the Bohr, Edison and Pasteur quadrants respectively. The first also corresponds to the Republic of Science and the second to the Realm of Technology in the terminology of Dasgupta and David (1994).

Figure 1. Stokes's Quadrants



Source: Adapted from Stokes (1997) and Dasgupta and David (1994)

Figure 1 shows for all disciplines the percentage of our academic respondents who described themselves as primarily belonging to each of the three quadrants. It is at once apparent that most academics consider themselves not as being in an "ivory tower" of pure basic research characterised by the Bohr or Republic of Science quadrant. Rather most perceive that they are involved either in research which is concerned wholly with considerations of use or in research that combines elements of user-inspiration and applied research.

The original conception behind the Stokes analysis was linked to an interpretation of the development of science policy with a focus on the natural sciences and technology based subjects. It is interesting, however, to consider the extent to which these characterisations of research translate into different disciplinary groupings beyond the science base. This is particularly so when policy frameworks increasingly promote STEM (Science, Technology, Engineering and Mathematics) based subjects relative to arts and humanities and social sciences because of the allegedly closer link of the former with "useful" impacts and connections with user communities.

Table 3. Stokes' Quadrants by Discipline

	Basic research (Bohr)	User-inspired basic research (Pasteur)	Applied research (Edison)	Total respondents
Health sciences	8.2	21.7	70.1	*3,170*
STEM	31.4	33.5	35.1	*7,212*
A&H	50.5	24.5	24.9	*3,001*
Social sciences	21.6	31.7	46.8	*6,539*
All (%)	27.4	29.7	43.0	
All (N)	*5,450*	*5,910*	*8,562*	*19,922*
	**	**	**	

Source: Authors' calculations from Hughes et al (2010b)
Note: ** Statistically significant at 5% level or better

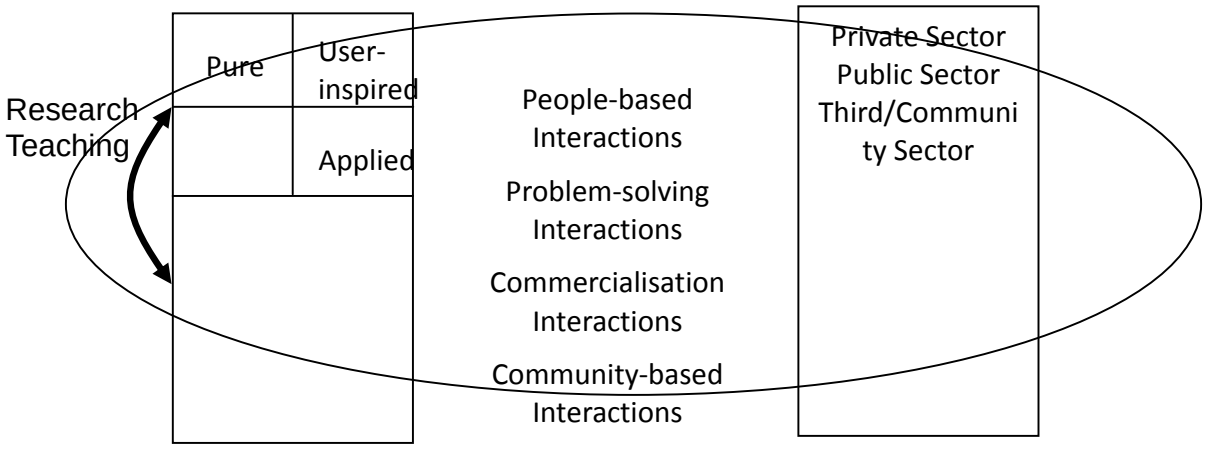
Table 3 maps academics classified by 4 broad disciplinary groupings into the quadrant framework. A number of striking findings emerge. First, in relation to the health sciences, there is an overwhelming pre-disposition to be concerned with user-inspired and applied research. Second, at the other extreme, academics from the arts and humanities academics are more likely to conceive of themselves as being concerned with pure basic research and to report less frequently that they are concerned with user-inspired and applied research. Third, the social sciences occupy an intermediate position; they share with the STEM disciplines a relatively high focus on user inspired research, but are more concerned with application than STEM. They rank second to health sciences in the applied research quadrant.

It is important to note that an individual academic may in the course of their career, or in the case of a particular project, move between these quadrants. Table 3 nonetheless reveals that academics believe that they have a very widespread interest in developing research which is user-inspired or applied and applications. Policies to encourage academics to spend more of their time in these applied quadrants should at least start from the recognition and very few academics themselves consider their activity purely concerned with basic research.

Pathways to Impact

So far we have considered the description of the nature of the research that academics undertake. It is now important to turn to the question of the pathways to impact by which this knowledge may be communicated with society and to meet societal needs. The schema shown in Figure 2 describes the possible set of interconnections which may exist between the university system and society and the pathways by which research may interact with it.

Figure 2. A Framework for the Analysis of University-Industry Knowledge Exchange



Source: Adapted from Hughes, Ulrichsen, and Moore (2010)

The left hand side of Figure 2 represents the combined teaching and research activities of the university sector. The ellipse encompasses a range of activities which represent pathways to potential impact (see for example, Salter et al, 2000 and Cosh et al, 2006). The societal constituencies are shown on the right hand side of the Figure. We have grouped the pathways into four broad categories. The first we describe as *people-based Interactions* which cover a range of interpersonal and people-based relationships, ranging from student placements and employee training through to standard setting forums and network participation. The second group include *problem-solving Interactions* spanning contract research, physical facility use activities and personal and informal advice more generally. The third category comprises *commercialisation* which ranges from taking out a patent to

licensing research output to a company, forming a spin-out company or the formation or running of a consultancy linked to research. It is of course the commercialisation pathways which have received the most attention in discussions of the strategic role that universities may play in economic growth or rebalancing. The fourth category is *community-based Interactions* ranging from public exhibitions to community lectures.

Commercialisation Activities

Table 4 shows for academics taken as a whole, and for each of the four broad disciplinary categorisations used in this paper, the percentage of academics who either took out a patent, licensed research output to a company, formed a spin-out company or formed or ran a consultancy in the three years prior to the survey. It also shows the proportion who either took out a patent or licensed research or formed a spin-out company - we term this *"hard" commercialisation.*

Table 4. Commercialisation Activities by UK Academics in a three year period (%)

	Taken out a patent	Licensed research outputs to a company	Formed a spin-out company	"Hard" Commercialisation	Formed or run a consultancy via your research	Total respondents
All	7.1	4.7	3.5	11.0	13.8	18,991
Health sciences	8.0	4.7	2.8	10.8	10.3	3,154
STEM	15.5	9.0	5.7	21.0	17.0	6,602
Arts and humanities	0.6	1.4	1.8	3.4	7.5	3,092
Social sciences	0.9	1.8	2.3	4.2	15.5	6,143
	**	**	**	**	**	

Source: Authors' calculations from Hughes et al (2010b)
Note: ** Statistically significant at 5% level or better

The proportion of academics as a whole taking out a patent is 7% with lower proportions engaged in licensing or forming a spin-out company. Around 11% of academics reported undertaking at least one of these activities. As might be expected the proportion of academics in the arts and humanities and social sciences who are involved in "hard" commercialisation activities is relatively small and much below the average for all academics. Equally, and also unsurprisingly, it is the STEM subjects which dominate in terms of patenting and licensing and new

