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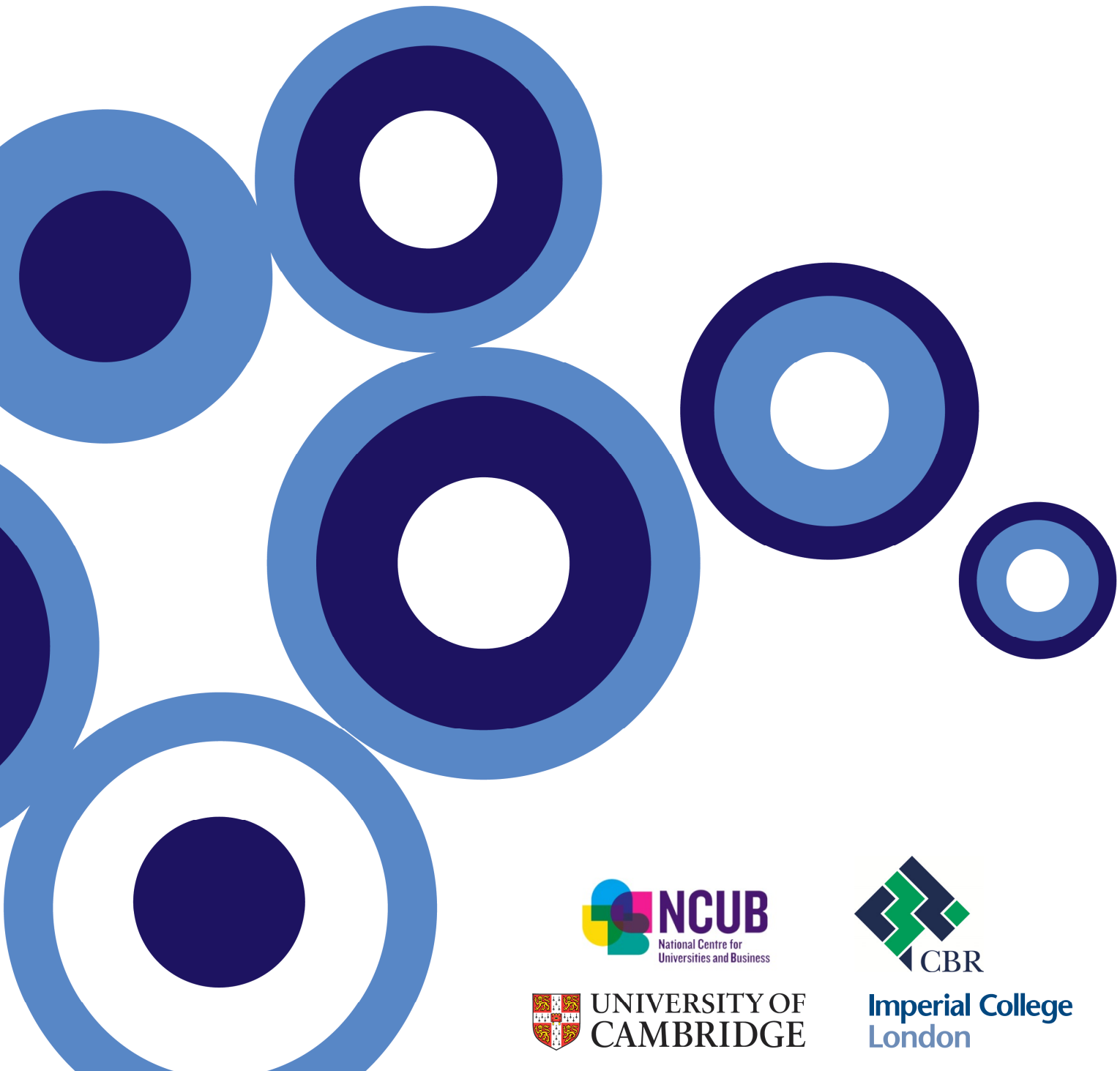
Connecting with the Ivory Tower: Business Perspectives on Knowledge Exchange in the UK

Alan Hughes and Michael Kitson



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Imperial College London

Acknowledgement

The authors acknowledge support from the Economic and Social Research Council in partnership with the Scottish Funding Council, Department for Employment and Learning in Northern Ireland, the Higher Education Funding Council for England (HEFCE) and the Higher Education Funding Council for Wales under grant RES-171-35-0018 'University Knowledge Exchange: Demand Pull, Supply Push and the Public Space Role of Higher Education Institutions in the UK Regions'.

The authors also wish to acknowledge the contribution of Maria Abreu and Vadim Grinevich who were, respectively, Research Fellow and Junior Research Fellow employed on this project at the Centre for Business Research (CBR) Cambridge in particular for their input into the survey instrument design, and the sample design for the business survey. Particular acknowledgement is due to Anna Bullock and Isobel Milner for their management of the business survey and undertaking the task of creating and cleaning the survey dataset, carrying out the response bias checks, and undertaking the core data preparation for this report. The survey instrument designs also benefitted substantially from discussion with Barry Moore, Thomas Ulrichsen and Nic Boyns of Public and Corporate Economic Consultants (PACEC) who, with one of the current authors, were project leaders on a parallel HEFCE-funded project evaluating the impact of third stream funding on English universities (CBR/PACEC, 2009). We are also grateful for the input of Philip Ternouth of the then Council for Industry and Higher Education (CIHE), now the National Centre for Universities and Business (NCUB) who took part in a series of pre-survey case studies that fed into the survey design.

Finally we would like to acknowledge the support of over 2500 businesses who gave up their valuable time to complete the survey. This report would not have been possible without them.

Alan Hughes
Judge Business School,
Director UK~IRC ,
Senior Research Fellow NCUB and CBR

Michael Kitsons
Judge Business School,
Director UK~IRC Knowledge Hub
Assistant Director CBR

Cambridge, November 2013

About the UK~IRC

The UK Innovation Research Centre (UK~IRC) is a joint venture between the Centre for Business Research at the University of Cambridge and Imperial College Business School to further research and knowledge exchange on innovation policy practice. The UK~IRC is global in scope and involves a large-scale, multi-year research programme and a Knowledge Hub to engage with and inform policy-makers and practitioners about innovation research. The research programme explores open innovation, service innovation, online communities and innovation policy-making. A further stream of research focuses on the nature of university-industry links and the role of higher education in innovation systems. Through the Hub, our aim is to maximise the effect of the research on policy and practice, so as to help the UK face its social, environmental and economic challenges

The Centre is co-funded by the Department for Business, Innovation and Skills (BIS), the Economic and Social Research Council (ESRC), the National Endowment for Science, Technology and the Arts (NESTA and the Technology Strategy Board (TSB). This support is gratefully acknowledged. www.ukirc.ac.uk

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Drawing on the 25 years' experience of our predecessor body, the Council for Industry and Higher Education (CIHE), the NCUB is committed to a programme of research, policy development and practical partnerships. From facilitating collaborative R&D to developing the entrepreneurial and employability skills of the labour force, the NCUB is working to boost the competitiveness of UK business and higher education institutions in the global market.

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Executive Summary

There is an increasing focus on the role of universities in stimulating innovation and economic growth in the UK. Despite this attention there are still gaps in understanding on the why, how and impact of university-business collaborations. This report fills some of these gaps by analysing the results of a large scale survey of UK businesses.

The Characteristics of the Survey Sample

The sample on which we have based this report covers the full range of industrial sectors and size categories, and includes large samples of firms from each region and devolved administration in the UK. The survey comprises 2,530 firms: over 20% were in the manufacturing sector: 28% were in wholesaling and retail trades; and 13% were in other business service activities. The relative predominance of service activities is a reflection of the extent to which they have become the dominant sector of the UK market economy. Approximately 38% of the sample were micro firms, 43% were small firms, 10% were medium-sized firms and 9% were large firms. The sample when grossed up to population totals is broadly representative of the UK business sector.

Innovation and Sources of Knowledge

Discussions of university-business relationships frequently focus on the potential gains from university links for the innovative activity of UK businesses.

Approximately a third of the sample carried out R&D, with a clear positive correlation with firm size. Furthermore 44% of the firms reported either a product, process or logistics innovation in the three years prior to the survey. The likelihood of reporting innovative activity also increases with size of business.

The sources of knowledge for the business are dominated by the firm itself, customers, suppliers, and competitors. These are followed by a range of what might be termed intermediary sources, including: the trade and technical press, professional and industry networks and associations, conferences, trade fairs, and exhibitions, and to a lesser extent, consultants and technical or standard setting bodies. Government or public research institutions, higher education institutions, and private R&D enterprises are at the bottom of the list.

In terms of higher education institutions, however, there is a clear upward gradient with firm size: whilst 27% of micro firms report using higher education institutions as a source of knowledge for innovation, over twice as many (58%) of the large firms do so.

A very similar pattern to that for frequency emerges when the importance attached to each source of knowledge is reported by users of each source. In relation to higher education institutions: 15% of businesses consider this source of knowledge as important or highly important.

Modes of Interaction between Businesses and Universities

There is much policy focus on the application of academic research and the benefits of businesses commercialising science. Much of the discussion focuses on aspects of the technology transfer process, including: academic spin-off activities, university licensing and patents. Although such commercialisation mechanisms are important modes of university-business exchange they are an incomplete representation of the wide process of knowledge exchange which encompasses multiple mechanisms and many disciplines including the social sciences and the humanities.

To identify the range and patterns of connectivity by the businesses in our sample, the survey inquired about these wider modes of interaction in three broad categories: people based, problem solving and community based.

Overall, 25% of firms engage in people based interactions, although there is distinct variation by firm size: 64% of large firms use people based interactions compared to only 18% of micro firms. The modes of interaction that were most frequently used were: training staff through enrolment on HEI courses or through personnel exchange; attending conferences which have HEI participation; supervising in-course student projects and funding internships; and participation in networks involving HEIs.

Innovating firms are far more likely to be engaged in people based interactions compared to non-innovating firms – and this pattern is consistent across all modes of interaction. Furthermore, fast growth firms are more likely to engage in people based interactions compared to medium growth firms and those that have stable growth or who are declining. Overall, the most engaged sector in terms of this mode is business services, followed by manufacturing, other activities and wholesale/retail.

In terms of problem solving interactions, these are used by 10% of firms. There is a distinct variation by firm size: 41% of large firms use problem based interactions compared to only 7% of micro firms. The modes of interaction that were most frequently used were: informal advice from academics; consultancy services; and joint research with academics. Innovating firms are far more likely to be engaged in problem solving interactions compared to non-innovating firms – and this pattern is consistent across all modes of interaction. Furthermore, fast growth firms are more likely to engage in problem solving interactions compared to medium growth firms and those that have stable growth or who are declining. Overall, the most engaged sector in terms of this mode is, once again, business services, closely followed by manufacturing, and wholesale/retail and other activities.

In terms of community based interactions, these are used by 15% of firms. The propensity to engage in such interactions being positively correlated with firm size: 45% of large firms engage in such interactions, compared to; 26% of medium-sized firms; 15% of small firms; and 11% of micro firms.

In addition to the modes of wider knowledge exchange, some of the interacting firms also engage in a range of commercialisation activities. Overall, the acquisition of patents and licences from non-HEIs is more than twice the level of the acquisition of patents and licences from HEIs. Furthermore, the propensity to acquire patents and licences tends to be positively correlated

with firm size; with a much higher propensity for larger firms compared to small and micro firms. As would be expected, innovating firms are far more likely to acquire patents and licences compared to non-innovating firms.

A traditional form of knowledge transfer is the use of academic publications to improve products and processes. This mode of interaction is used by 27% of all interacting firms - substantially higher than the use of patents of collaboration with spin-outs and consistent with traditional academic output modes being of value to business.

There has been a focus on business interactions with science-based disciplines such as engineering. Engineering is indeed the discipline which has the highest level of business interactions. There are, however, a range of other disciplines that have relatively high levels of interactions. These include: business and financial studies; mathematics and computing; and architecture, planning and urban design. This indicates the importance of broadening the policy agenda, and considering the role and impact of all disciplines, not just those from science and engineering.

There has been an increasing emphasis on the role of proximity in the innovation process. Overall, proximity is most important with respect to skilled labour – 58% of businesses consider this to be important or highly important. Furthermore, 20% of businesses consider it important or highly important to be close to other firms in their industry; and 18% of businesses consider it important or highly important to be close to service specialists. Conversely, only 8% of businesses consider it important or highly important to be close to universities or government support agencies. It is important to bear these orders of magnitude in mind when considering HEIs as key players in regional and local innovation ecosystems.

Creating Partnerships: How interactions are developed

Knowledge exchange between business and academia requires the development of effective partnerships. Many universities have developed technology transfer capabilities in order to improve the connections with business particularly in the realm of the commercialisation of science and technology.

Overall, 17% of interacting firms had their interaction with a HEI in the last three years initiated by the university's technology transfer office (TTO). But this was the least frequently cited initiation process: the most frequently cited initiation processes were: the actions of the firm in approaching academics or the HEI directly; contact by individual academics; connection by a third party organisation; mutual actions following up informal contacts; and mutual actions following up contact at a formal conference or meeting. This emphasises the importance of informal impact pathways and the need to foster an 'open' approach to developing business-HEI links.

For many of these processes there is positive correlation with firm size, with large firms being more likely to use such mechanisms compared to small and micro firms. Micro firms were the least likely to have used the technology transfer office route whilst medium and large firms were most likely to have used this mechanism.

As expected the TTO is most likely to be used by businesses connecting with engineering and material sciences as these are disciplines where the use of formal technology transfer mechanisms is relatively high. However, even in these disciplines, own actions by academics and the businesses are relatively high – and much higher than connections through the TTO. The use of third party organisations is particularly high when connecting with health sciences and biology, chemistry and veterinary sciences.

The evidence shows the important role of the firm in initiating contact with HEIs either unilaterally or mutually with HEIs – and this is particularly important for larger firms. Overall, 13% of firms employ someone who performs this role, but there is a pronounced positive correlation with firm size, for instance only 8% of micro firms employ someone to liaise with HEIs compared to 54% of large firms. This suggests that larger firms have more connective capacity which facilitates their connections with universities and academics. There is therefore a potential capacity barrier facing smaller businesses that seek to initiate interaction with HEIs.

The Motivations and Impact of Knowledge Exchange

Interacting firms were asked to identify the **primary activities** in the value chain of their businesses which motivated their interaction with HEIs. Firms could identify such primary activities in terms of six categories: inbound logistics; operations; outbound logistics; marketing and sales; service-related activities; and the introduction of new products and/or processes.

When interacting firms are classified by industry, a number of sectoral differences are revealed Marketing and sales as a motivation is highest in business services and in manufacturing whilst business services are the most likely to cite service-related activities as a key motivating factor.

Manufacturing is easily the most significant sector in terms of the extent to which the introduction of new products and/or new processes is the motivating factor with nearly 50% of the respondents citing this as a motivating activity. The manufacturing sector is followed by wholesaling and retailing and business services.

The disciplines that firms interact with vary considerably across activities. Firms citing inbound logistics as a factor behind their interactions were much more likely to have been interacting with business and financial studies. Those motivated by operational considerations were more likely to be interacting with a substantial range of science-based disciplines topped by engineering and materials science, but also by interactions with business and financial studies. Business and financial studies were also relatively more important for those concerned with outbound logistics. Marketing and sales were relatively highly linked to economics and social science, business and financial studies and the arts and humanities. The picture which emerges is of a very wide range of academic disciplinary interactions across the full range of primary business activities.