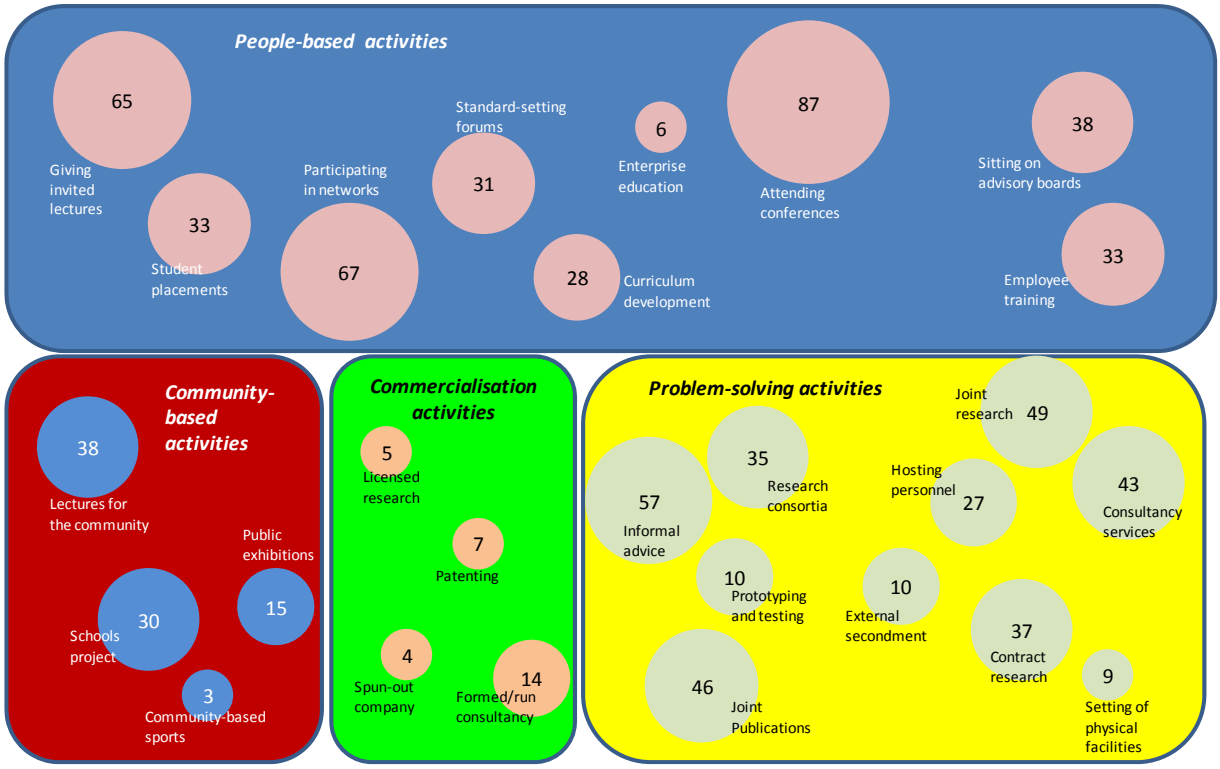
company formation, followed by the health sciences. When we turn to the formation or running of consultancies, however, a somewhat different picture emerges. In the arts and humanities 7.5% of academics report this kind of business activity compared to 10% for health sciences, over 15% in social sciences and 17% in the STEM subjects.

The extent of licensing based on patents taken out in the past three years or in previous years is somewhat lower than the proportion reporting patents. One reason for the difference may be that there has been an increasing tendency to take out patents so that licensing research from prior patents relates to smaller prior percentages of academics patenting before the three years prior to the survey. Furthermore, many patents may not yield licence income**.**

The Broad Spectrum of Knowledge Exchange: Multiple Mechanisms

Arguments for the importance of the STEM and science subjects based on their patenting, licensing and new business formation is clear and on those grounds might lead to some emphasis on these aspects of university activity in developing strategic relationships with the rest of society. However, it is important that this range of activities should be placed in the context of the wider range of relationships with external organisations which academics report and upon which commercialisation activities themselves may depend. Insofar as these other impacts lead to connections which promote the development of user-inspired or user-related research activities and lead to commercialisation activities they may be important components of the overall commercialisation process. This is quite apart from the intrinsic value to society which these other interaction pathways themselves may lead to.

Figure 3. Impact Pathways of UK Academics (% of academics reporting the interaction with an external organisation)



Source: Data based on authors' calculations from Hughes et al (2010b); format based on Ulrichsen (2009)

This overall pattern of interactions, as depicted in Figure 3, shows that direct commercialisation pathways are in the distinct minority of all academic interactions with external organisations. The most frequent forms of interaction with external organisations are associated with people-based activities. Over two thirds of academics report giving invited lectures, participating in networks or attending conferences organised with external organisations and around a third or more are involved in student placements, standard setting forums, employee training or sitting on advisory boards. A relatively small proportion are directly involved in specific enterprise education, but over a quarter are involved in curriculum development.

The next most prolific form of interaction is concerned with problem-solving activities: 57% of academics report that they are involved in the provision of informal advice to external organisations and between 40 and 49% report joint publications, joint research and consultancy services provided to external organisations. Over a third of academics report being involved in research

consortia or contract research. As might be expected, given the specialised nature of the interactions, relatively small proportions are involved in prototyping and testing and the setting up of physical facilities, although they may play a critical role in particular disciplines. Finally, it is important to note the degree to which academics are involved in the broad range of community-based activities. These include most significantly lectures for the community and heavy involvement in the development of school projects. Around 15% of academics have been involved in public exhibitions of one kind or another. Taken as a whole, this set of data reveals the extremely wide range of the potential pathways of impact arising from the external interactions of academics. It reveals a picture of extensive interactions within which direct commercialisation activities play a relatively small role.

The Broad Spectrum of Knowledge Exchange: Many Disciplines

In addition to setting out the extensive range of interactions, it is also possible using our database to analyse the extent to which patterns of external interactions vary by discipline. Table 5 provides a comparison of the proportion of academics in four broad disciplines who exhibit multiple interactions within our five broad categories of "hard" commercialisation, consultancy, problem-solving, people-based and community-based interaction.

Table 5. High interaction intensity by discipline (%)

	"Hard" Commercialisation	Consultancy	Problem solving interaction	People based interaction	Community based interaction	All interactions	Total respondents
Health sciences	10.8	10.3	19.3	26.4	16.3	22.6	*3,606*
STEM	21.0	17.0	23.7	17.0	23.1	21.9	*7,551*
A&H	3.4	7.5	8.1	17.3	34.5	14.0	*3,655*
Social sciences	4.2	15.5	18.8	19.4	24.3	20.1	*7,204*
All (%)	11.0	13.8	17.7	21.7	22.2	20.2	
All (N)	*19,090*	*19,034*	*3,842*	*4,763*	*4,705*	*4,452*	*22,016*
	**	**	**	**	**	**	

Source: Authors' calculations from Hughes et al (2010b)
Note: ** Statistically significant at 5% level or better

In Table 5 we classify high interaction intensity academics as: those who participated in 6 or more out of the possible 9 people-based interactions; those who were involved in 6 or more out of the possible 10 interactions within the problem-solving domain; and those who were involved in 2 or more out of a possible 4 interactions in the community-based segment. In the "hard" commercialisation

domain we identified those who had taken part in any one such activity. There are approximately 11% of the sample who are high intensity interactors in the commercialisation domain and this is most frequently the case, as might be expected, in the STEM subjects where 21% have this characteristic which is twice as high as the next most important proportion in the health sciences.

In terms of the people-based interaction domain and the community-based interaction domain, approximately a fifth of academics as a whole are high intensity interactors. In the case of the problem solving domain the arts and humanities academics are considerably less likely to be engaged in these activities compared to academics from other disciplines. Health scientists are most likely to be multiple interactors in the people-based domain followed by the social sciences with little differences between STEM and Arts and Humanities subjects. Arts and humanities academics are most frequently highly intensively interactive in the community-based domain where over 34% exhibit this characteristic. In terms of consultancy, STEM and social sciences are the most important, followed by health sciences and the arts and humanities. Taken as a whole, Table 5 shows clearly that a focus on narrow issues of commercialisation will massively understate the extent to which academics in health sciences, the arts and humanities, and social sciences are involved in intensive interactions in other domains. Neglecting this wide spectrum of interaction pathways in the pursuit of narrow strategic aims connected with "hard" commercialisation misrepresents the potential role that universities can and do play in society.

The Broad Spectrum of Knowledge Exchange: Many Partners

Although the focus of much of the research on knowledge exchange has been concerned with engagement with private business sector, the evidence from the survey of academics reveals that this is only part of the picture as there is extensive engagement with the public and charitable sectors. As shown in Table 6, more than 40 % of academics from all disciplines are interacting with private sector businesses. The STEM disciplines have the highest level of interaction with the private sector with more than half of academics from this group engaging with business. There is, however, also a high level of private sector interaction with other disciplines outside of STEM including: health sciences (39%), social sciences (38%) and the arts and humanities (30%). This suggests that businesses connect with academia for a range of reasons and this issue is discussed further below.

The focus on how academics interact with businesses can distract or conceal the extent of interactions with the public and third sectors. As shown in Table 6, 53% of academics interact with the public sector, with health sciences having the highest level of interaction which probably reflecting interactions with the National Health Service. Similarly, the extent of interactions with the social sciences is also high with 63% of academics interacting with the public sector. Overall, 44% of academics engage with the third sector - slightly higher than the level of engagement with the private sector. Furthermore, the disciplines with particularly high levels of engagement with this sector contrast with those who have high engagement with the business sector. The discipline with the highest engagement with the third sector is health sciences (57%), followed by social sciences (49%), the arts and humanities (46%) and STEM (33%).

Table 6. Academic interaction with the Pivate, Public and Charitable Sectors by Discipline

	Health Sciences	STEM	Arts & Humanities	Social Sciences	All
Private sector companies	38.8	50.5	30.4	37.7	41.1
Public sector organizations	66.4	44.2	37.7	63.3	53.0
Charitable or voluntary organisations	57.4	32.8	46.3	48.7	44.3
	**	**	**	**	**

Source: Authors calculations from Hughes et al. (2010b)
Note: ** Statistically significant at 5% level or better

Robustness Checks: Some Multivariate Analysis

So far we have focused on differences across our disciplinary groupings without taking into account other factors relating to individual academics which may influence the results across disciplines. For example it is known that age, seniority, gender and institutional affiliation may each affect the likelihood of participation in knowledge exchange activities in addition to the role that discipline plays. It is possible that our results may be confounded if there are underlying and substantial differences in the gender, age, seniority and institutional composition of our disciplinary sub-groups. In order to check on the possibility that our description of differences across disciplines may be confounded by these factors, we conducted a set of multivariate probit regressions. In these analyses we regressed, in turn,

measures of the extent of involvement in commercialisation (in the sense of having taken out one or more patents, spun-off one or more companies, or licensed on one or more occasions in the past three years), consultancy activity and high intensity interactions in terms of people-based interactions, problem-solving interactions and community-based interactions respectively. We carried out similar regressions for the likelihood of being engaged in activities with private, public or charitable sector organisations. Our probit analyses contained in each case a series of dummy variables designed to capture four academic age groups, three seniority groups by post held, gender, and membership of four university groups. The university groups were broadly drawn to reflect the research intensive and self-selective Russell Group of universities, a group of universities established before 1992, a group of universities established after 1992 broadly corresponding to the group of former polytechnics in the UK, and finally a small group of specialist institutions linked to the performing arts and agricultural research. The results of these tests are summarised in Tables 7, 8 and 9. In each case for reasons of space we report only the marginal disciplinary effects derived from the probit regressions.

Table 7. Commercialisation and consultancy activities by Discipline: Marginal Effects

	Commercialisation		Consultancy	
STEM	0.194	**	0.110	**
Health	0.130	**	0.049	**
Social sciences	0.020	**	0.098	**
N	18248		18193	
Wald Chi^2 (11)	1247.94	**	509.41	**
Percent correctly classified	88.97		86.13	

Source: Authors' calculations from Hughes et al (2010b)

Note: The estimates are marginal effects relative to Arts and Humanities and are drawn from a probit equation in which dummy variables were included to capture 4 academic age groups, 3 seniority groups by post held, gender and membership of 4 university groups (based on research intensity and date of formation). ** Statistically significant at 5% level or better

Table 8. High Intensity Interactions by Discipline: Marginal Effects

	People-based interactions		Problem-solving interaction		Community-based interaction	
STEM	0.034	**	0.190	**	-0.072	**
Health	0.122	**	0.165	**	-0.130	**
Social sciences	0.094	**	0.105	**	-0.138	**
N	20898		20694		20193	
Wald Chi^2 (11)	1513.94	**	1476.26	**	659.64	**
Percent correctly classified	78.44		82.45		78.03	

Source: Authors' calculations from Hughes et al (2010b)

*Note: The estimates are marginal effects relative to Arts and Humanities and are drawn from a probit equation in which dummy variables were included to capture 4 academic age groups, 3 seniority groups by post held, gender and membership of 4 university groups (based on research intensity and date of formation). ** Statistically significant at 5% level or better.*

Table 9. Patterns of engagement with private, public and charitable sectors by Discipline: Marginal Effects

	Private		Public		Charitable	
STEM	0.219	**	0.085	**	-0.114	**
Health	0.119	**	0.279	**	0.101	**
Social sciences	0.086	**	0.256	**	0.030	**
N	20846		20768		20644	
Wald Chi^2 (11)	1181.72	**	1845.84	**	1140.80	**
Percent correctly classified	63.36		63.40		60.20	

Source: Authors' calculations from Hughes et al (2010b)

*Note: The estimates are marginal effects relative to Arts and Humanities and are drawn from a probit equation in which dummy variables were included to capture 4 academic age groups, 3 seniority groups by post held, gender and membership of 4 university groups (based on research intensity and date of formation).** Statistically significant at 5% level or better.*

The marginal effects for STEM, the health sciences and social sciences are shown relative to Arts and Humanities (the reference group). In each case we report for completeness the number of observations in the regression, the Wald statistic and a goodness-of-fit test based on the percent correctly classified correctly on the basis

on the equation. Our concern here is with the ordering of the effects by discipline. The Tables reveal that the pattern of relative importance attached to each of these activities by discipline is the same as that revealed by our univariate analysis in the previous discussion. We can thus conclude that our findings reflect systematic differences across the disciplines having controlled for possible confounding effects due to the age, gender and seniority composition of the underlying samples of academics as well as variations in their university affiliation.