The survey also asked whether the motivation for enterprises to interact was concerned with the **support activities** in the value chain of the firm. These included the procurement of raw materials, spare parts, building and machines, technology development in terms of research and development, process alteration, design and re-design, human resource management in terms of

recruiting, staff development, education, retention and the compensation of employees and managers, and firm infrastructure (general management, planning management, legal, finance, accounting, public affairs and quality management).

Technology development and human resource management were the dominant support activities around which businesses sought interactions with higher education institutes. Around 30% of interacting firms reporting that these two areas were a source of motivation. Firm infrastructure and procurement were much less important.

For manufacturing, over half of the firms cite technology development as a support activity in motivating interactions with HEIs. This is far higher than any other sector. For business services, human resource management is the dominant factor motivating interactions.

As might be expected, technology development is a much more important motivating factor for innovative firms. Non-innovators and innovators show, however, a very similar proportion of enterprises requiring support in relation to human resource management.

Overall, approximately 9 out of 10 firms report that their interactions with academia were successful or partially successful.

The firms were also asked to identify any wider impact that their interactions with higher education institutions had on the nature of their business more generally, and on the kind of research that they did. Approximately a quarter of all interacting firms reported that the interaction had: provided new insights; strengthened the firm's reputation; and led to new connections.

The survey provides information on how firms measured the impact of their interactions. Measures related to wider business objectives were the most frequently cited, followed by qualitative assessment information, technical objectives based assessment and finally by investment objectives.

Constraints

The survey provides information on factors which businesses report as constraints on interactions with HEIs. Firms were most likely to report a lack of resources to manage interactions. The next most frequent constraints reported were a lack of central and regional government policies to encourage interactions. These constraints were closely followed by difficulty in identifying partners, insufficient benefits from the interaction, lack of experience in dealing with academics and/or HEIs and bureaucratic inflexibility in HEI administrations. It is interesting to note that incompatibility of time scales for deliverables, cultural differences and difficulty in reaching agreement on intellectual property were the least frequently cited constraints. This suggests that arguments based on these particular reasons for incompatibility between business and universities in knowledge exchange are overstated.

In the case of difficulty in reaching an agreement on intellectual property, this is only likely to be a perceived constraint in areas where intellectual property is an important part of the interaction.

The relatively low proportion reporting constraints from this source could therefore be a reflection of the rather narrow group of enterprises involved in IP related interactions.

Innovators are more likely to report constraints than non-innovators. It is interesting to note nearly half of innovating firms reported that they lacked the resources to manage the interaction. The broad rankings of constraints were, however, broadly similar to those reported by non-innovators and by firms as a whole. Furthermore, in most cases, fast growth firms experienced higher frequencies of constraints than other firms.

The survey also shows how the constraints have evolved over a three year period. The constraints that had increased the most include: difficulty in reaching agreement on intellectual property, and bureaucracy and inflexibility of HEI administration. As we have noted, the first of these is a constraint which is reported by relatively few businesses. Bureaucracy and inflexibility of HEI administration is, in contrast, relatively frequently cited as a constraint, and also has significantly deteriorated. This raises important questions about the extent to which the increased emphasis in HEIs on the management of knowledge exchange has been associated with worsening rather than improving interactions between HEIs and businesses.

Around 70% of businesses do not interact with HEIs. The most common reasons for not interacting were: not considered relevant; a lack of information on potential benefits; and a lack of information on how to develop interactions. In terms of firm size, micro and small businesses are most likely to report that interactions are not considered relevant.

Concluding Remarks

The evidence in this report systematically reveals that businesses report a rich and diverse pattern of engagement with academia in the UK. Knowledge exchange reported by businesses includes technology transfer through patents, licences and spin-outs; but it also includes more widespread mechanisms which include people based, problem solving and community orientated activities. Second, businesses report connections to academics from all disciplines – not just those in science and engineering. Third, businesses connect for a range of reasons – many not directly concerned with innovation - to improve performance and strategy. Fourth, the main constraints reported by businesses that hinder or limit the knowledge exchange process include insufficient internal capability to manage relationships. Problems concerning cultural differences between academics and business and disputes concerning IP are not frequently cited by businesses.

These patterns of responses are remarkably similar to those reported by academics in the parallel survey carried out by the CBR team. This reinforces the power of the findings from each survey.

Section 1 Introduction

The Wider Perspective on Connecting with the Ivory Tower: 10 Key Issues

There is an increasing focus on the role of universities in stimulating innovation and economic growth in the UK (Sainsbury, 2007, Wilson, 2012 and Witty, 2013).

This focus has become sharper following the financial crisis and the era of austerity as policy makers have shifted attention to promoting recovery from recession and the need to rebalance economies. Despite this attention there are still gaps in understanding of the why, how and impact of university-business collaborations. This report intends to fill some of these gaps; and this section considers the key results of the CBR survey of the relationships with universities of over 2,500 UK businesses (Hughes et al, 2010a). In this section we identify the key findings from this survey and in doing so we draw on the results of a parallel CBR survey of academics[1] which received over 22,000 responses (Hughes et al, 2010b; Hughes and Kitson, 2012).

1. Hidden connections: the extent of business connections with academia

There are widespread connections between academia and business beyond what is often revealed in conventional metrics.

It has been widely accepted that there has been a significant change in knowledge exchange between universities and business in the UK during the past 15 years (Sainsbury 2007; Wilson, 2012). The extent and breadth of knowledge exchange has, however, often been underestimated. As documented in this report, there are many mechanisms through which businesses engage with academia and this often involves a rich variety of disciplines.

It is difficult to fully capture the landscape of university-business interactions because of a lack of comprehensive metrics. As the Wilson Review (2012) observed: 'further development within the specialist domains of business–university collaboration requires a focused approach. However, in the context of broader policy formulation, knowledge of the entire landscape is absolutely critical if we are to realise the full potential of universities in supporting UK economic growth' (p.24). The evidence from the university-business survey suggests that previous estimates of university business interactions have underestimated the extent of connectivity. One of the most frequently cited sources is the Community Innovation Survey (CIS) which asks respondents: "Did your business co-operate on any innovation activities with any of the following: universities or other higher education institutions?" (CIS6, Q18). This reveals that 15% of business collaborate with universities or other HEIs for innovation. There are two limitations to the evidence derived from the CIS survey question. First, the question asks about collaboration with universities or other HEIs which may not capture collaboration with individual academics – which has been shown to be highly prevalent (Hughes and Kitson, 2012). Second, as the question is concerned with innovation, it may not capture collaboration for other reasons – as discussed in section 6 of this report, businesses interact with

[1] This section draws on Hughes and Kitson (2012). For a systematic survey of the academic literature on university- business links see Perkmann, et al (2013).

academics for a wide range of reasons including those – such as human resource management and marketing – which may be beyond the narrow realm of innovation. Thus, the evidence from the business survey shows that nearly a third of businesses are collaborating with academia – significantly higher to that reported in the results from the CIS surveys which, as we have argued, focus on a narrower range of connections.

2. Knowledge exchange is wider than technology transfer

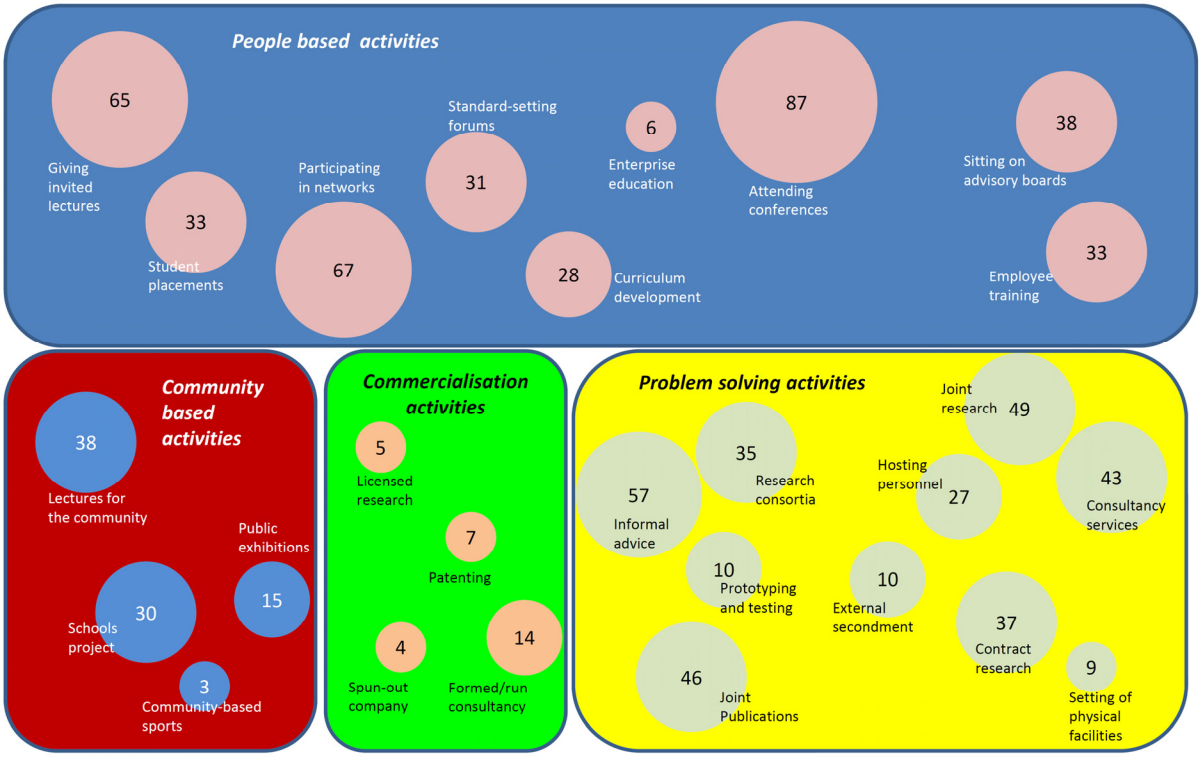
The connectivity between business and academia includes a wide range of people based, problem solving and community activities.

A particular focus of university-business interactions has been concerned with how technology can be transferred from the science base – often through such mechanisms as patents, licences and spin outs. Although technology transfer mechanisms are an important part of the knowledge exchange spectrum they are an incomplete representation of the wider process of knowledge exchange which encompasses multiple mechanisms (Salter and Martin, 2001; Hughes and Kitson, 2012). The evidence presented in section 4 of this report shows that very few firms are engaged in formal technology transfer with academia. Similarly, very few academics are engaged in technology transfer: the survey of academics showed that over a three year period: 7% had taken out a patent; 5% had licensed research and 4% had formed a spin-out company.

The connectivity between business and academia is wider than the narrow confines of the commercialisation of science and technology transfer. As discussed in section 4 of this report, the range and patterns of connectivity by the businesses can be categorised into three broad modes of interaction: people based, problem solving and community based. Overall, 25% of collaborating firms engage in people based interactions; 10% engage in problem solving interactions; and 15% engage in community based interactions. This illustrates the breadth of knowledge exchange beyond the narrow confines of technology transfer.

The analysis of the knowledge exchange activities of academics revealed in the parallel CBR survey of academics is shown in Exhibit 1.1. This reveals a higher propensity to engage with external partners than the business survey. However, the academic survey includes interactions with the public and third sectors as well as business. Overall, the findings from the surveys of both businesses and academics reveal a wide range of pathways to impact arising from these external interactions. It reveals a picture of extensive interactions within which technology transfer activities play a relatively small role.

Exhibit 1.1 Impact Pathways of UK Academics (% of academics reporting the interaction with an external organisation)



Source: Hughes and Kitson (2012)

3. Knowledge exchange involves a wide range of disciplines

Businesses connect with expertise from a range of disciplines: including the social sciences, the arts and humanities as well as science and engineering.

The study of innovation frequently focuses on how science and engineering can improve the innovative performance of businesses through technological developments which will lead to new products and processes. It is important, however, to broaden the research agenda and consider and analyse engagement from all disciplines and not just those from science and engineering.

The evidence from the business survey reported in section 4 of this report shows that engineering is the discipline which has the highest level of business interactions: 34% of collaborating firms report interacting with this discipline. But there are a range of other disciplines that have relatively high levels of interactions including: business and financial studies (27%); mathematics and physics (19%); and architecture, planning and urban design (16%). The survey of academics shows that more than 40 % of academics from all disciplines interact with private sector businesses (Kitson and Hughes, 2012). And, as may be expected, engineering was the most engaged discipline; more than three-quarters of academics from the discipline interact with the private sector. But academics from disciplines outside the science base, including social sciences (40%) and the arts and humanities (30%), report a high level of interaction with external partners.

Overall, the evidence shows that businesses draw expertise from a range of disciplines (Abreu et al, 2009). This indicates the importance of broadening the policy agenda, and considering the role and impact of all disciplines, not just those from science and engineering.

4. Improving business performance not just innovation

Businesses connect to academia for a range or reasons – many not concerned with innovation - to improve performance and strategy.

Much of the debate on the role of university-business collaboration focuses on technology and innovation. According to the Witty (2013) Review:

> 'Universities should assume an explicit responsibility for facilitating economic growth, and all universities should have stronger incentives to embrace this "enhanced Third Mission" – from working together to develop and commercialise technologies which can win in international markets to partnering with innovative local Small and Medium Enterprises (SMEs)'. (p.6)

Universities play an important role in the innovation system but knowledge exchange is not solely concerned with innovation – particularly innovation which is concerned with developing new technologies. As shown in section 6 of this report, 27% of collaborating firms are motivated to engage to support the introduction of a new product or a new process. But motivations to engage with universities are also connected to many other areas of business activities. In terms of primary business activities, 34% of collaborating firms are motivated to connect to support service activities (that maintain and enhance the product value such as customer support); 24% of firms are motivated by marketing and sales. The notion that businesses connect with scientists to improve their innovative performance is important but incomplete. Improving business performance involves the many and varied aspects of business organisation, business model development and strategy and this is reflected in the multiple reasons why businesses connect with academia (Hughes and Kitson, 2012).

Whereas businesses are primarily motivated to connect with academics to improve corporate performance, academics are primarily motivated to engage with external organisations to support their research and teaching. The survey of academics shows that the main motivations to engage with external organisations were: gaining insights in the area of the academic's research; keeping up to date with research in external organisations; and testing the practical application of research. Conversely, the motivations that had the lowest rank were concerned with financial or commercial gain such as: personal income and business opportunities (Abreu et al, 2009). This suggests that engagement with external organisations strengthens the two core missions of academics – research and teaching and the notion of a separate 'third mission' or 'third stream' may be a misnomer as knowledge exchange is centrally linked with the core missions of academia.

5. Beyond business performance: connecting with the public and third sectors

There is a high degree of interactions between academia and the public and third sectors.

The focus of much of both the academic literature and the policy discourse has been how, and through which mechanisms, academics engage with business. But the evidence from the academic survey shows a high degree of interactions with the public and third sectors (which includes charities, voluntary organisations and social enterprises) (Hughes and Kitson, 2012). Overall, 53% of academics interact with the public sector, with health sciences having the highest level of interaction which probably reflects interactions with the National Health Service. The extent of interactions with the social sciences is also high with 63% of academics interacting with the public sector. Furthermore, 44% of academics engage with the third sector - slightly higher than the level of engagement with the private sector. 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%).

It is important to consider connectivity to the public and third sectors. The public and the third sectors are important contributors to the economy. Furthermore they are important sectors that contribute to welfare and the quality of life (Hughes et al, 2011).