What are the Constraints on Interactions?

> "UK universities have a strong science base, and there is significant potential to transfer this knowledge to business in the form of IP. These transfers take a range of different forms and have been growing at a rapid pace in recent years. Most universities have developed technology transfer offices, and staff numbers are rising rapidly. However, there are a number of barriers to commercialising university IP." (Lambert, 2003, p.4)

The Lambert Review of University-Business collaborations in the UK tells a convincing narrative about the role of universities in the economic system. It stresses that the most effective forms of "knowledge transfer" involve human interactions and that the biggest challenge for the UK is on the demand side from businesses (Lambert, 2009). But the Lambert narrative is partial and incomplete: it is story that focuses on how businesses can connect with the science base to improve their technology and R&D performance and largely ignores the other reasons why businesses may connect with academia. It also hides behind the convenient veil of IP to explain the constraints or barriers to interactions.

The motivations of British business to interact with academia are shown in Table 10. When evaluating the responses from all interacting firms, the motivations in order are, to support: marketing, sales and support services (cited by 49% of interacting firms); innovation activities (43%); human resource management (38%); and logistics, procurement and operations (24%). So overall, despite being important, support for innovation is not as highly cited as support for marketing and related activities. The picture is different if we solely concentrate on those firms that only had an interaction with academics from the science base: here support for innovation is the most highly cited reason, although many firms also interact with scientists for other reasons. But another different picture is apparent when we look at business interactions with academics from the social sciences: here the main reasons are for marketing and related activities and human resource management - with support for innovation being much less frequently cited. The

simple narrative that businesses connect with scientists to improve their innovative performance is both powerful and distortionary. Improving business performance is not simply about innovation and technology, it involves the many and varied aspects of business organisation and strategy. And this is reflected in the multiple reasons why businesses connect with academia.

Table 10. Motivations of UK Businesses to interact with Universities
All collaborating interacting firms; weighted data

	Logistics, procurement and operations	Innovation activities	Marketing, sales and support services	Human resource management
All firms with interactions	24	43	49	38
STEM interaction only	18	64	36	19
Social sciences interaction only	34	17	50	50
Interaction with STEM and any other	26	47	59	45
Any interaction except with STEM	27	24	53	50
	**	**	**	**

Source: Authors' calculations from Hughes et al (2010a)
Note: ** Statistically significant at 5% level or better

The narrow focus on technology transfer from science to business is also reflected in much of the debate concerning the constraints or hurdles which prevent or hinder interactions between academics and other partners - with an emphasis on the cultural differences between academics and businesses (Lambert, 2003) and disputes over IP (Bruneel et al, 2009). It is important to evaluate whether these constraints are perceived to be important by both academics and businesses particularly in the context of the wider knowledge exchange spectrum which embraces, but moves beyond, technology transfer from the science base. The data in Table 11 show the factors that constrained or prevented interactions with external organisations as perceived by academics. Overall, for academics from all disciplines the most important constraints are: lack of time (cited by 66% of all academics); university bureaucracy (31%) and insufficient rewards from an interaction (29%). Whereas the least cited constraints were: cultural differences (7%) and disputes over IP (10%). An analysis of constraints cited by academics from different disciplines shows that there is some variation in terms of disputes over IP; with 16% of academics from STEM citing this as a factor, compared to 10% of academics from the health sciences, 7% of academics from the social sciences and 6% of academics from the arts and humanities. In terms of the other constraints, a broadly similar pattern is apparent for all disciplines with a few

notable differences. In particular, in addition to conflicts over IP, there a number of constraints that are more highly cited by academics from STEM disciplines compared to other academics, such as: lack of interest by external organisations; unwillingness of the external organisation to meet the full cost; difficulty in identifying partners; and lack of resources in the external organisation to manage the interactions. These results are consistent with Lambert Review's contention that much of the problem of interacting with the UK science base is due to demand side weaknesses from British business.

Table 11. Constraints on Academic Interactions with External Organisations (% of respondents)

	All	Health sciences	STEM	A&H	Social sciences	
Total respondents	*16,594*	*2,953*	*5,402*	*2,462*	*5,777*	
Lack of time to fulfil all university roles	65.9	62.6	61.8	70.6	69.4	**
Bureaucracy and inflexibility of administrators in your institution	31.2	30.1	30.0	28.6	33.9	**
Insufficient rewards from interaction	28.7	23.9	28.3	31.2	30.4	**
Insufficient resources devoted by your institution to activities with external organisations	25.7	24.3	21.7	28.5	28.9	**
Unwillingness in the external organisation to meet the full cost of the interaction	25.1	23.8	31.7	18.5	22.4	**
Lack of resources in the external organisation to manage the interaction	23.7	23.3	25.5	21.7	23.0	**
Difficulty in identifying partners	23.2	20.8	28.0	21.9	20.6	**
Differences in timescale	22.1	19.8	22.8	18.5	24.2	**
Lack of interest by external organisations	20.2	16.6	25.5	17.6	18.1	**
Lack of experience in the external organisation for interacting with academics	17.3	17.0	17.0	16.3	18.2	
Poor marketing, technical or negotiation skills of administrators in your institution	17.0	15.1	16.9	17.7	17.7	**
Difficulty in reaching agreement with external organisation on terms of the interaction such as IP	10.4	11.2	16.1	5.6	6.6	**
Cultural differences	7.0	6.4	7.0	7.1	7.2	
Other	1.6	1.7	1.5	1.6	1.6	

=Low
=High

Source: Authors' calculation from Hughes et al (2010a)
Note: **Statistically significant at 5% level or better (Chi Square test)

Although, in general, disputes over IP are not frequently cited they are more apparent in the STEM disciplines: and this probably reflects that academics from the STEM disciplines are more likely to use the commercialisation paths of knowledge exchange; and these are the routes where disputes over IP are more likely to occur. To examine this in more detail, Table 12 shows the perceived constraints for those academics engaged in an interaction involving commercialisation. Overall, academics involved in commercialisation are more likely to cite disputes over IP (26%) than the sample of all academics (10%). And within the group of commercialising academics, those from the STEM and health sciences are much more likely to cite disputes over IP compared to those the social sciences and the arts and humanities. It is, however, important to put these results into context: overall all constraints are perceived to be higher by the commercialising academics compared to the sample as a whole with the exception of a lack of time. But the latter is still the most cited constraint for the commercialising group with a number of other constraints - including university bureaucracy and unwillingness of external organisation to meet the full cost of interactions – being more frequently cited than disputes over IP.

Table 12. Constraints on Academic Interactions with External Organisations (% of respondents engaged in Commercialisation)

	All	Health sciences	STEM	A&H	Social sciences	
Total respondents	*1,943*	*325*	*1,275*	*94*	*249*	
Lack of time to fulfil all university roles	60.9	57.2	60.0	72.3	66.3	**
Bureaucracy and inflexibility of administrators in your institution	42.5	46.2	38.5	46.8	56.2	**
Unwillingness in the external organisation to meet the full cost of the interaction	41.1	40.9	43.1	36.2	32.5	**
Lack of resources in the external organisation to manage the interaction	31.8	30.2	32.4	29.8	31.3	
Insufficient rewards from interaction	31.4	30.8	29.7	42.6	36.5	**
Insufficient resources devoted by your institution to activities with external organisations	28.4	28.6	25.5	38.3	39.0	**
Difficulty in reaching agreement with external organisation on terms of the interaction such as IP	26.0	27.4	29.0	13.8	13.3	**
Poor marketing, technical or negotiation skills of administrators in your institution	25.8	27.4	23.6	34.0	32.1	**
Difficulty in identifying partners	25.6	24.9	27.8	23.4	16.5	**
Differences in timescale	25.4	19.1	25.8	29.8	29.7	**
Lack of interest by external organisations	24.1	20.6	26.8	18.1	17.3	**
Lack of experience in the external organisation for interacting with academics	23.2	20.3	22.2	26.6	30.9	**
Cultural differences	7.5	4.3	7.8	10.6	8.8	*
Other	1.1	1.2	1.1	1.1	1.2	

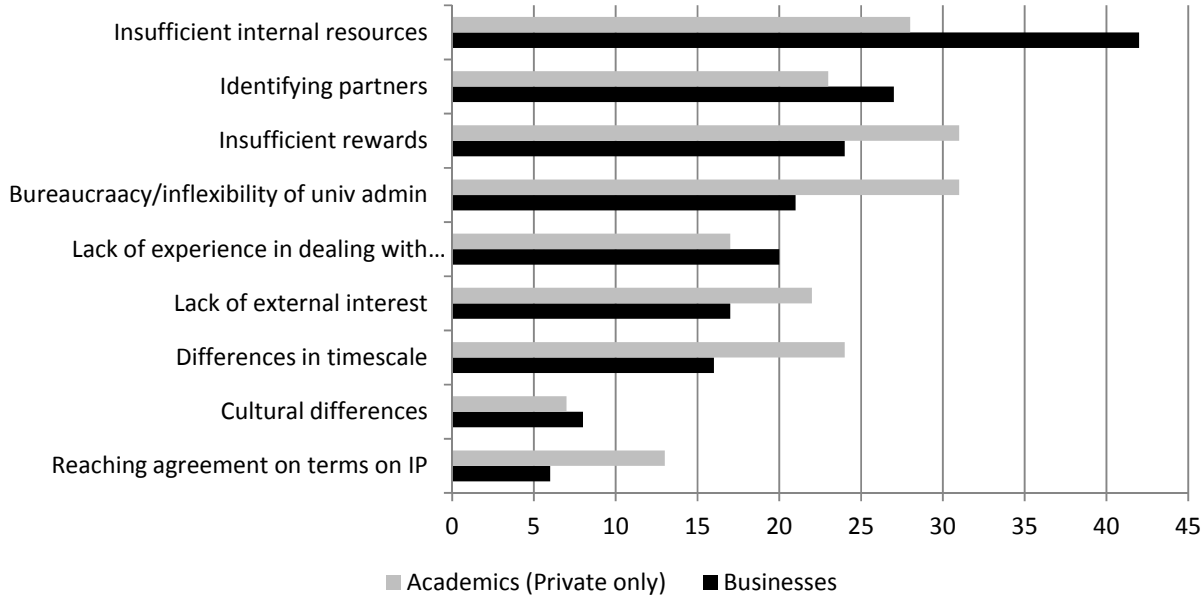
=Low
=High

Source: Authors' calculation from Hughes et al (2010b)
Note: ** Statistically significant at 5% level or better

The picture of the constraints that prevent or hinder interactions is more complex than a focus on IP and cultural differences would suggest. And this complexity is also apparent when a comparison is made between the perceptions of academics with those of businesses. The data in Figure 5 shows the constraints cited by both businesses and by academics who only interact with the private business sector – this allows comparability as academics may perceive different constraints concerning interactions with the public and charitable sectors. Although the broad picture shown in Figure 5 shows that there are many similarities between the

constraints perceived by both academics and businesses there are also important contrasts. First, the most frequently cited constraints concern internal capability: businesses consider that they lack the internal resources to manage interactions and academics are concerned about the problems of university bureaucracy. This suggests the importance of capacity building and developing 'boundary spanning' functions that will help to identify and manage interactions (Hughes et al, 2011). Second, both academics and businesses identify 'insufficient rewards' as a constraint. Here it is important to note that notion of 'rewards' will differ between the two groups – whereas businesses are likely to be concerned with business performance, academics tend to engage in external interactions to support their research and teaching (Abreu et al, 2009). This suggests the importance of aligning incentives and rewards – it may be in the area of Pasteur's quadrant where this is most easily achieved. Third, both academics and business cite the identification of partners as an important constraint. This suggests that part of any boundary spanning function should help to deal with the information failure identified by both partners. Fourth, whereas 13% of academics that are only engaged private sector interactions see conflict over IP as a constraint, only 6% of businesses see this as a problem. It seems that this issue is only a problem for a minority of academics – and is even less of an issue for most businesses.

Figure 5. Constraints on Interactions: Businesses and Academics engaged with private sector only (% of respondents)



Source: Authors' calculations from Hughes et al (2010a)

4. Conclusions

> *"The day is not far off when the economic problem will take the back seat where it belongs, and the arena of the heart and the head will be occupied or reoccupied, by our real problems — the problems of life and of human relations, of creation and behaviour and religion."* Keynes (1946)

Unfortunately, the day is still far off when the economic problem will take a back seat where Keynes stated in belongs. The pursuit of growth and, more recently, the financial crisis have kept the economic problem firmly in the driver's seat of much of public policy. And this has infected the attitudes towards, and expectations of, universities. No longer are they just bastions of scholarship and education but now they are key economic drivers of the 'knowledge economy' and the means to rebalance economies made wobbly by bingeing on debt. But of course this is a figment, as universities have long supported economic growth, at least since the industrial revolution, by educating workers and generating ideas. But now this economic role is becoming more prominent, explicit, codified and directed. But this direction is itself may create dangers and pitfalls. First, most universities have provided a home for a range of disciplines, subjects, ideas and opinions where "the problems of life and of human relations, of creation and behaviour and religion" can be studied and taught. They are one of the few institutions in modern economies where such plurality is not only tolerated but (mainly) encouraged. But if universities become considered purely, or primarily, as economic engines then their raison d'être may be threatened. Second, many ideas that do generate economic growth emerge from the fundamental understanding that many academics pursue. Ideas that can improve the standard of living and the quality of life often emerge through a process involving some combination of chance, serendipity and unintended consequences – and often with a long time lag between the idea and the impact. If we consider the Stokes's quadrants: Bohr was a Danish physicist whose work was not driven by 'consideration of use' but his impact was to lead to major scientific advances in quantum mechanics. And these advances would ultimately lead to new products and process and economic growth. It is very unlikely that Bohr would have expected such outcomes; and it is likely that much of contemporary research will lead to positive economic impacts in the future but the researchers undertaking the work will struggle to indentify such impacts now. Third, when focus is narrowly concerned with how ideas from academia can impact on economies and societies now (and in the future) it is important to widen the discussion beyond the commercialisation of science and technology transfer. The purpose of this paper is to contribute to this issue of widening the discussion from technology transfer to knowledge exchange – but it is rooted in the context of

recognising the other strengths and important contributions of universities in modern societies.