6. People are more important than patents

Personal interactions are the most important means of developing and fostering connectivity.

Knowledge exchange between business and academia requires the development of effective partnerships that facilitate and manage contractual and relational interactions (Abreu et al, 2008). Many universities have developed technology transfer offices (TTOs) in order to improve the connections with business particularly in the realm of the commercialisation of science and technology. The survey of business shows that approximately one sixth of collaborating firms had their interaction initiated by a university's technology transfer office. But this was the least frequently cited initiation process by firms in the survey: the most frequently cited initiation processes were: the actions of the firm in approaching academics or the HEI directly; contact by individual academics; connection by a third party organisation; mutual actions following up informal contact; and mutual actions following up contact at a formal conference or meeting. The evidence from the survey of academics (Hughes et al, 2010b) is consistent with that of the survey of businesses. The academic survey showed that the most frequently cited initiator were individuals associated with the external organisation and the least frequently cited initiator was the TTO.

This evidence suggests two important features characteristics of the knowledge exchange process. First, the relative minor importance of TTOs probably reflects that many of the knowledge exchange interactions are informal and people based and do not require the contractual and transactional inputs from a TTO (Abreu et al, 2009). Second, many businesses initiate contact with HEIs either unilaterally or mutually with HEIs. And the capacity to connect and engage is much stronger in larger

firms compared to SMEs. The survey of businesses shows only 8% of micro firms employ someone to liaise with HEIs compared to 54% of large firms.

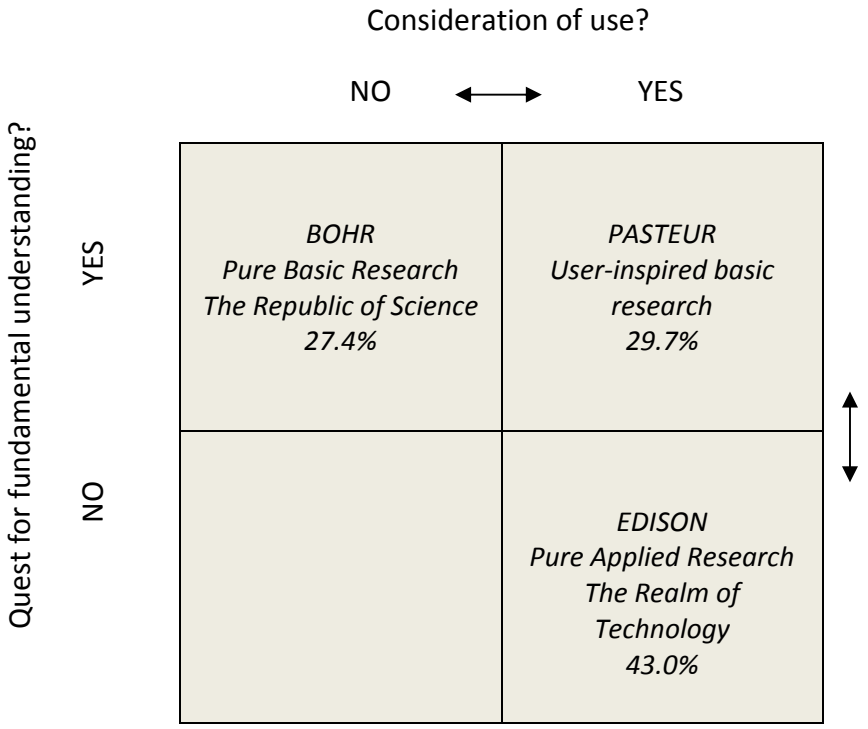
7. Too sharp a distinction between basic and applied research is unhelpful

The distinction between basic and applied research is too simplistic and often ignores the links and feedbacks between basic and applied research.

A common theme in discussion of the role of universities in promoting innovation and growth has been the need to encourage a shift to more applied research. This is reflected in the insistence in the UK that applications for research grants identify pathways to impact and case studies of impact are an important part of the Research Evaluation Framework (REF) which is evaluating the research performance of UK academia.

In addition both the ESRC and EPSRC make impact acceleration awards to universities receiving their research funding. A useful approach to the discussion of pure and applied research is that developed by Stokes (1997). He distinguished between: basic, user-inspired and applied research. 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. The types of research are mapped in a quadrant diagram (Exhibit 1.1), using the labels following Stokes (1997): basic research (Bohr); applied research (Edison); and user-inspired basic research (Pasteur).

Exhibit 1.2 Stokes's Quadrants



Source: Hughes and Kitson (2012) adapted from Stokes (1997) and Dasgupta and David (1994)

Exhibit 1.2 also shows the percentage of academics engaged in the different types of research based on the respondents to a large scale survey of academics as reported in Hughes and Kitson (2012). Most academics consider themselves as not being in an "ivory tower" of pure basic research characterised by the Bohr quadrant but 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.

There are, of course, differences across disciplines. First, in relation to the health sciences, there is a strong propensity to be engaged with user-inspired and applied research (Hughes and Kitson, 2012). Second, academics from the arts and humanities are more likely to be engaged in pure basic research compared with user-inspired and applied research (Hughes, et al, 2011). Third, the social sciences occupy an intermediate position; they share with the STEM (science, technology, engineering and mathematics) disciplines a relatively high focus on user-inspired research, but are more concerned with application than STEM.

There are a number of implications for the impact agenda. First, policies to encourage academics to spend more of their time engaged in applied research should acknowledge that relatively few academics are engaged in basic research. Second, many individual academics may, in the course of their career, undertake different types of research – that is, move between the Stokes quadrants. Third, much basic (Bohr) research may lead to new products or processes in the future – beyond what may have ever been envisaged by the researchers. Finally, businesses and academics in each of these quadrants may connect using the extensive set of interaction pathways we have discussed.

8. Constraints: are they the usual suspects?

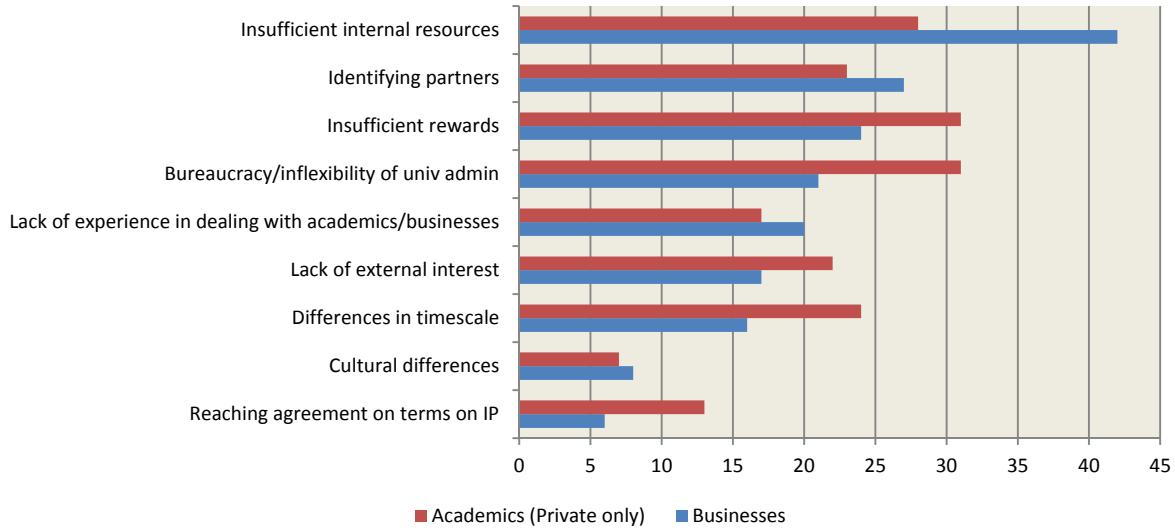
Issues related to intellectual property and cultural difference between business and academics are not widespread constraints. The most frequently cited constraints concern internal capability to develop and manage relationships.

It is commonly argued that cultural differences frequently hinder interactions between universities and business. According to the Lambert Report: 'companies and universities are not natural partners: their cultures and their missions are different' (Lambert, 2003, p.15). Furthermore, it is also argued 'there are a number of barriers to commercialising university IP' (Lambert, 2003, p.4).

The results from the survey of business, as shown in Exhibit 1.3 (and reported more extensively in section 7), show that enterprises were most likely to report that their interactions had been constrained by a lack of their own resources to manage the interaction. The next most frequent constraints reported were: a lack of central and regional government policy to encourage interactions; difficulty in identifying partners; insufficient benefits from the interaction; lack of experience in dealing with academics and/or HEIs; and bureaucratic inflexibility in HEI administrations. The least frequently cited constraints were: incompatibility of time scales for deliverables; cultural differences and difficulty in reaching agreement on intellectual property. The results from the survey of academics, as shown in Exhibit 1.3, paint a similar picture (Hughes and Kitson, 2012). Overall, for academics from all disciplines the most important constraints were: lack of time; university bureaucracy and insufficient rewards from an interaction. Whereas the least cited constraints were: cultural differences and disputes over IP.

The picture of the constraints that prevent or hinder interactions is more complex than a focus on IP and cultural differences would suggest. 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 business cite the identification of partners as an important constraint: this suggests that boundary spanning should address the information failure identified by both partners. Third, both academics and businesses identify 'insufficient rewards' as a constraint. Rewards for business are primarily concerned with corporate performance whereas academics tend to engage in external interactions to support their research and teaching (Abreu et al, 2009). Thus boundary spanning needs to align incentives and rewards – which may be most easily achieved in the area of Pasteur's quadrant.

Exhibit 1.3 Constraints on Interactions: Businesses and Academics engaged with the private sector (% of respondents)



Source: Hughes and Kitson (2012)

9. Does proximity matter?

The geography of interactions is complex: although proximity to skilled labour is considered to be important, and universities contribute to that, for most businesses proximity to universities *per se* is infrequently perceived to be important.

There is increasing emphasis on the role of place in delivering economic growth (Heseltine, 2013); the localism agenda stresses that different places have different economic structures, assets and needs. Universities contribute to the local economy in several ways: they act as significant employers and purchasers; they produce a skilled workforce; and they provide a focus for coordinating local activity through the formal and informal exchange of knowledge and expertise (Kitson et al, 2009). The issue of proximity may create tensions between regional economic growth and the concentration of research in centres of excellence. According to Lambert (2003, p.6): 'proximity matters when it comes to business-university collaboration. SMEs, in particular, find it difficult to work with research departments on the other side of the country. If resources are increasingly concentrated on a small number of world-class research departments, there is likely to be a negative impact on the level of business-university collaboration in the UK.'

The evidence from the business survey suggests that the simple notion that proximity to universities is important may be exaggerated. Overall, proximity is most important with respect to skilled labour – 58% of businesses consider this to be important or highly important influencing location. Furthermore, 20% of businesses consider it important or highly important to be close to other firms in their industry; and 18% of businesses consider it important or highly important to be close to service specialists. But, only 8% of businesses consider it important or highly important to be close to universities or government support agencies. This suggests that proximity to universities may be most important in their role as suppliers of skilled labour. Yet, here the picture is complex, as the

geography of recruitment is complex and covers many different spatial scales: 47% of firms recruit from their local area; 43% recruit from their administrative region; and 46% recruit from the rest of the UK.

10. Be careful what you wish for: the future of universities

It is important that the increased focus on impact does not harm the strength of the university sector in the UK.

The emerging picture of the knowledge exchange spectrum shows the high degree of connectivity between the academic community and businesses as well as other parts of the economy and society. The notion of an 'ivory tower' seems to be a myth (Hughes and Kitson, 2012) but improving the breadth, depth and impact of knowledge exchange may generate economic and social benefits. There are, however, 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 suggests that policy should focus on improving both the skills and organisations that connect 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 will not have an immediate impact on economic growth as substantial changes take time to emerge. There is moreover limited capacity for substantial increases in knowledge exchange: academics report a lack of time to fulfil their various responsibilities. 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 success of universities in the UK has been built.

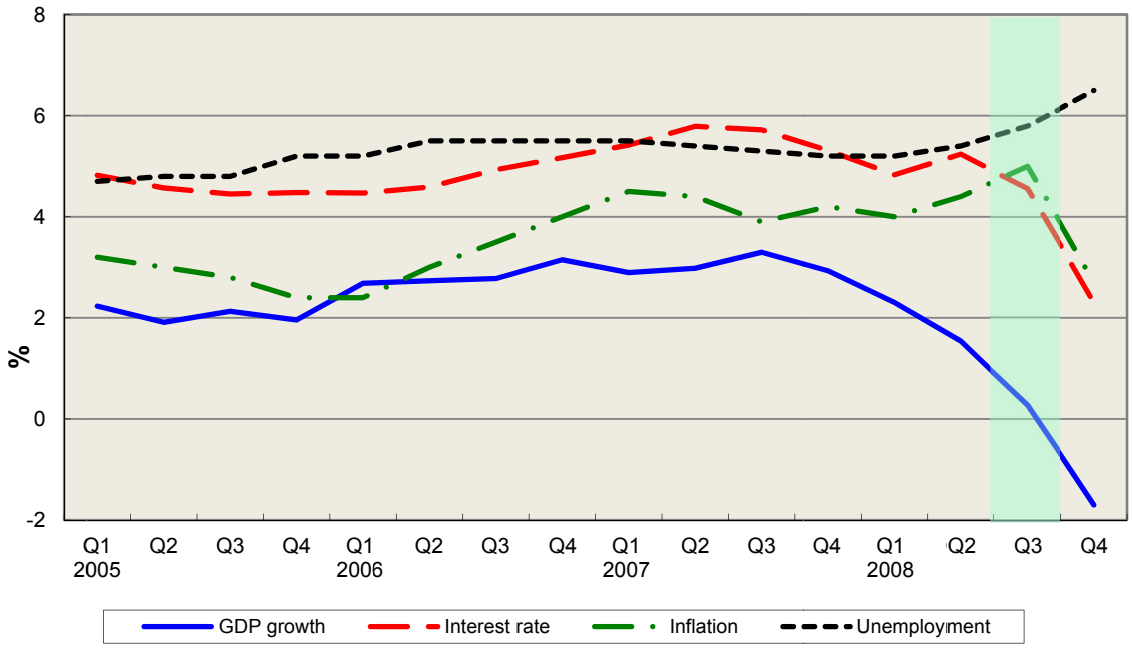
Section 2 The Characteristics of the Survey Sample

In this section we present a description of the characteristics of the survey sample. This indicates the range of businesses covered by the survey and provides the basis for identifying various ways in which we cross cut the data by size, innovation and other characteristics.

The survey was carried out principally in the third quarter of 2008 and covers all firms with 5 or more employees in the UK manufacturing and services sectors. The survey had a response rate of 11.3% and an achieved sample of 2,530 firms. Full details of the survey design and an analysis of potential response biases are contained in Annex 1 which also describes the weighting scheme use to gross up the results in the sections which follow. In this section which focuses on the sample characteristics we report the unweighted sample survey results.

It is important to note the economic context in which the survey took place. Exhibit 2.1 presents four economic indicators of the macroeconomic performance for the UK economy over the 3 years covered by the survey responses. The shaded area shows the period in which the survey was conducted. The respondents have experienced three years of relatively stable macroeconomic performance, but were replying at the beginning of the slump, which may have dampened their expectations in relation to investment and innovation prospects and their willingness to invest in long-term university-industry relationships.

Exhibit 2.1 Economic indicators and the survey period



Business status and the sectoral, size, age and growth distribution of the sample

To ensure full coverage of the business section the sample design includes not only independent firms, but also businesses that were part of a group. Exhibit 2.2 summarises the distribution of the

sample firms in terms of these categories. Firms which were part of a group are classified either as the parent of the group or a subsidiary of the group. The exhibit shows that the vast majority of the sample are micro and small independent firms and are not part of a group. Of the 557 who were part of a group, the majority were subsidiaries and are predominantly to be found in the micro, small and medium groups. Group parents are, as to be expected, more likely to be larger businesses. In this report we analyse the sample as a whole and leave for further research the possibility of distinctions in characteristics between the independent and subsidiary or group business.

Exhibit 2.2 The sample by status

				------ Part of group ------		
	All firms	Independent	Not part of group	Part of group	Parent	Subsidiary
All	2,508	2,174	1,951	557	223	334
Micro	947	881	857	90	24	66
Small	1,076	962	894	182	68	114
Medium	253	187	142	111	45	66
Large	232	144	58	174	86	88

Exhibit 2.3 shows the distribution of the sample of businesses by industrial and commercial activity[2]. Over 20% of the sample firms were in the manufacturing sector, a further 28% of the sample is accounted for by wholesaling and retail trades and a further 13% were in other business service activities. The relative predominance of service activities is of course a reflection of the extent to which they have become a predominant part of the UK market economy. The exhibit also shows the distribution of survey respondents by four broad size classes. In this exhibit, and throughout this report, micro firms are those employing between 5 and less than 10 people, small firms employ between 10 and less than 50 people, medium firms employ 50 and less than 250 people, and large firms are those employing 250 employees or more. Using this broad classification the exhibit shows that around 38% of the sample were micro firms, around 43% were small and much smaller proportions of 10% and 9% respectively fell into the medium and large categories. In presenting results in the other sections in this report we weight the sample appropriately so that the results reflect the sectoral, size and regional characteristics of the relevant UK business population. The weighting process is discussed in Annex 1.

[2] The number of firms is higher than in Exhibit 2.2 because a small number of firms which responded did not indicate their independent / group / or subsidiary status and are excluded from Exhibit 2.1.

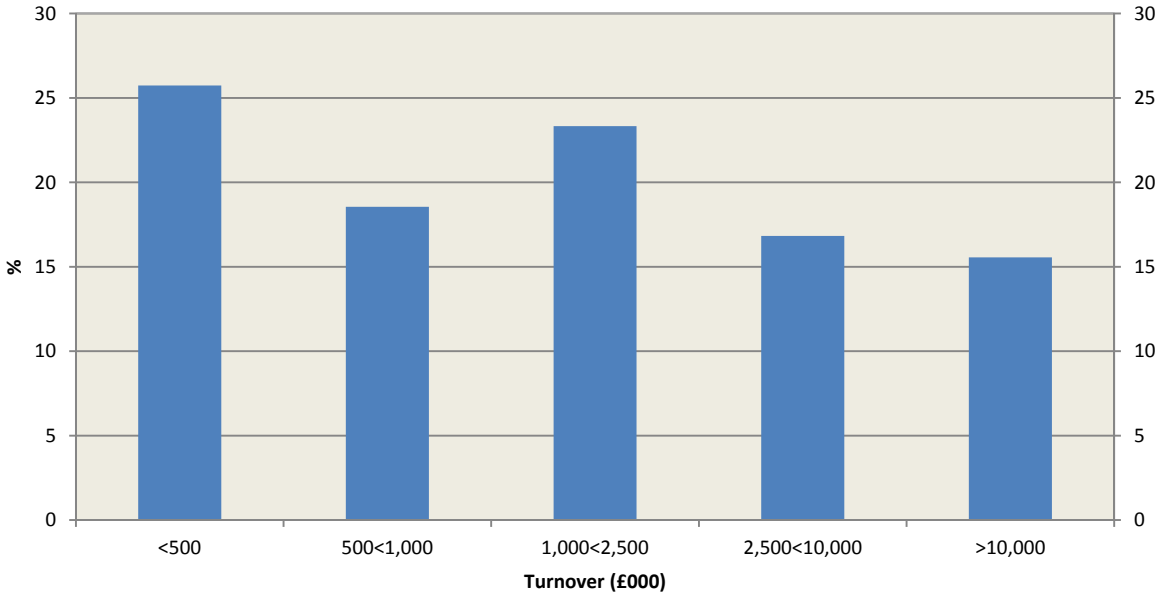
Exhibit 2.3 The sample by employment size and activity

Activity	All		Micro		Small		Medium		Large	
	No.	%	No.	%	No.	%	No.	%	No.	%
Manufacture of food, clothing, wood, paper, publishing and printing	160	6.3	47	4.9	80	7.4	16	6.3	17	7.3
Manufacture of fuels, chemicals, plastics, metals and minerals	224	8.9	68	7.1	110	10.1	32	12.6	14	6.0
Manufacture of electrical and optical equipment	67	2.6	23	2.4	25	2.3	12	4.7	7	3.0
Manufacture of transport equipment	19	0.8	6	0.6	7	0.6	1	0.4	5	2.1
Other manufacturing	44	1.7	12	1.3	25	2.3	5	2.0	2	0.9
Construction	360	14.2	130	13.6	190	17.5	29	11.4	11	4.7
Wholesale and commission trade	425	16.8	183	19.1	179	16.5	36	14.2	27	11.6
Retail trade and repair	296	11.7	162	16.9	100	9.2	17	6.7	17	7.3
Hotels and restaurants	135	5.3	61	6.4	57	5.3	9	3.5	8	3.4
Transport and storage	119	4.7	36	3.8	56	5.2	14	5.5	13	5.6
Post and communications	18	0.7	6	0.6	5	0.5	4	1.6	3	1.3
Financial intermediation	68	2.7	16	1.7	13	1.2	9	3.5	30	12.9
Real estate	46	1.8	20	2.1	22	2.0	3	1.2	1	0.4
Renting	30	1.2	12	1.3	15	1.4	1	0.4	2	0.9
Computer and related activities	53	2.1	25	2.6	20	1.8	4	1.6	4	1.7
R&D	14	0.6	4	0.4	5	0.5	4	1.6	1	0.4
Architectural and engineering activities	107	4.2	46	4.8	52	4.8	3	1.2	6	2.6
Technical testing and analysis	10	0.4	2	0.2	4	0.4	3	1.2	1	0.4
Other business activities	335	13.2	100	10.4	119	11.0	52	20.5	64	27.5
Total responses (no.)	2,530	100.0	959	100.0	1,084	100.0	254	100.0	233	100.0
Total responses (%)	100.0		37.9		42.8		10.0		9.2	

So far we have focused on employment size. The survey firms also show considerable variation in size measured in terms of turnover.

Exhibit 2.4 shows that around a quarter of the sample had a turnover of £500,000 or less with a median turnover of £1.1m. At the other extreme 15.6% had a turnover of £10m or more with a median turnover of £97m. The sample therefore covers a very wide range of turnover and employment experience in the UK economy.

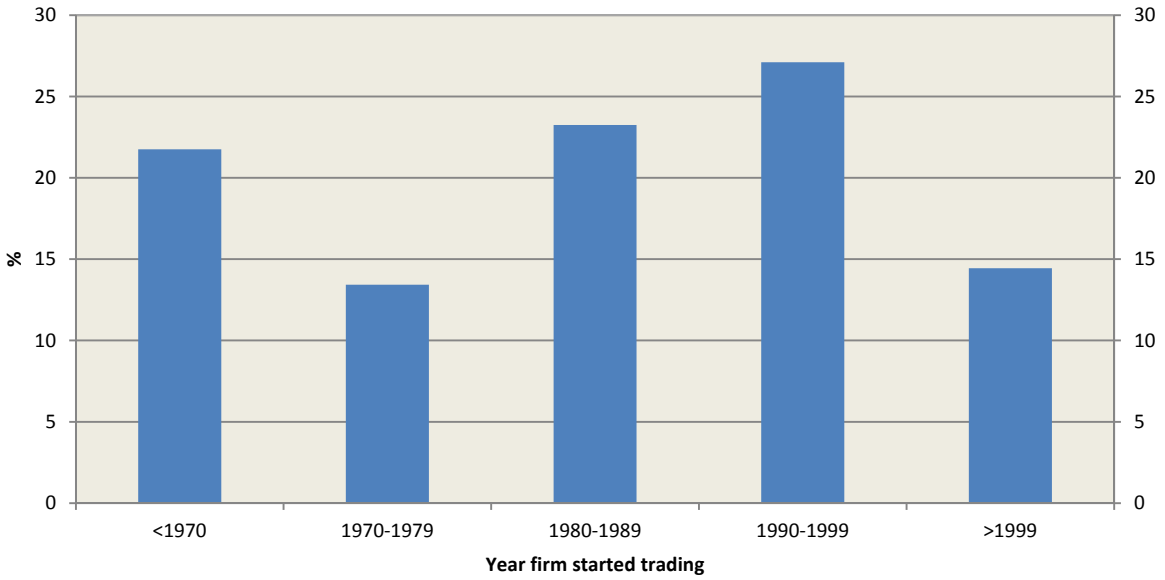
Exhibit 2.4 Business size distribution by turnover



N=2,199

The size structure of firms is reflected in the age structure of the sample as larger businesses tend to have survived for the longest time. In Exhibit 2.5 we show the distribution of the sample in terms of the year in which they started trading.

Exhibit 2.5 Distribution of businesses by year of start of trading

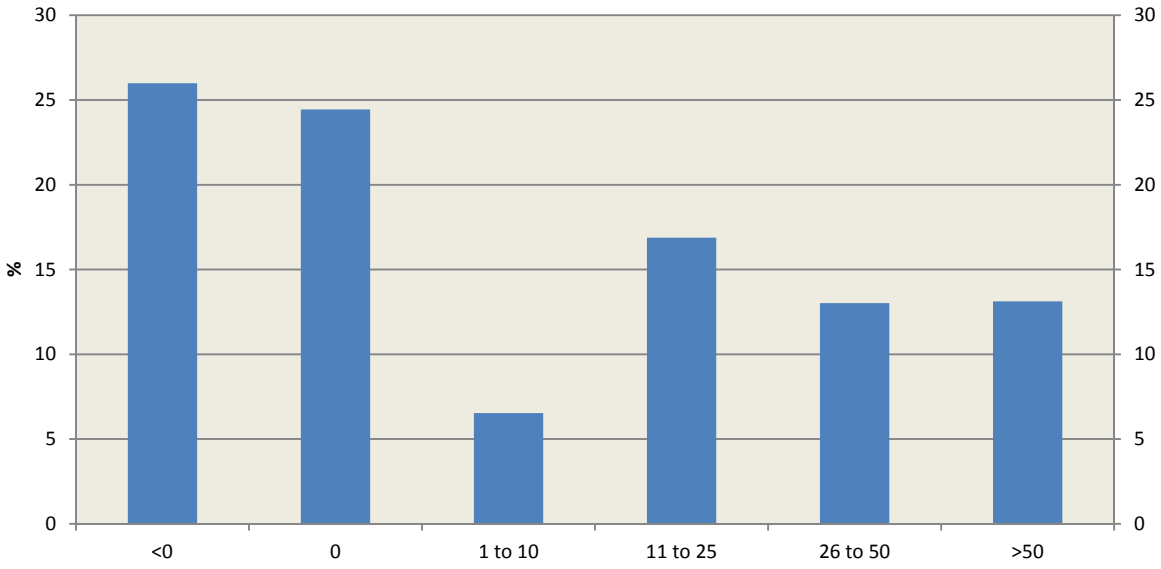


N=2,464

Once again, the sample provides a very good cross section of ages of business. The median age of the businesses was 22 years in 2008. However, 21.8% of the sample started trading before 1970, whilst 14.4% started trading in the year 2000 or later. Micro and small firms are youngest whilst the median age of medium-sized firms was 27 years and of large firms 37 years.

The firms responding to the survey were asked about their size three years earlier and this enables us to consider the growth characteristics of the sample. Exhibit 2.6 shows that in terms of employment growth around a quarter of the sample declined in size and a similar proportion did not grow. Of those firms which did grow 6.5% grew by 1-10% over the previous three years, 16.9% grew by between 11% and 25% and around 13% respectively grew by between 26-50% and over 50%. In subsequent analyses, when we wish to examine characteristics cross cut by growth, we use these categories and classify firms into zero and negative growth, medium growth (1-25%) and high growth (26% and over).

Exhibit 2.6 The distribution of businesses by employment growth (%)



N=1,943

Competition, the geographical spread of markets and exporting

Exhibit 2.7 shows the distribution of the sample in terms of their perception of the number of serious competitors they face. The exhibit shows a clear positive gradation between the number of competitors faced and the size of the business.

Exhibit 2.7 Number of serious competitors (%)

Category	0	1-4	5-9	≥10	N
All	8.8	36.5	23.8	30.9	2,234
Micro	14.7	37.4	18.7	29.2	838
Small	6.8	40.1	24.1	29.0	945
Medium	2.1	29.1	32.9	35.9	237
Large	1.9	25.2	32.2	40.7	214

**

Thus the medium-sized and large firms report having higher proportions of competitors: numbering 5 or more and, in particular, 10 or more. Micro and small firms, who may consider themselves to be operating in niche or geographically localised markets, were much more likely to report that they have none, or a limited number, of competitors.

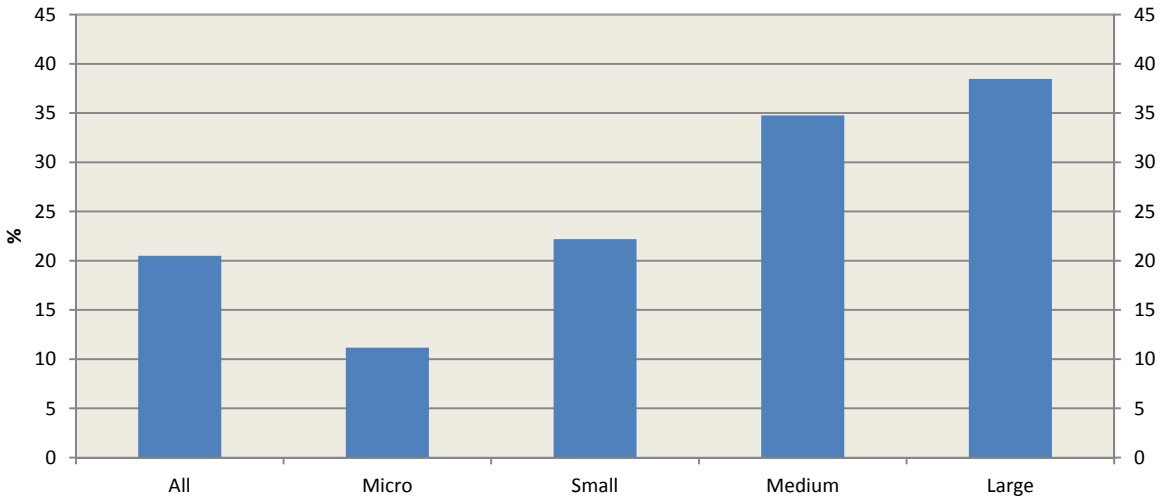
This pattern of perceived competition relates to the geographical markets the firms serve. Thus Exhibit 2.8 shows the geographical market pattern of the sales of services and goods produced by the firms in the survey. The exhibit distinguishes between sales to: the local area (within 10 miles of the business); the administrative region; the rest of the UK beyond the administrative region; the rest of Europe; and the rest of the world. Medium-sized and large firms are much more likely to report sales to the rest of Europe and to the rest of the world, whilst micro firms are much more likely to report a high percentage of sales concentrated in the local market. The same is true for small firms and no doubt relates to the smaller number of competitors they perceive. It should be noted, however, that medium-sized and large firms also report substantial amounts of activity locally and in the administrative region, so that it is not only small firms that matter for the local economy. This is important to bear in mind in discussing the extent to which a focus on local business relationships by universities necessarily implies a focus on small and medium sized businesses.