The evidence in this paper suggests a number of strategic issues to consider in moving the discussion beyond technology transfer to knowledge exchange. First, although knowledge exchange includes technology transfer through patents, licences and spin-outs; it also includes more widespread mechanisms which include people-based, problem-solving and community orientated activities. Second, knowledge exchange involves academics from all disciplines – not just those in science and engineering. Third, academics are interacting with a range of partners in the economy and society – including businesses but also the public and third (charitable or not-for-profit) sectors. Fourth, the main constraints that hinder or limit the knowledge exchange process include a lack of time, insufficient internal capability to manage relationships; and insufficient information to identify partners. Problems concerning cultural differences between academics and business and disputes concerning IP are not highly cited by most academics or most businesses.

The emerging picture of the knowledge exchange spectrum shows the high degree of connectivity between the academic community and other parts of the economy and society. The notion of an 'ivory tower' seems to be a myth. Improving such connectivity may reap economic and social rewards. It nonetheless faces a number of challenges including: the lack of skills and competences to manage relationships and a lack of information on how to implement and exploit the benefits of knowledge exchange. This may suggest the need for improved boundary spanning skills or institutions that improve the connectivity of academia to other parts of the economy and society. Even if such connectivity is improved, expectations of impact will need to be managed. Improving knowledge exchange is a long-term game which rewards patience: substantial impacts will take time to emerge. There is moreover limited capacity for substantial increases in knowledge exchange: academics report a lack of time to fulfill their various responsibilities – which is brought into sharp relief by the reality check that there are 130,000 academics in the UK and over two million businesses with employees. Most importantly, the increased focus on the role of universities to improve innovation and economic growth should not distort or divert from the foundations of scholarship on which the substantial past success and social legitimacy of universities has been built.

Annex: The Academic and Business Surveys

1. The Business Survey

The Sampling Frame

The sample design aimed to produce an achieved sample sufficiently large to enable us to obtain an accurate estimate of the incidence of university-business links in each of the 12 regions and nations of the UK. The population of firms to be studied was those employing 5 people or more and the population data was taken from the "UK Business: Activity, Size and Location 2005" report, published by the Office of National Statistics (ONS).

We assumed the primary variable of interest, the proportion of firms with formal or informal links to academics, to be 0.25 or lower. This estimate was taken from the UK Fourth Community Innovation Survey (UK CIS 4), based on a question on universities as a source of information for innovation. We expected a response rate of 15% based on previous surveys carried out by the research team at the Centre for Business Research, and sought a sample size designed to produce a 95% confidence interval[3].

Because of the relatively small numbers of large firms with over 1000 employees we decided to approach all of them using contact information from the FAME Financial Accounts Database. Given that modification we used an optimal allocation method[4] to allocate the ONS sample to sectors and size classes within each region[5].

Survey Instrument and Pilot Study

This permitted piloting of many questions. A further pilot study was carried out for this project. The pilot instrument was sent to 200 firms stratified by size broad sector and broad regional grouping in June 2008. As a result of the pilot the layout of one of the questions was altered.

Main Survey

The main survey was carried out from July to September 2008. The first mailing went out in July and the last completed reponse was received in February 2009. Table A1 analyses the response rate which was 11.3% yielding a sample of 2551 usable responses from which we removed 20 cases which occurred in two sectors

too small to yield grossing up estimates and 1 case because of a missing identifier on the survey return.

Table A1 Business Survey: Response Rate Analysis

Sampling frame	25,015	
(less firms excluded for being ineligible)		
Ceased trading	172	
Outside scope	4	
Acquired	30	
Address unrecognised	2,331	9.3%
Total number of ineligible firms	2,537	
Surveyed firms (25,015-2,537)	22,478	
Refused	653	
No response	19,274	
Total responses*	2,551	11.3%

* 21 cases were removed from the analysis in this paper ; 11 from the mining and quarrying sector and 9 from the utilities sector as it was thought there were too few to weight up to the population; 1 additional return was excluded because the respondent removed the identifier code from the questionnaire.
Source: CBR Survey and Database Unit

Table A2 shows the 2530 final responses by sector and size and Table A3 by region .

Table A2 Size by sector (No of firms)

	5-49	50-249	250+	Total
Manufacturing	408	51	55	514
Construction	324	25	11	360
Wholesale/Retail	636	39	46	721
Hotels	116	12	7	135
Transport, Storage and Communications	104	18	15	137
Business and other services	487	58	118	663
Total	2075	203	252	2530

Source: CBR Survey and Database Unit

CBR Survey and Database Unit

The survey instrument was designed in the light of previous university-industry surveys carried out by the present authors and others (e.g. Cosh et al 2006, Cosh and Hughes 2007, D'Este and Patel 2007) and in parallel with a survey of academics carried out as part of the HEFCE funded project designed to evaluate the impact of third stream Higher Education Innovation Fund support on University culture and practices.

Table A3 Region (No of firms)

	N
Scotland	200
North East	200
Yorkshire and Humberside	221
North West	349
West Midlands	236
East Midlands	224
East Anglia	195
Wales	19
South West	236
South East	190
London	127
Northern Ireland	159
Total	2530

Source: CBR Survey and Database Unit

Response Bias Analysis

Two sets of response bias analysis were undertaken. From within the sampling frame data we compared the respondents with the non-respondents in terms of employment size sector region and age. For variables within the survey document we compared respondents in successive waves on the assumption that those requiring successive prompts were increasingly likely to share characteristics with those who ultimately did not reply at all. Tables A4 and A5 show that the sampling frame comparisons suggested a small bias towards higher response rates by firms in the 10-49 group and somewhat lower response rates in the over 250 groups. The median size of the respondents and the non-respondents was however the same.

Table A4 Respondents and Non-Respondents by size group

Employment	Respondents		Non respondents		All	
	(%)	*(N)*	(%)	*(N)*	(%)	*(N)*
5-9	39.5	1,007	39.9	7,953	39.9	8,960
10-49	42.4	1,081	38.5	7,675	39.0	8,756
50-249	8.1	207	8.1	1,623	8.1	1,830
250-999	4.9	124	5.8	1,148	5.7	1,272
1000+	5.2	132	7.7	1,527	7.4	1,659
All	100.0	2,551	100.0	19,926	100.0	22,477

Statistically significantly different at 5% (Chi square), 10% (Mann Whitney)
Source: CBR Survey and Database Unit

Table A5 Employment Size of Respondents and Non-Respondents

	Median value
Response	12
Non response	12

No statistically significant difference - Mann-Whitney U-test.
Source: CBR Survey and Database Unit

Table A6. Sector by Response Group

Sector Group	Respondents %	Non-Respondents %	All %
Mining, Quarrying Utilities	0.8	0.7	0.7
Manufacturing	20.1	18.5	18.6
Wholesale and Commission Trade	14.1	11.4	11.7
Retailing and Repair	11.6	11.6	11.6
Computing, R&D, Architectural and Technical Testing Services	7.2	6.5	6.5
Other Business Services	13.1	14.0	13.9
Other Services	16.4	22.7	22.1
All	100.0	100.0	100.0

Statistically Significantly Different at 5% (Chi Square test)
Source: CBR Survey and Database Unit

Table A7 Respondents and Non-Respondents by Year of formation

	Median value
Response	1988
Non response	1990

Statistically significant difference at 5% (Mann-Whitney U test)
Source: CBR Survey and Database Unit

The response bias analysis by response wave (not reported here for reasons of space) revealed no differences in terms of self reported employment size, year of starting trading, or value of sales which confirms the sampling frame business register data analysis. The response wave analysis does however suggest that the early respondents are statistically significantly more likely than later respondents to have collaborated with HEIs. In the first wave the proportion of such collaborators was 44.4% which fell to 34.0% by the second wave and to 29.4% by the third. Our focus in this paper is on the collaborators alone so that this potential bias which would affect attempts to gross up collaborative numbers to the population level is not of concern. We did, however, check whether the pattern of motivations and constraints among these collaborating firms used in this paper was biased across successive waves. The wave analysis shows in Table A8 no response bias in any of these variables.