Exhibit 2.8 Geographic markets (%)

	Local area (10 miles)	Administrative region	Rest of the UK	Rest of Europe	Rest of the world	N
All	39.2	23.1	28.6	4.9	4.2	2,313
Micro	51.4	22.6	21.0	2.7	2.3	871
Small	37.5	24.8	28.9	4.9	3.9	996
Medium	21.0	22.7	41.4	8.0	6.9	245
Large	17.4	16.7	44.4	10.9	10.6	201
	**	**	**	**	**	

If we turn to international activity more directly, Exhibit 2.9 shows that only a minority of firms were involved in exporting activity. Thus only 20% of the sample firms reported exports. The exhibit shows that the proportion of large firms who reported exports was, at 39%, more than three times that of the micro firms, of whom only 12% reported export activity. Moreover, in terms of the absolute values of exports, the largest exporters are naturally to be found amongst the medium-sized and large enterprises of whom 19% and 33% respectively reported exports of over £1m in the year preceding the survey. These variations in export activity are likely to be related to the extent to which the businesses report facing more numerous competitors. It also shows the significance of focusing on university-industry links with medium sized and larger businesses in so far as existing businesses are concerned, and on possible impact which encourage smaller firms to begin exporting.

Exhibit 2.9 Percentage of exporting businesses by size



N=2,175

Concluding remarks

The sample on which we have based this report covers a full range of industrial sectors, size categories and exporting firms. In the remaining sections of the report we present grossed up results which take account of the differences between the size sector and regional distribution of the sample and of the business population covered by our survey.

Section 3 Innovation and Sources of Knowledge

Discussions of university-business relationships frequently focus on the potential gains from university links for the innovative activity of businesses. In this section we present the main R&D and innovation characteristics of UK businesses as a background to the discussion in later sections of the nature of their relationship with universities. We also locate their use of universities as a form of knowledge for innovation alongside other internal and external sources.

R&D and Innovation Activity

The firms were asked to report their R&D expenditure in the latest year preceding the survey date. Exhibit 3.1 shows, first of all, the percentage of firms who report R&D expenditure. Around a third of the sample carry out R&D, with a clear positive correlation with firm size with the largest firms more likely to report R&D. Of those with R&D there is, as might be expected, a similar positive correlation in the absolute median value of R&D per firm by size class. The median value R&D expenditure for large firms is £542,100 compared to £12,000 for micro firms. Interestingly, when the median R&D is expressed per employee in the size classes, there is no difference in R&D intensity between small, medium-sized and large firms. However, as a group they spend less per head than micro firms. This suggests the presence in the sample of a number of R&D intensive small technology businesses. Such businesses are relatively unusual in terms of reporting expenditure on R&D, but tend to have a relatively high R&D expenditure per head.

Exhibit 3.1 R&D expenditure (£000)

	All firms		Of those with R&D				
Category	N (un-weighted)	N (weighted)	N (un-weighted)	N (weighted)	% firms with R&D	Median R&D per firm (£000)	Median R&D per head (£000)
All	1,229	164,777	407	47,833	29.1	25.0	1.5
Micro	407	72,032	84	16,277	22.6	12.0	2.1
Small	528	70,681	170	21,669	30.7	24.2	1.3
Medium	151	16,952	85	7,926	46.7	60.0	0.8
Large	143	5,112	68	1,961	37.8	542.1	1.0
					**	**	**

The firms in the survey were asked a number of questions about their innovative activity and, in particular, whether or not they had introduced an innovation in the three years prior to the survey. Exhibit 3.2 summarises their innovation activity by size of business. The exhibit shows that 44% of firms reported either a product, process or logistics innovation in the three years prior to the survey.

Product and process innovation tends to be more pervasive than logistics innovation, which is reported only by 8% of firms, compared to 28% for process innovations and 37% for product innovations. The likelihood of reporting innovative activity increases with size of business up to the medium sized group. A similar pattern is also revealed when the innovative activity is broken down into product innovations, process innovations or logistics innovations. A positive relationship with firm size is also apparent when innovations introduced are classified in terms of whether they were new to the industry, which here are classed as novel innovations, or new to the firm itself, which here are classed as diffusion innovators in the sense that, whilst not new to the industry, their innovations were new to the firm. The exhibit suggests, as might be expected, that for each class of innovation there are fewer novel than diffusion innovators.

Exhibit 3.2 Engagement in innovation activities (%)

	All	Micro	Small	Medium	Large	
Non innovators	55.9	64.2	54.0	28.3	34.3	
Innovators	44.1	35.8	46.0	71.7	65.7	**
Introduction of product innovations						
Innovators	36.6	28.5	39.4	59.8	55.2	**
Novel innovators	18.7	13.8	21.6	28.0	28.4	**
Introduction of process innovations						
Innovators	28.0	20.8	29.4	53.7	46.3	**
Novel innovators	11.4	8.0	11.9	23.9	20.9	**
Introduction of logistic innovations						
Innovators	7.9	6.0	8.4	11.9	17.9	**
Novel innovators	2.7	2.0	3.3	1.4	10.4	**
N (un-weighted)	2,470	932	1,064	249	225	
N (weighted)	341,732	157,942	144,319	30,225	9,246	

Exhibit 3.3 provides a broad classification of those firms which reported an innovation into closed, open and adaptive innovators. The closed innovators are those that say they mainly relied for the development of their innovations on the firm or firm group itself. For the sample as a whole 71% classify themselves in this group and the proportion doing so was highest in the medium-sized group. The open innovation group, who reported that their innovations were developed mainly in collaboration with other firms or institutions, comprised 13% of the sample. The largest firms were more likely to classify themselves in this group: 17% of large firms classified themselves as open innovators compared with between 12% and 13% for the other size classes for each of the other three size categories.

Finally, the exhibit shows that a reverse pattern is revealed for the adaptive innovators (i.e. those who report that their innovations were mainly adapted after development by other firms or institutions). Nearly 26% of micro firms reported that this was the case. This was nearly twice as high as the proportion for large firms. Collaborative activity of this sort is therefore a relatively significant part of the innovation activity of these firms.

Exhibit 3.3 How innovations were developed (% of innovating firms)

	All	Micro	Small	Medium	Large
Mainly within your firm or firm group (Closed)	70.6	61.6	74.2	81.9	75.6
Mainly in collaboration with other firms or institutions (Open)	12.8	12.6	12.9	11.6	17.1
Mainly adapted after development by other firms or institutions (Adaptive)	16.7	25.8	12.9	6.5	7.3
N (un-weighted)	1,099	324	445	174	156
N (weighted)	144,265	54,809	62,269	21,439	5,748

Exhibit 3.4 shows another form of innovation: changes to business structure. The firms were asked whether they had made any changes in business structure and activities in the last three years. The changes included: the development or implementation of new corporate strategies; implementation of advanced management techniques including knowledge management systems; implementation of major changes to organisational structure, such as setting up cross functional teams or the outsourcing of major business functions; and implementation of changes in marketing concepts or strategies. The latter, alongside the implementation of new or significantly changed corporate strategy, was likely to occur in around a third of the businesses. In all cases the likelihood of implementing such changes to business structure was higher for medium-sized and large businesses. In the large firm category, over half of the sample reported changes in each of these dimensions of business structure. Around a quarter of large and medium sized firms also reported changes in the implementation of advanced management techniques, such as knowledge management systems.

Exhibit 3.4 Changes to business structure (% of firms)

	All	Micro	Small	Medium	Large	
Implementation of a new or significantly changed corporate strategy	28.4	20.1	30.3	53.7	55.2	**
Implementation of advanced management techniques such as knowledge management systems etc.	15.3	10.4	17.8	26.3	22.4	**
Implementation of major changes to organisational structure such as setting up cross-functional teams, outsourcing of major business functions	17.7	10.3	18.9	39.0	55.2	**
Implementation of changes in marketing concepts or strategies	34.5	25.6	38.1	57.8	49.3	**
N (un-weighted)	2,458	923	1,060	248	227	
N (weighted)	339,893	155,901	144,566	30,126	9,300	

Sources of knowledge and information for innovation

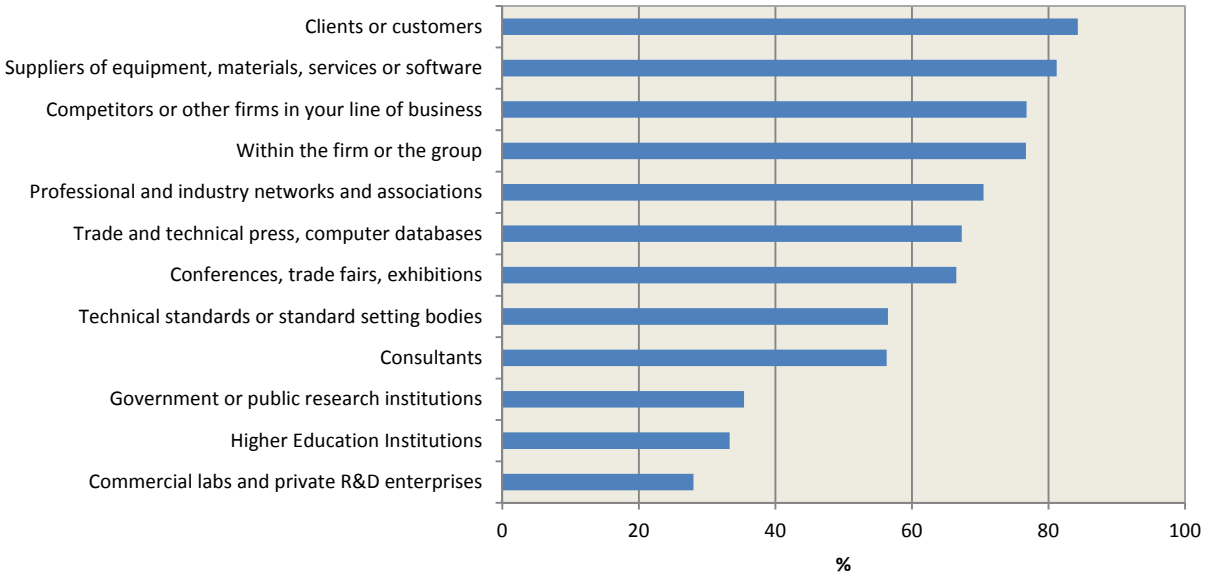
Here we report the relative frequency of using particular sources of knowledge for innovation and the importance placed upon each of these sources of knowledge.

Exhibits 3.5 and 3.6, which report the frequency of use of different sources of knowledge, show, in keeping with many other surveys of the business community, that knowledge sources are dominated by the firm itself, customers, suppliers, and competitors. These are followed by a range of what might be termed intermediary sources, including: the trade and technical press, professional and industry networks and associations, conferences, trade fairs, and exhibitions, and to a lesser extent, consultants and technical or standard setting bodies. Government or public research institutions, higher education institutions, and private R&D enterprises are at the bottom of the list. In terms of higher education institutions, however, there is a clear upward gradient with firm size: whilst 27% of micro firms report using higher education institutions as a source of knowledge for innovation, over twice as many (58%) of the large firms do so.

Exhibit 3.5 Use of sources of knowledge and information for innovation (% of firms)

	All	Micro	Small	Medium	Large	
Within the firm or the group	76.7	69.1	79.3	96.3	95.5	**
Suppliers of equipment, materials, services or software	81.2	75.7	84.6	88.5	95.5	**
Clients or customers	84.3	79.8	85.9	95.9	95.5	**
Competitors or other firms in your line of business	76.8	72.0	78.5	87.2	95.5	**
Consultants	56.3	49.0	58.8	74.3	77.6	**
Commercial labs and private R&D enterprises	28.0	22.7	29.2	43.1	44.8	**
Higher Education Institutions	33.3	26.8	34.6	51.8	58.2	**
Government or public research institutions	35.4	31.8	35.6	46.6	52.2	**
Technical standards or standard setting bodies	56.5	50.1	58.7	73.4	74.2	**
Conferences, trade fairs, exhibitions	66.5	58.5	70.3	80.3	91.0	**
Trade and technical press, computer databases	67.3	61.7	69.8	77.5	86.6	**
Professional and industry networks and associations	70.5	63.2	74.0	87.2	80.6	**
N (un-weighted)	2,361	876	1,012	249	224	
N (weighted)	326,481	149,007	138,025	30,212	9,237	

Exhibit 3.6 Sources of knowledge used in innovation activities (%of firms)



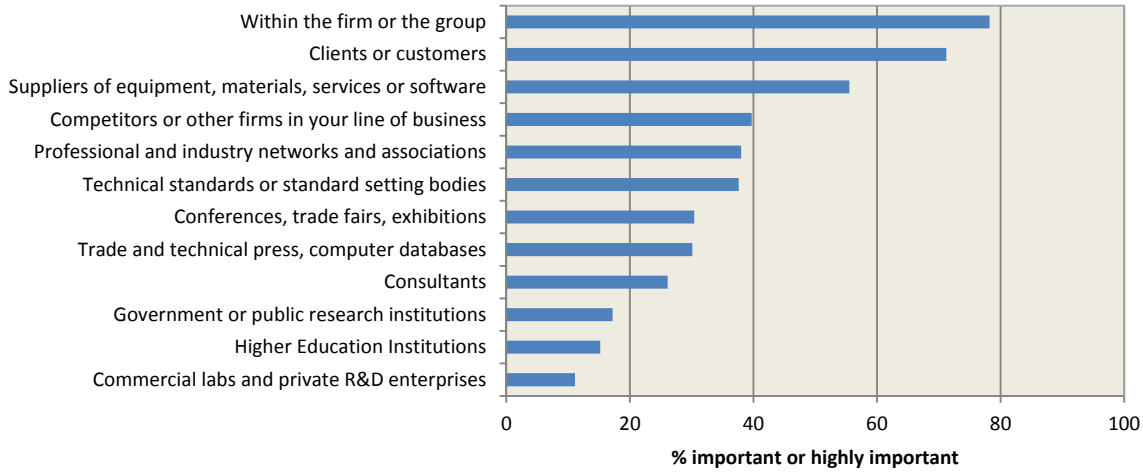
All N (un-weighted)=2,361; N (weighted)=326,841

A very similar pattern to that for frequency emerges when the importance attached to each source of knowledge is reported by users of each source. Exhibits 3.7 and 3.8 show that those sources which are most frequently used, are also most likely to be highly valued. In relation to higher education institutions: 15% of businesses consider this source of knowledge as important or highly important. This compared, for example, with 78% reporting themselves or their business group as important or highly important and 71% reporting clients or customers as important or highly important. Micro and small businesses do not differ greatly from large businesses in the value they place on HEIs, whilst firms in the medium category employing between 50 and 249 workers are most likely to place the highest value on this source of knowledge (25% compared to 13% for micro, 15% for small and 10% for large).

Exhibit 3.7 Sources of knowledge or information used in innovation activities rated as important or highly important (% of firms): by firm size

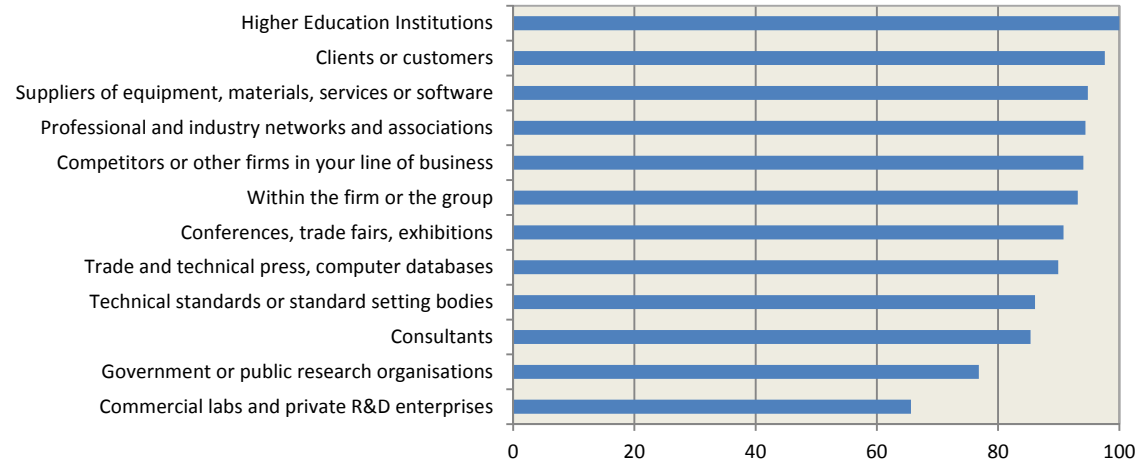
	All	Micro	Small	Medium	Large	N (un-weighted)	N (weighted)	
Within the firm or the group	78.2	73.6	79.5	88.6	81.3	1,844	250,467	**
Suppliers of equipment, materials, services or software	55.5	53.5	58.6	52.8	48.4	1,975	265,003	**
Clients or customers	71.2	69.5	72.8	70.8	74.6	2,017	275,096	
Competitors or other firms in your line of business	39.7	41.5	37.2	43.7	37.5	1,841	250,707	
Consultants	26.1	28.3	23.2	30.2	21.2	1,338	183,569	**
Commercial labs and private R&D enterprises	11.1	10.2	12.4	9.6	6.9	700	91,197	
Higher Education Institutions	15.2	12.8	14.5	24.8	10.3	834	108,606	**
Government or public research institutions	17.2	18.0	18.9	8.8	19.4	869	115,475	**
Technical standards or standard setting bodies	37.6	37.8	39.4	31.9	32.0	1,366	184,469	
Conferences, trade fairs, exhibitions	30.4	33.2	29.2	31.8	11.3	1,605	216,958	**
Trade and technical press, computer databases	30.1	29.9	32.0	27.2	19.0	1,646	219,781	
Professional and industry networks and associations	38.0	35.7	38.1	45.5	37.7	1,684	230,123	

Exhibit 3.8 Importance of sources of knowledge for innovation activities: % of firms rating source as important or highly important



All N (un-weighted)=1,844; N (weighted)=250,467

Exhibit 3.9 % businesses using HEIs as a source of knowledge what % also use other sources of knowledge



Users of HEIs: N (un-weighted)= 834; N (weighted)= 108,606

Concluding remarks

The survey reveals a high degree of innovation activity and organisational changes. UK businesses are revealed as using multiple sources of knowledge for their innovative activities. This includes interaction with higher education institutions, but these are in general both less likely to be cited as sources of knowledge and less highly valued than sources within the business sector itself.

Section 4 Modes of Interaction between Businesses and Universities

There is much policy focus on the application of academic research and the benefits of businesses commercialising science. Much of the discussion focuses on aspects of technology transfer process, including: academic spin-off activities, university licensing and patents. Although such commercialisation mechanisms are important modes of university-business exchange they are an incomplete representation of the wide process of knowledge exchange which encompasses multiple mechanisms and many disciplines including the social sciences and the humanities (Hughes and Kitson, 2012). The patterns of interactions, and their importance, vary by sector, the size and life cycle of the business, and its form of the production process.

Wider knowledge exchange

To identify the range and patterns of connectivity by the businesses in our sample, the survey inquired about three wider modes of interaction in three broad categories: people based, problem solving and community based.

Exhibit 4.1 shows the propensity to engage in a variety of people based interactions categorised by firm size. Overall, 25% of firms engage in people based interactions, although there is distinct variation by firm size: 64% of large firm use people based interactions compared to only 18% of micro firms. The modes of interaction that were most frequently used were: training staff through enrolment on HEI courses or through personnel exchange (13%); attending conferences which have HEI participation (10%); supervising in-course student projects and funding internships (8%); and participation in networks involving HEIs (7%).

Exhibit 4.1 Engagement in people based activities by firm size (% of firms)

	All	Micro	Small	Medium	Large	
Training staff through enrolment on HEI courses or through personnel exchange	13.2	7.7	14.9	25.8	41.8	**
Supervising in-course student projects; funding internships and studentships; KTPs	8.4	6.1	7.8	15.7	33.8	**
Joint curriculum development with HEIs	2.3	1.8	1.6	2.8	20.9	**
Attending conferences which have HEI participation	9.7	6.7	8.7	22.1	35.8	**
Attending conferences organised by HEIs	6.7	3.4	7.1	15.2	29.9	**
Participation in standard setting forums involving HEIs	2.7	1.5	2.3	8.8	9.0	**
Participation in networks involving HEIs	6.6	4.5	6.1	12.4	29.9	**
Sitting on advisory boards of HEIs	1.6	0.8	1.4	3.7	13.2	**
Organising invited lectures and/or brainstorming sessions with academics	4.4	2.9	3.6	10.6	19.4	**
Involvement with Enterprise Education	3.2	1.9	4.3	3.2	9.0	**
Any of the above	25.0	18.4	25.3	46.6	64.2	**
N (un-weighted) (rows 1-9)	2,493	943	1,073	247	230	
N (un-weighted) (row 10)	2,486	940	1,070	248	228	
N (un-weighted) (row 11)	2,508	949	1,078	250	231	
N (weighted) (rows 1-9)	345,373	160,479	145,582	30,001	9,311	
N (weighted) (row 10)	344,466	159,704	145,403	30,084	9,275	
N (weighted) (row 11)	347,217	161,325	146,319	30,212	9,361	

As shown in Exhibit 4.2, innovating firms (40%) are far more likely to be engaged in people based interactions compared to non-innovating firms (18%) – and this pattern is consistent across all modes of interaction. Furthermore, fast growth firms (40%) are more likely to engage in people based interactions compared to medium growth firms (35%) and those that have stable growth or who are declining (21%).

Exhibit 4.2 Engagement in people based activities by innovation activity and growth performance (% of firms)

	All	Innovation			Growth category			
		Non-innovators	Innovators		Stable/ Declining	Medium growth	Fast growth	
Training staff through enrolment on HEI courses or through personnel exchange	13.2	11.0	22.7	**	11.5	19.5	24.9	**
Supervising in-course student projects; funding internships and studentships;KTPs	8.4	5.4	16.4	**	6.9	13.3	16.7	**
Joint curriculum development with HEIs	2.3	1.7	4.8	**	1.4	3.8	6.4	**
Attending conferences which have HEI participation	9.7	5.1	18.8	**	7.9	13.9	16.7	**
Attending conferences organised by HEIs	6.7	4.6	14.5	**	6.3	10.6	14.7	**
Participation in standard setting forums involving HEIs	2.7	1.1	5.6	**	1.9	3.1	5.8	**
Participation in networks involving HEIs	6.6	3.1	13.7	**	5.7	8.6	13.3	**
Sitting on advisory boards of HEIs	1.6	1.1	5.3	**	1.9	3.5	4.4	**
Organising invited lectures and/or brainstorming sessions with academics	4.4	1.9	9.1	**	3.3	3.1	11.6	**
Involvement with Enterprise Education	3.2	2.3	6.6	**	2.9	4.6	6.9	**
Any of the above	25.0	17.7	39.9	**	21.0	35.0	39.5	**
N (un-weighted) (rows 1-9)	345,373	189,349	149,268		134,674	57,232	72,427	
N (un-weighted) (row 10)	344,466	189,176	149,366		134,220	57,332	71,935	
N (un-weighted) (row 11)	347,217	190,228	150,144		134,971	57,382	72,817	
N (weighted) (rows 1-9)	2,493	1,309	1,135		971	452	498	
N (weighted) (row 10)	2,486	1,305	1,137		969	453	494	
N (weighted) (row 11)	2,508	1,315	1,143		974	454	501	

Exhibit 4.3 Engagement in people based activities (% of firms)

	All	Manufacturing	Wholesale/ Retail	Business services	Other	
Training staff through enrolment on HEI courses or through personnel exchange	13.2	13.1	9.8	16.2	13.3	**
Supervising in-course student projects; funding internships and studentships;KTPs	8.4	9.6	3.6	14.8	5.9	**
Joint curriculum development with HEIs	2.3	1.0	0.5	3.4	3.4	**
Attending conferences which have HEI participation	9.7	10.6	6.0	16.4	6.0	**
Attending conferences organised by HEIs	6.7	5.6	4.3	12.0	4.5	**
Participation in standard setting forums involving HEIs	2.7	1.0	1.6	4.1	3.2	**
Participation in networks involving HEIs	6.6	6.6	3.5	12.1	3.8	**
Sitting on advisory boards of HEIs	1.6	2.3	0.3	3.1	0.9	**
Organising invited lectures and/or brainstorming sessions with academics	4.4	5.3	1.9	9.0	1.6	**
Involvement with Enterprise Education	3.2	4.5	2.9	3.9	2.3	
Any of the above	25.0	24.3	18.8	33.9	22.2	**
N (un-weighted) (rows 1-9)	2,493	507	709	654	623	
N (un-weighted)(row 10)	2,487	512	707	654	614	
N (un-weighted)(row 11)	2,509	512	713	657	627	
N (weighted) (rows 1-9)	345,373	54,707	87,361	97,990	105,315	
N (weighted)(row 10)	344,643	55,199	87,040	98,343	104,061	
N (weighted)(row 11)	347,393	55,199	87,750	98,507	105,937	

Exhibit 4.3 shows, engagement in people based activities by sector. Overall, the most engaged sector is business services (34% of firms engage in at least one people based activity), followed by manufacturing (24%), other activities (22%) and wholesale/retail (19%). For business services and manufacturing, the most highly used activities include training, attending conferences and participation in networks.

Exhibit 4.4 Engagement in problem solving activities, by firm size (% of firms)

	All	Micro	Small	Medium	Large	
Hosting academics on a short or long-term basis to address specific needs of your firm	2.5	1.0	2.1	7.5	17.6	**
Personnel secondment (short or long-term) to HEIs	1.3	0.3	1.6	2.8	5.9	**
Joint research with academics/HEIs (original research work undertaken by both partners)	2.9	1.1	3.1	7.5	17.6	**
Contract research by academics/HEIs (original research work done by HEIs)	2.2	1.4	1.9	3.8	13.4	**
Research consortia involving HEIs	1.6	0.7	1.1	6.1	10.4	**
Consultancy services by academics/HEIs (no original research is undertaken)	3.5	2.4	3.4	7.5	10.3	**
Getting informal advice from academics on a non-commercial basis	5.0	3.6	4.8	9.9	14.9	**
Use of HEIs for prototyping and testing	1.8	0.9	1.5	5.6	10.3	**
Joint creation of physical facilities in HEIs (such as new labs, campus buildings, etc)	1.3	0.2	0.8	5.5	14.9	**
Dissemination of knowledge through joint publications with HEIs	1.9	1.0	2.0	4.6	6.0	**
Any of the above	10.4	6.5	9.8	23.5	41.2	**
N (un-weighted) (rows 1-8)	2,480	936	1,069	245	230	
N (un-weighted) (rows 9-10)	2,487	941	1,070	248	228	
N (un-weighted) (row 11)	2,501	946	1,076	249	230	
N (weighted) (rows 1-8)	342,286	158,296	145,186	29,452	9,352	
N (weighted) (rows 9-10)	344,643	159,881	145,402	30,084	9,276	
N (weighted) (row 11)	346,300	160,775	146,035	30,138	9,352	

Exhibit 4.4 shows the propensity to engage in a variety of problem solving interactions categorised by firm size. Overall, 10% of firms engage in problem solving interactions, and as with people based interactions there is distinct variation by firm size: 41% of large firms use problem solving interactions compared to only 7% of micro firms. The modes of interaction that were most frequently used were: informal advice from academics (5%); consultancy services (4%); and joint research with academics (3%). As shown in Exhibit 4.5, innovating firms (18%) are far more likely to be engaged in problem solving interactions compared to non-innovating firms (4%) – and this pattern is consistent across all modes of interaction. Furthermore, fast growth firms (17%) are more likely to engage in problem solving interactions compared to medium growth firms (13%) and those that have stable growth or who are declining (8%).

Exhibit 4.5 Engagement in problem solving activities, by innovation activity and growth performance (% of firms)

	All	Innovation			Growth category			
		Non-innovators	Innovators		Stable/ Declining	Medium growth	Fast growth	
Hosting academics on a short or long-term basis to address specific needs of your firm	2.5	1.0	4.2	**	1.0	2.7	5.4	**
Personnel secondment (short or long-term) to HEIs	1.3	0.4	2.4	**	0.5	1.0	2.5	**
Joint research with academics/HEIs (original research work undertaken by both partners)	2.9	0.9	5.6	**	1.1	4.1	4.7	**
Contract research by academics/HEIs (original research work done by HEIs)	2.2	1.0	3.7	**	0.9	2.4	3.5	**
Research consortia involving HEIs	1.6	0.4	3.2	**	1.3	1.0	2.9	**
Consultancy services by academics/HEIs (no original research is undertaken)	3.5	1.0	6.7	**	2.2	2.9	6.6	**
Getting informal advice from academics on a non-commercial basis	5.0	1.8	8.7	**	4.0	5.1	8.0	**
Use of HEIs for prototyping and testing	1.8	0.7	3.3	**	1.4	1.7	3.7	**
Joint creation of physical facilities in HEIs (such as new labs, campus buildings, etc)	1.3	0.7	2.1	**	1.1	1.9	2.3	
Dissemination of knowledge through joint publications with HEIs	1.9	0.8	3.2	**	1.0	1.7	3.1	**
Any of the above	10.4	4.4	17.8	**	7.8	12.6	17.0	**
N (un-weighted) (rows 1-9)	2,480	1,302	1,133		967	453	493	
N (un-weighted) (row 10)	2,487	1,305	1,138		969	453	495	
N (un-weighted) (row 11)	2,501	1,313	1,143		974	454	498	
N (weighted) (rows 1-9)	342,286	187,497	148,733		133,633	57,346	71,342	
N (weighted) (row 10)	344,643	189,176	149,544		134,219	57,332	72,112	
N (weighted) (row 11)	346,300	189,985	150,171		134,865	57,382	72,528	

Exhibit 4.6 Engagement in problem solving activities by sector (% of firms)

	All	Manufacturing	Wholesale/ Retail	Business services	Other	
Hosting academics on a short or long-term basis to address specific needs of your firm	2.5	3.5	1.3	4.4	1.1	**
Personnel secondment (short or long-term) to HEIs	1.3	1.8	0.8	2.1	0.7	**
Joint research with academics/HEIs (original research work undertaken by both partners)	2.9	5.3	1.6	4.7	1.3	**
Contract research by academics/HEIs (original research work done by HEIs)	2.2	3.8	1.0	4.1	0.5	**
Research consortia involving HEIs	1.6	2.0	1.3	2.3	1.1	
Consultancy services by academics/HEIs (no original research is undertaken)	3.5	4.8	1.6	6.9	1.2	**
Getting informal advice from academics on a non-commercial basis	5.0	10.6	2.2	8.4	1.1	**
Use of HEIs for prototyping and testing	1.8	4.3	1.6	2.3	0.4	**
Joint creation of physical facilities in HEIs (such as new labs, campus buildings, etc)	1.3	0.5	0.6	2.7	0.9	**
Dissemination of knowledge through joint publications with HEIs	1.9	4.5	0.3	3.5	0.3	**
Any of the above	10.4	16.1	6.2	16.7	4.9	**
N (un-weighted) (rows 1-8)	2,480	507	703	650	620	
N (un-weighted) (rows 9-10)	2,487	512	707	654	614	
N (un-weighted) (row 11)	2,502	512	711	656	623	
N (weighted) (rows 1-8)	342,286	54,747	86,571	96,635	104,333	
N (weighted) (rows 9-10)	344,643	55,199	87,039	98,344	104,061	
N (weighted) (row 11)	346,299	55,199	87,445	98,497	105,158	

Exhibit 4.6 shows, engagement in problem solving activities by sector. Overall, the most engaged sector is business services (17% of firms engage in at least one problem solving activity), closely followed by manufacturing (16%), and wholesale/retail (6%) and other activities (5%). For business services and manufacturing, the most highly used activity was informal advice.