Table A8 Questions asked of HEI collaborators only

Q15. Does motivation to interact with HEIs have to do with the following primary activities in the value chain of your firm:

	Response wave				
	1st wave	2nd wave	3rd wave	All	
Inbound logistics					
No	93.4	94.5	95.2	94.3	
Yes	6.6	5.5	4.8	5.7	n.s.
Operations					
No	84.6	84.9	85.5	85.0	
Yes	15.4	15.1	14.5	15.0	n.s.
Outbound logistics					
No	95.1	93.8	96.6	94.8	
Yes	4.9	6.2	3.4	5.2	n.s.
Marketing and Sales					
No	78.0	72.5	75.9	74.9	
Yes	22.0	27.5	24.1	25.1	n.s.
Service					
No	68.7	67.0	64.8	67.0	
Yes	31.3	33.0	35.2	33.0	n.s.
Introduction of new product and/or new process					
No	67.0	69.4	71.0	69.1	
Yes	33.0	30.6	29.0	30.9	n.s.

Q16 Does motivation to interact with HEIs have to do with the following support activities in the value chain of your firm:

	Response wave				
	1st wave	2nd wave	3rd wave	All	
Procurement					
No	91.7	90.5	93.2	91.5	
Yes	8.3	9.5	6.8	8.5	n.s.
Technology Development					
No	66.3	68.1	69.9	68.0	
Yes	33.7	31.9	30.1	32.0	n.s.
Human Resource Management					
No	68.0	69.1	61.6	67.0	
Yes	32.0	30.9	38.4	33.0	n.s.
Firm Infrastructure					
No	83.4	82.5	77.4	81.5	
Yes	16.6	17.5	22.6	18.5	n.s.

Q22. Have the following factors constrained interactions with HEIs in last 3 years?

	Response wave				
	1st wave	2nd wave	3rd wave	All	
Cultural differences					
No	85.5	77.8	83.5	81.4	
Yes	9.3	11.6	6.0	9.7	
D/K	5.2	10.5	10.5	9.0	n.s.
Incompatibility of timescales for deliverables					
No	77.9	72.8	76.7	75.2	
Yes	16.3	15.6	13.5	15.3	
D/K	5.8	11.6	9.8	9.5	n.s.
Insufficient benefits from interaction					
No	64.2	58.5	65.9	61.9	
Yes	28.3	29.8	24.2	28.1	
D/K	7.5	11.6	9.8	10.0	n.s.
Bureaucracy and inflexibility of HEI administration					
No	68.4	66.2	71.2	68.0	
Yes	26.3	23.3	18.9	23.2	
D/K	5.3	10.5	9.8	8.8	n.s.
Lack of interest by academics and/or HEIs					
No	71.3	69.1	72.7	70.6	
Yes	23.4	20.4	17.4	20.6	
D/K	5.3	10.5	9.8	8.8	n.s.
Lack of resources in the firm to manage the interaction					
No	50.3	52.7	53.0	52.1	
Yes	45.0	38.9	39.4	40.8	
D/K	4.7	8.4	7.6	7.1	n.s.
Difficulty in identifying partners					
No	63.7	58.9	65.2	61.8	
Yes	31.0	30.9	25.0	29.6	
D/K	5.3	10.2	9.8	8.7	n.s.
Lack of experience dealing with academics and/or HEIs					
No	73.7	67.8	67.4	69.4	
Yes	21.6	23.6	23.5	23.0	
D/K	4.7	8.7	9.1	7.6	n.s.
Difficulty in reaching agreement on intellectual property					
No	86.5	80.4	85.6	83.4	
Yes	8.8	8.0	4.5	7.4	
D/K	4.7	11.6	9.8	9.2	*
Lack of central government programmes that encourage interactions					
No	63.2	59.8	62.7	61.4	
Yes	31.0	28.6	23.9	28.2	
D/K	5.8	11.6	13.4	10.3	n.s.
Lack of regional programmes that encourage interactions					
No	62.0	59.8	59.7	60.4	
Yes	32.2	29.0	27.6	29.6	
D/K	5.8	11.2	12.7	10.0	n.s.

Source: CBR Survey and Database Unit

Weighting procedure

To gross up the survey responses to give population representative data we used a rim weighting programme (Ccount). Two sets of grossed up results were calculated using employment and business count data respectively for the business population in each size class, sector and region. To calculate the proportions of firms and employment in each of these categories, data from the SME Statistics for the UK and Regions 2008 taken from the Department of Business Innovation and Skills (BIS) website was used.

The following size, sector and regional groupings were used in the weighting procedure:

Employment Size: 5-9, 10-49, 50-249, 250+; *Sector:* Manufacturing, Construction, Wholesale/Retail, Hotels, Transport, storage and communications, Business and other services; *Region:* Scotland, North East, Yorkshire & the Humber, North West, West Midlands, East Midlands, East, Wales, South West, South East, London, Northern Ireland

2. The Academic Survey

The Sampling Frame

The required sampling frame was all academics active in teaching and/or research in 2008 in all disciplines in all UK higher education institutions. There is no publicly available database which provides contact details for this sampling frame. A list was therefore constructed of all UK higher education institutions from data compiled by the Higher Education Statistical Agency (HESA), Universities UK, the Higher Education Funding Councils of England, Wales, and Scotland and the Northern Ireland Department for Employment and Learning. A list of all academics in all departments and faculties was collated manually from the websites of all of these institutions. This email directory was the sampling frame to which a web based questionnaire was addressed. Difficulties with web access led to the exclusion of 4 smaller specialist HEIs from the sampling frame.

Prior to the administration of the survey instrument, the appropriate bodies concerned with the Freedom of Information Act rules and web conventions relating to large-scale web based surveys were consulted. This led to the specific design of the covering letter accompanying the survey instrument which gave full details of the project with which the survey was associated, contact details of the research team and the research programme of which the survey was a part. It also included

clear routes by which individuals could decline to participate or be prompted. It also guaranteed confidentiality in the treatment of all data collected.

The Survey Instrument

The survey instrument was designed in the light of previous research in this area and of a parallel survey conducted as part of an evaluation commissioned by the Higher Education Funding Council of England (HEFCE) on the impact of third stream funding on university, culture and practice (CBR/PACEC 2009), of which one of the current authors was a project leader. This process allowed a significant amount of piloting before the conduct of the survey described here. The instrument also drew on the findings of a suite of detailed case studies of university-industry interactions completed at an earlier stage of the project (Abreu et al., 2008).