In addition to business orientated activities, the survey also provides evidence on the extent to which firms engaged in community based activities with Higher Education Institutions. Exhibit 4.7 shows that 15% of firms engage in community based interactions; with the propensity to engage in such interactions being positively correlated with firm size: 45% of large firm engage in such interactions, compared to: 26% of medium-sized firms; 15% of small firms; and 11% of micro firms. The mode of interaction that was most frequently used was involvement with schools projects (12%).

Exhibit 4.7 Engagement in community based activities, by firm size (% of firms)

	All	Micro	Small	Medium	Large	
Giving public lectures for the community	4.2	2.8	4.2	8.3	14.9	**
Provision of community based sports	2.0	1.0	1.9	6.4	7.5	**
Provision of public exhibitions	2.5	1.4	2.5	6.0	11.9	**
Involvement with schools projects	11.9	8.7	12.3	21.2	32.8	**
Any of the above	14.8	10.5	15.2	26.1	44.8	**
N (un-weighted)	2,487	941	1,070	248	228	
N (weighted)	344,643	159,881	145,403	30,083	9,276	

Exhibit 4.8 shows that involvement in community based activities tend to be broadly consistent across sectors although the highest level of engagement is by the business and other service forms. Involvement in school projects is the mechanism that has the highest propensity to be used by all sectors.

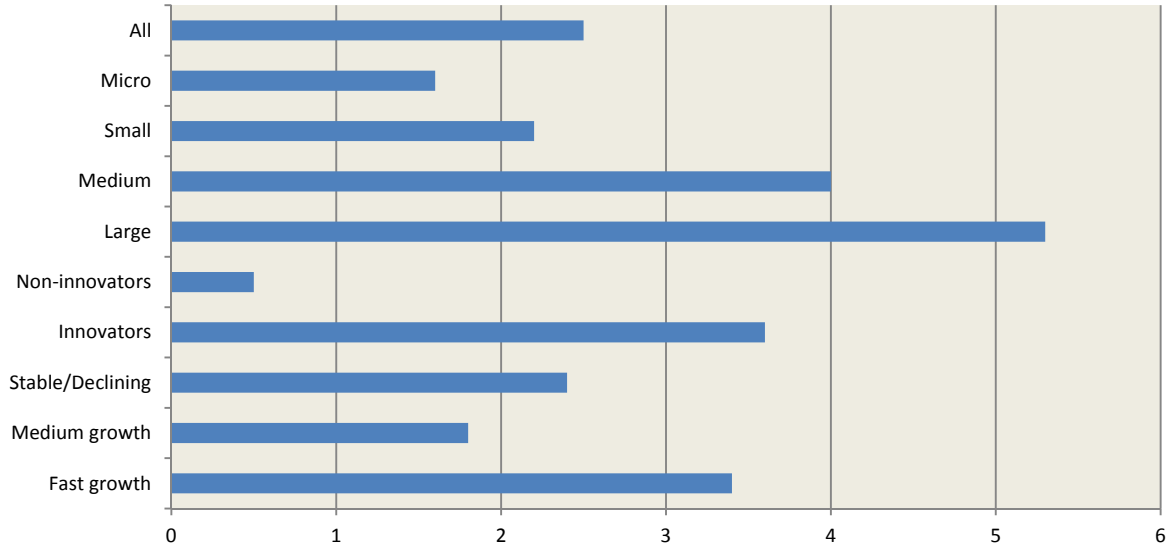
Exhibit 4.8 Engagement in community based activities by sector (% of firms)

	All	Manufacturing	Wholesale/ Retail	Business services	Other	
Giving public lectures for the community	4.2	3.0	2.9	7.7	2.5	**
Provision of community based sports	2.0	0.8	1.7	2.5	2.3	
Provision of public exhibitions	2.5	2.3	3.2	3.2	1.6	
Involvement with schools projects	11.9	10.8	9.2	16.9	10.0	**
Any of the above	14.8	13.3	13.2	19.3	12.6	**
N (un-weighted)	2,487	512	707	654	614	
N weighted)	344,644	55,199	87,040	98,344	104,061	

Commercialisation activities

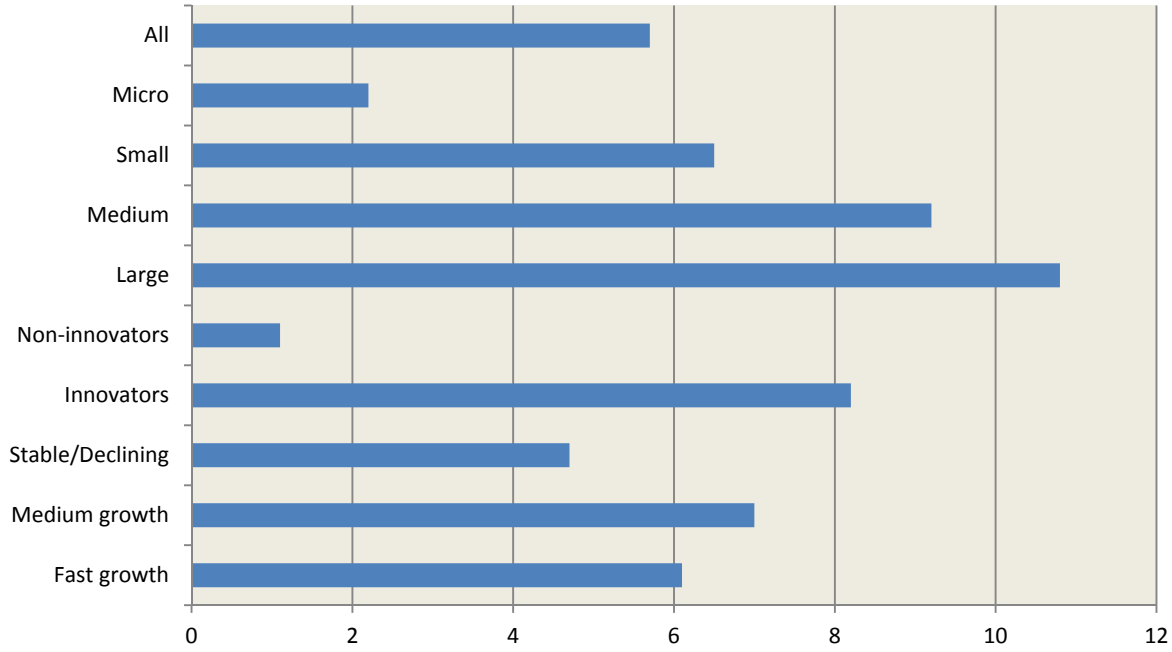
In addition to the modes of wider knowledge exchange, some of the interacting firms also engage in a range of commercialisation activities. The data in Exhibits 4.9 and 4.10 shows the extent to which businesses acquire patents and licences: the former shows the acquisition of patents and licences owned by HEIs whereas the latter shows the acquisition of patents and licences owned by non-HEIs. Overall, the acquisition of patents and licences from non-HEIs is more than twice the level of the acquisition of patents and licences from HEIs. Furthermore, the propensity to acquire patents and licences tends to be positively correlated with firm size; with a much higher propensity for larger firms compared to small and micro firms. As would be expected, innovating firms are far more likely to acquire patents and licences compared to non-innovating firms. The relationship between patenting/licensing and firm growth, however, is less clear cut – and there is no statistically significant relationship.

Exhibit 4.9 Acquisition of patents and licences owned by HEIs (% of interacting firms)



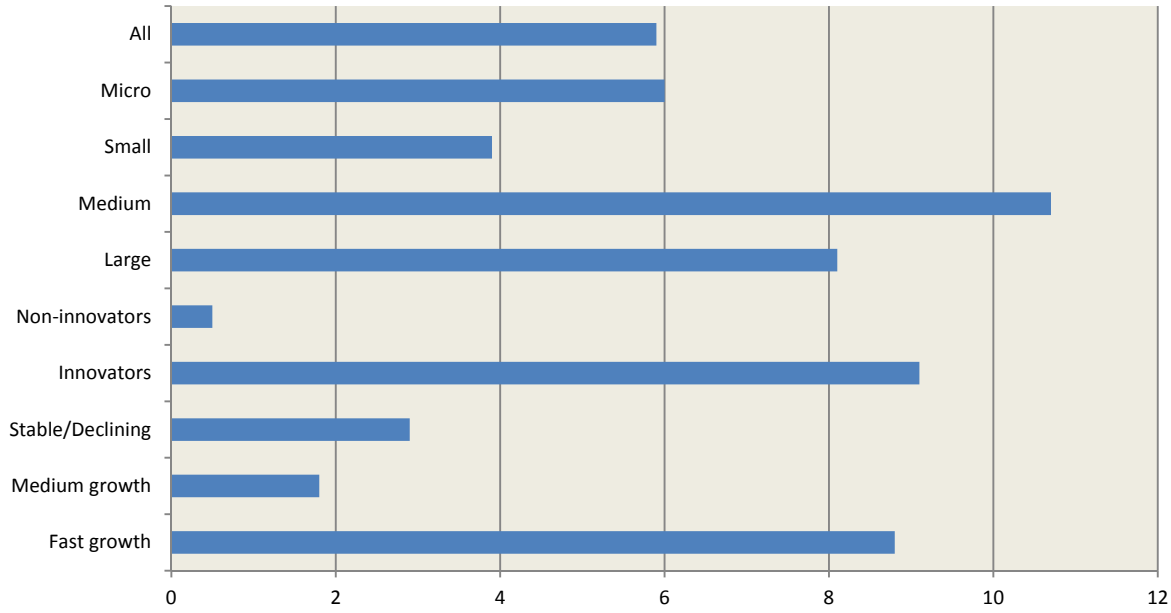
All N (un-weighted)=616; N (weighted)= 72,978

Exhibit 4.10 Acquisition of patents and licences owned by non-HEIs (% of interacting firms)



All N (un-weighted)=616; N (weighted)=72,978

Exhibit 4.11 Collaboration with a spin-out firm formed by an HEI to exploit research (% of interacting firms)

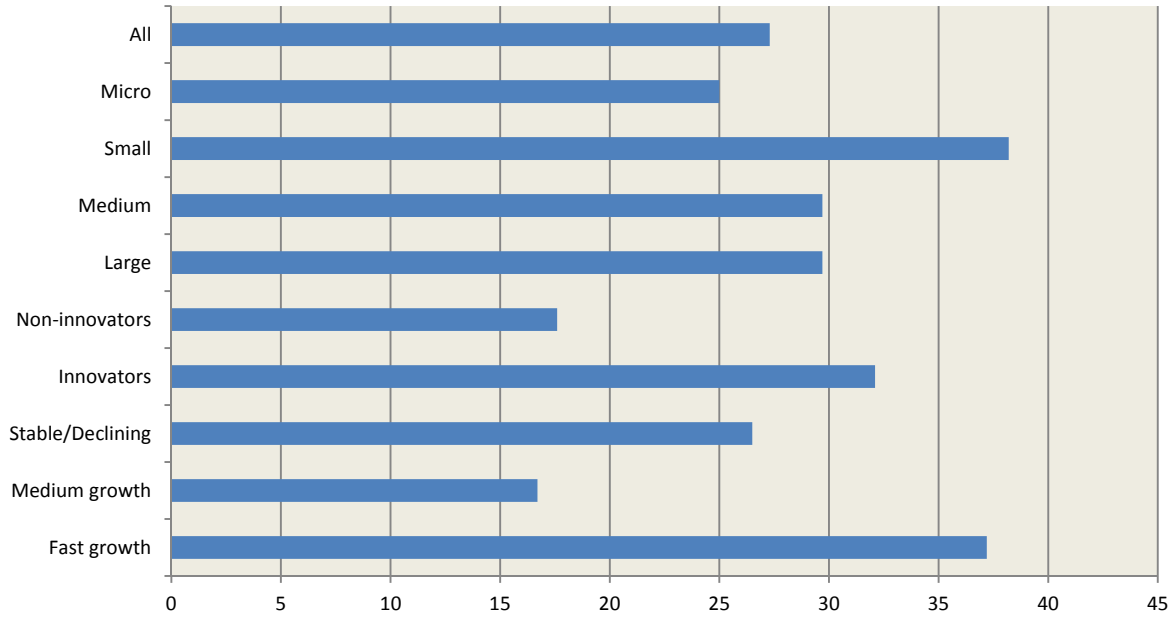


All N (un-weighted)=616; N (weighted)= 72,978

Exhibit 4.11 shows the propensity of businesses to collaborate with a spin-out firm formed by an HEI in order to exploit research. This is substantially higher than the level of the acquisition of patents and licences from HEIs and is higher by medium and larger firms compared to micro and small firms. The propensity to collaborate with a spin-out firm is more than 20 times higher amongst innovating firms compared to non-innovating firms; it is also substantially higher with fast growth firms compared to those that are stable and declining or that have slow growth.

A traditional form of knowledge transfer is the use of academic publications to improve products and processes. As shown in Exhibit 4.12, this mode of interaction is used by 27% of all collaborating firms - substantially higher than the use of patents or of collaboration with spin-outs formed by an HEI. There is no statistically significant difference by firm size; but innovating firms are twice as likely to use academic publications compared to non-innovating firms; and fast growth firms have a higher propensity to use academic publications compared to those firms that are stable and declining or that have slow growth.

Exhibit 4.12 Making use of academic publications to improve products and processes (% of interacting firms)



All N (un-weighted)=616; N (weighted)=72,978

Exhibit 4.13 shows commercialisation activities by sector. Overall, manufacturing and business services firms are more likely to acquire patents and licences owned by non-HEIs – and collaborate with spin-outs - compared to the other sectors. The business services sector had the highest propensity to use academic publications, followed by the manufacturing, then wholesale/retail and the other sectors. The overall picture shows that commercialisation activities are not concentrated in manufacturing but are spread across different sectors of the economy.