The survey instrument was administered using the Qualtrics survey software suite. Because of the scale of the survey which was to be sent to over 126,000 academics identified in the sampling frame, the survey was conducted in a series of regional waves. After the completion of the first regional wave an assessment was made of the functionality of the instrument and a small number of minor changes were made which involved closing a number of open codes.

Response Rates

The survey involved an initial web mailing followed two or three weeks later by a follow-up prompt. The first wave began in September 2008 and the final wave closed in June 2009. Table A9 shows an analysis of the responses

Table A9 Academic Survey Response Analysis

	Total	%
Total sample	126,120	
less:		
Failed email address	220	
Total surveyed sample	125,900	
Completed returns	22,465	17.8
of which:		
Without	12,283	9.8
After reminder	10,182	8.1
No response	101,932	81.0
Refused	1,503	1.2
Total surveyed sample	125,900	100.0
Out of scope*	295	
Total usable sample**	22,170	

* These respondents were excluded because their survey return indicated that they were not active in either teaching or research at their institutions in the survey period.

** Completed returns minus out of scope returns.

Source: CBR Survey and Database Unit

The Table shows that, of the total sampling frame of 126,120 academics, 220 could not be contacted because of failed email addresses. Of the total surveyed sample of 125,900, we achieved 22,465 returns for an overall response rate of 17.8%. Of this total, 9.8% replied without being prompted and 8.1% replied after the prompt had been sent. No responses were received in 81% of the cases, and a further 1.2% replied refusing to take part. Of the 22,465 returns a further 295 were deemed out of scope, because their returns indicated that they were not actively involved in either teaching or research.

Representativeness of the Sample and response Bias Analysis

It is possible to compare the age, gender and seniority and disciplinary backgrounds of the respondents with broadly disaggregated data prepared by the Higher Education Statistics Agency (HESA). Tables A10 and A11 provide comparisons in terms of seniority and gender and discipline and gender respectively. They reveal that the sample is quite representative in terms of gender balance across disciplines and in the sample as a whole. Professors are, however, relatively overrepresented in the sample (for both men and women). The latter finding suggests that since external interactions rise with seniority our sample will

overstate the degree of interactions for the academic sector taken as a whole. The distribution of responses by broad discipline compared to that given by the HESA data as Table A12 reveals that health sciences are underrepresented in the sample and STEM and social sciences overrepresented.

Table A10 Comparison with HESA by Seniority and Gender

Seniority	CBR Survey			HESA		
	Male %	Female %	Total	Male %	Female %	Total
Professors	15	4	19	8	2	10
Readers, senior lecturers and senior researchers	18	11	29	13	8	21
Lecturers, researchers and research/teaching assistants	22	20	42	27	24	51
Other grades	5	4	9	9	8	17
Total	60	39	99	57	42	99

Source: CBR Database Unit and HESA Resources of Higher Education Institutions 2007/08, Table 12

Table A11 Comparison with HESA by Discipline and Gender

Discipline	CBR Survey		HESA	
	Male %	Female %	Male %	Female %
Health Sciences	45	55	43	57
STEM	73	27	74	26
Arts & Humanities	55	45	54	46
Social Sciences	57	43	56	44
All	60	40	57	43

Source: CBR Database Unit and HESA Resources of Higher Education Institutions 2007/08, Table 12

Table A12 Comparison with HESA by Discipline

Discipline	Academic staff	
	HESA 2007/08 **%**	CBR/ESRC Survey 2008/09 %
Health sciences	25	16
STEM	29	34
A&H	17	16
Social sciences	29	33
	100	100

Source: CBR Database Unit and HESA Resources of Higher Education Institutions 2007/08, Table 12

Response Bias

In addition to comparisons of representativeness based on the HESA statistics, we carried out an analysis of response characteristics by wave. On the assumption that those requiring prompting will be increasingly similar to those not responding, then if there is response bias we might expect later waves to display different characteristics to unprompted responses. The large sample size means that even small quantitative differences may be statistically significant. The results are shown in Table A13. It shows that those requiring prompting were both statistically and quantitatively less likely to report public non-commercial and charitable sector activities than immediate responders. Private sector and commercialisation interactions are occasionally statistically significantly different from those requiring a prompt. They were, however, quantitatively very similar and therefore display no practically important bias.

Table A13 If undertaking research, which of the following closely describes it (%)

	Basic research	User-inspired basic research	Applied research
Without reminder	27	30	43
After reminder	28	29	43

Disagreement/agreement (1-5) with: Academia should focus on basic research and should not be concerned with its actual or potential application

	Mean	Median
Without reminder	2.34	2
After reminder	2.35	2

Disagreement/agreement (1-5) with: Over the past few years, universities have gone too far in attempting to meet the needs of industry to the detriment of their core teaching and research roles

	Mean	Median
Without reminder	3.25	3
After reminder	3.26	3

If undertaking research: It has been applied in a commercial context

	% ticked
Without reminder	19**
After reminder	18

If undertaking research: It is in a general area of commercial interest to industry

	% ticked
Without reminder	35
After reminder	35

Undertaken activities with private sector companies in last 3 years

	% ticked
Without reminder	43**
After reminder	40

Undertaken activities with public sector organisations in last 3 years

	% ticked
Without reminder	56**
After reminder	50

Engaged in activities with charitable or voluntary organisation in last 3 years

	% ticked
Without reminder	47**
After reminder	41

If undertaking research: It has relevance for non-commercial external organisations

	% ticked
Without reminder	73**
After reminder	70

If undertaking research: It has no relevance for external organisations

	% ticked
Without reminder	11**
After reminder	12

Source: CBR Survey and Database Unit

Notes

[1] The concern about these perceived trends and the need to resist such implications have led to a series of contributions in defence of a wider view (Bakhshi et al 2008; Bate, 2011; British Academy, 2008 and 2010; Bullen et al 2004; CIHE, 2010; Crossick ,2009; Goddard, 2009; Howells, 2010; Kitson et al, 2009; Nussbaum, 2010; Royal Society 2010; Universities UK, 2010).

[2] A very small number of academics chose the option of replying that none of the above closely described their research. These have been excluded from the analysis by discipline shown in Figure 1.

[3] The formula used to calculate the total sample size was: $n_0 = \frac{Z^2 pq}{e^2}$ where n_0 is the sample size, Z^2 is the point in the normal curve that cuts off an area α at the tails ($1-\alpha$ is the desired confidence level, e.g., 95%), p is the estimated proportion of interest, q is $1-p$ and e is the desired level of precision. The sample size was then adjusted using a finite population correction: $n = \frac{n_0}{1+\frac{(n_0-1)}{N}}$ where n is the adjusted sample size, and N is the population size.

[4] This was done using the Neyman allocation formula: $n_h = \frac{n(N_h S_h)}{\sum_{i=1}^{H} N_i S_i}$ where n is the total sample size, n_h is the sample size of stratum h, N_h is the population size of stratum h, S_h is the standard deviation of stratum h, and H is the total number of strata. A stratum which is large or has a large within stratum variance is allocated a larger number of sampling units than a stratum that is smaller or more internally-homogeneous. The variance for each stratum was estimated using the UK CIS 4 survey, with additional information on the variance for firms with 5-9 employees relative to firms with 10-49 employees taken from the 2004 CBR Small and Medium-Sized Business Survey.

[5] Due to a coding error in the file supplying addresses from the D&B register the North West Region was oversampled. The effect of this oversampling is removed when grossing up results to national level in this paper.

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