Exhibit 4.13 Commercialisation activities by sector (% of interacting firms)

	Acquisition of patents and licences owned by HEIs	Acquisition of patents and licences owned by non-HEIs	Collaboration with a spin-out firm formed by an HEI to exploit research	Making use of academic publications to improve products and processes	N (un-weighted)	N (weighted)
All	2	6	6	27	616	72,978
Sector						
Manufacturing	2	9	9	30	142	13,106
Wholesale/Retail	3	3	1	15	145	16,320
Business services	3	7	10	41	221	27,142
Other	-	3	3	13	108	16,410
		*	**	**		

Connecting with the spectrum of academic disciplines

There has been a focus on business interactions with science-based disciplines such as engineering. And as shown in Exhibit 4.14, engineering is the discipline which has the highest level of business interactions: 34% of interacting firms report interacting with this discipline. But there are a range of other disciplines that have relatively high levels of interactions including: business and financial studies (27%); mathematics and physics (17%); and architecture, planning and urban design (16%). This indicates the importance of broadening the policy agenda, and considering the role and impact of all disciplines, not just those from science and engineering. Exhibit 4.14 also shows how the propensity to connect with different disciplines by firm size; overall there is no consistent pattern across all disciplines. But for some disciplines there is a positive correlation between firm size and the propensity to engage, including: physics and mathematics, business and financial studies and arts and humanities.

Exhibit 4.14 Most important academic discipline in terms of knowledge and technological activities in last 3 years (% of interacting firms)

	All	Micro	Small	Medium	Large	
Discipline (Firms can use more than one discipline)						
Engineering and Materials science	34.1	28.1	37.6	36.5	37.5	
Biology, Chemistry, Veterinary science	11.3	6.8	13.5	13.5	15.4	
Health sciences	6.1	7.3	4.6	5.5	10.3	
Physics, Mathematics	19.4	17.7	16.0	20.5	45.0	**
Architecture/ Building/ Planning and Urban design	15.9	15.1	17.3	12.2	17.9	
Economics and social science	8.1	5.2	11.3	5.4	7.7	
Business and financial studies	27.3	32.5	18.6	40.5	30.0	**
Arts and Humanities	18.3	14.7	19.8	13.7	35.9	**
N (un-weighted)	623	143	239	102	139	
N (weighted)	74,947	26,515	32,835	10,167	5,430	

Exhibit 4.15 shows how the propensity to engage with different disciplines varies according to innovation activity and growth performance. In general, innovating firms are more likely to connect with a range of disciplines compared to non-innovating firms. The exceptions are: architecture, planning and urban design, where non-innovating firms have a higher propensity to connect, and; business and financial studies, and the arts and humanities where there is no statistically significant difference between innovating and non-innovating firms. In terms of growth performance, the propensity to connect with physics and mathematics and the arts and humanities is higher for fast and medium growth firms compared to those firms that are stable or declining. Conversely, the propensity to connect with academics in business and financial studies is negatively correlated with growth performance. This suggests that engagement with business schools may be associated with corporate stress and underperformance rather than helping the management of fast growth firms.

Exhibit.4.15 Most important academic discipline in terms of knowledge and technological activities in last 3 years (% of interacting firms)

		Innovation			Growth			
	All	Non-innovators	Innovators		Stable/ Declining	Medium growth	Fast growth	
Discipline (Firms can use more than one discipline)								
Engineering and Materials science	34.0	21.1	40.7	**	33.7	33.0	37.3	
Biology, Chemistry, Veterinary science	11.3	4.2	15.0	**	11.8	8.9	10.5	
Health sciences	6.4	2.1	8.3	**	2.8	5.4	7.2	
Physics, Mathematics	19.3	12.6	23.6	**	11.7	21.4	20.3	**
Architecture/ Building/ Planning and Urban design	15.8	20.0	13.6	*	13.5	20.5	15.7	
Economics and social science	8.0	5.2	9.8	*	5.1	7.1	9.8	
Business and financial studies	27.3	30.9	25.4		36.0	23.9	19.0	**
Arts and Humanities	18.3	17.4	19.5		10.1	17.9	21.6	**
N (un-weighted)	623	185	424		190	141	173	
N (weighted)	74,947	26,325	46,851		24,642	15,543	21,172	

The role of proximity

There has been an increasing emphasis on the role of proximity in the innovation process, with recent contributions including Porter's focus on clusters (1998), although the antecedents of this can be traced to Marshall's notion of industrial districts (1890). According to Porter (1998) clusters are: 'geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example universities, standards agencies, and trade associations) in particular fields that compete but also co-operate.' (p.197).

Exhibit 4.16 shows the extent to which businesses believe it is important to be near universities and other partners or resources in the production system. Overall, proximity is most important with respect to skilled labour – 58% of businesses consider this to be important or highly important. Furthermore, 20% of businesses consider it important or highly important to be close to other firms in their industry; and 18% of businesses consider it important or highly important to be close to service specialists. Conversely, only 8% of businesses consider it important or highly important to be close to universities or government support agencies.

Exhibit 4.16 Importance of geographic proximity to certain resources, by firm size (% of firms stating proximity is important or highly important)

	Skilled labour	Other firms in your industry	Venture capital	Service specialists (patent lawyers, accountants etc)	Government support agencies	Higher Education Institutions	N (un-weighted)	N (weighted)
All	57.8	19.9	10.5	17.5	7.9	8.2	2,479	342,825
Micro	53.0	22.3	12.0	18.1	8.7	7.9	936	158,522
Small	60.6	18.0	9.9	17.6	7.8	7.6	1,065	145,082
Medium	68.5	16.7	7.9	15.3	5.6	12.0	249	29,897
Large	60.3	17.6	3.0	14.9	4.4	7.5	229	9,324
	**	**	**					

As shown in Exhibit 4.17, 61% of innovating firms consider it to be important or highly important to be close to skilled labour compared to 55% of non-innovating firms. Conversely innovating firms consider it less important to be close to other firms in their industry, service specialists and government support agencies compared to non-innovating firms. In terms of growth performance, proximity to venture capital and HEIs is positively correlated with growth performance whereas proximity to government support agencies is more important for stable and declining firms compared to those firms that have fast or medium growth.

Exhibit 4.17 Importance of geographic proximity to certain resources, by innovation activity and growth performance (% of firms stating proximity is important or highly important)

	Skilled labour	Other firms in your industry	Venture capital	Service specialists (patent lawyers, accountants etc)	Government support agencies	Higher Education Institutions	N (Un-weighted)	N (weighted)
All	57.8	19.9	10.5	17.5	7.9	8.2	2,479	342,825
Innovation								
Non-innovators	54.9	22.3	11.0	18.8	8.6	7.9	1,295	187,209
Innovators	60.9	16.7	9.3	15.8	6.4	7.9	1,146	150,165
	**	**		*	**			
Growth category								
Stable/Declining	54.4	23.4	9.0	16.3	9.9	6.6	963	132,571
Medium growth	64.0	13.0	6.5	13.5	5.3	9.2	454	57,412
Fast growth	59.5	20.7	11.8	17.3	6.8	9.7	501	72,749
	**	**	**		**	**		

The importance of access to human capital is also shown in Exhibit 4.18 which shows where undergraduates, graduates or postgraduates are recruited from. Overall, the geography of recruitment is complex and covers many different spatial scales: 47% of firm recruit from their local area; 43% recruit from their administrative region; and 46% recruit from the rest of the UK. In general recruitment from the local area is *inversely* correlated with firm size whereas recruitment from the region, the UK, Europe and the rest of the world is *positively* correlated with firm size. Furthermore, growing firms are more likely to use a wider labour marker compared to those firms that are stable or who are declining.

Exhibit 4.18 Location of undergraduates, graduates or postgraduates recruited from, by size of firm (% of firms)

	Local area (10 miles)	Administrative region	Rest of the UK	Rest of Europe	Rest of the world	N (un-weighted)	N (weighted)
All	47.0	42.8	46.1	16.9	15.9	726	97,032
Micro	58.1	34.6	36.9	6.9	12.8	142	30,076
Small	44.2	43.6	41.1	18.1	14.4	290	45,097
Medium	35.7	52.2	66.4	25.7	22.1	130	15,625
Large	42.2	53.3	77.8	33.3	28.9	164	6,234
	**	**	**	**	**		

Exhibit 4.19 Location of undergraduates, graduates or postgraduates recruited from, by innovation activity and growth performance (% of recruiting firms)

	Local area (10 miles)	Administrative region	Rest of the UK	Rest of Europe	Rest of the world	N (un-weighted)	N (weighted)
All	47.0	42.8	46.1	16.9	15.9	726	97,032
Innovation							
Non-innovators	55.8	40.0	42.4	13.3	12.2	260	40,756
Innovators	39.6	45.2	48.2	19.7	18.2	451	54,762
	**			**	**		
Growth category							
Stable/Declining	49.3	38.2	39.4	7.1	8.0	211	31,150
Medium growth	46.3	37.0	47.8	17.0	17.0	153	18,651
Fast growth	40.9	50.5	52.1	21.4	19.2	213	29,711
		**	**	**	**		

Section 5 Creating Partnerships: How interactions are developed

Knowledge exchange between business and academia requires the development of effective partnerships. Many universities have developed technology transfer capabilities in order to improve the connections with business particularly in the realm of the commercialisation of science and technology.

Initiation of Interactions

Exhibit 5.1 shows that 17% of interacting firms had their interaction with an HEI in the last three years initiated by the university's technology transfer office. But this was the least frequently cited initiation process. The most frequently cited initiation processes were: the actions of the firm in approaching academics or the HEI directly (45%); contact by individual academics (34%); connection by a third party organisation (32%); mutual actions following up informal contacts (30%); and mutual actions following up contact at a formal conference or meeting (22%). For many of these processes there is positive correlation with firm size, with large firms being more likely to use such mechanisms compared to small and micro firms. Micro firms were the least likely to have used the technology transfer office route (13%) whilst medium and large firms were most likely (27% and 21% respectively).

Exhibit 5.1 How interactions with HEIs are initiated, by firm size (% of interacting firms)

	University knowledge/technology transfer office or other university administrative office	Individual academics	Own actions in approaching academics and/or HEIs directly	A third party organisation	Mutual actions following up contact at a formal conference or meeting	Mutual actions following up informal contacts (including those through your employees)	N (un-weighted)	N (weighted)
All	17.3	34.1	44.7	32.3	22.4	30.1	623	73,744
Micro	13.3	34.6	34.4	34.1	12.3	18.9	139	24,827
Small	16.5	32.2	43.8	28.1	27.7	32.6	245	33,479
Medium	27.4	31.5	65.8	34.2	24.7	39.7	102	10,132
Large	21.1	48.7	59.0	46.2	31.6	48.7	137	5,306
	**		**		**	**		

Within the business population as a whole in Exhibit 5.2 shows that innovating firms have a higher propensity to use a range of initiating mechanisms compared to non-innovating firms. This includes their own actions in approaching academics or HEIs directly; contact by a third party organisation; mutual actions following up contact at a formal conference or meeting; and mutual actions following up informal contacts. Furthermore, Exhibit 5.2 also shows that fast growth firms are more likely to use the following mechanisms compared to other firms: a university technology transfer office; their own actions in approaching academics or HEIs directly; and mutual actions following up contact at a formal conference or meeting. Conversely, third party organisations were more likely to be used by slow growth and declining firms compared to those firms that had moderate or fast growth. In general it appears that there is a rich set of mechanisms producing interactions between the business sector and the HEI sector with a strong focus on direct actions by business. Of the minority of interactions initiated by technology transfer offices there is a clear tendency for such actions to be focused on fast growing innovative businesses.

Exhibit 5.2 How interactions with HEIs are initiated, by innovation activity and growth performance (% of interacting firms)

	University knowledge/ technology transfer office or other university administrative office	Individual academics	Own actions in approaching academics and/or HEIs directly	A third party organisation	Mutual actions following up contact at a formal conference or meeting	Mutual actions following up informal contacts (including those through your employees)	N (un-weighted)	N (weighted)
All	17.3	34.1	44.8	32.4	22.4	30.1	623	73,745
Innovation								
Non-innovators	15.7	36.2	33.7	27	13.5	23.9	186	25,515
Innovators	18	32.8	50.9	35.2	27	33.1	425	46,740
			**	*	**	**		
Growth category								
Stable/Declining	12.1	32.4	34.7	39.9	16.8	24.3	193	23,957
Medium growth	13.8	31.6	44	22.2	18.8	33.6	146	16,105
Fast growth	24.5	41.1	56.3	31.3	29.1	32.7	169	20,820
	**		**	**	**			

Exhibit 5.3 How are interactions with HEIs initiated by sector (% of interacting firms)

	University knowledge/technology transfer office or other university administrative office	Individual academics	Own actions in approaching academics and/ or HEIs directly	A third party organisation	Mutual actions following up contact at a formal conference or meeting	Mutual actions following up informal contacts (including those through your employees)	N (un-weighted)	N (weighted)
All	17.3	34.1	44.8	32.4	22.4	30.1	623	73,745
Sector								
Manufacturing	17.9	44.7	55.8	36.2	29.5	31.6	141	13,126
Wholesale/Retail	14.8	19.1	30.4	38.3	13	24.3	148	15,904
Business services	16.7	38.4	54.2	30.5	29.1	36.9	225	28,159
Other	21	33	34	27	14	23	109	16,556
		**	**		**	*		

Exhibit 5.3 shows how interactions with HEIs are initiated by sector. Direct action by businesses in approaching academics/HEIs is particularly high in manufacturing (56% of interacting businesses) and business services (54%) compared to the other activities (34%) and wholesale/retail (30%). Furthermore, approaches by individual academics are also relatively high in manufacturing (45%) and business services (38%) compared to the other activities (33%) and the wholesale/retail sector (19%). Manufacturing and business services are also more likely to use mutual actions following a conference or an informal contact as ways of connecting compared to the other activities and the wholesale/retail sector. Taken together these exhibits suggest that there is a rich pattern of interactions across a wide range of initiation routes. These will be underestimated if attention focuses on technology transfer offices alone. It should be noted that the focus here is on initiation and that the role of technology transfer offices may be more important when relationships develop and become more formalised.

Exhibit 5.4 shows how interactions with HEIs are initiated by discipline. As expected the TTO is most likely to be used by businesses connecting with engineering and material sciences as these are disciplines where the use of formal technology transfer mechanism is relatively high. However, even in these disciplines, own actions by academics and the businesses are relatively high – and much higher than connections through the TTO. The use of third party organisations is particularly high when connecting with health sciences and biology, chemistry and veterinary sciences.

Exhibit 5.4 How are interactions with HEIs initiated by discipline (% of interacting firms)

	University knowledge/ technology transfer office or other university administrative office		Individual academics		Own actions in approaching academics and/or HEIs directly		A third party organisation		Mutual actions following up contact at a formal conference or meeting		Mutual actions following up informal contacts (including those through your employees)		N (un-weighted)	N (weighted)
All	17.3		34.1		44.8		32.4		22.4		30.1		623	73,745
Discipline														
Engineering and Materials science	23	**	44.9	**	51.7	*	37.6		31.5	**	33.1		228	24,697
Biology, Chemistry, Veterinary science	19		48.3	**	46.6		50	**	37.9	**	44.8	**	93	8,027
Health sciences	11.4		34.3		58.8		64.7	**	54.3	**	40		41	4,774
Physics, Mathematics	19.6		45.1	**	48		31.4		31.4	**	43.1	**	131	14,111
Architecture/ Building/ Planning and Urban design	22.6		38.6		46.4		35.7		34.5	**	45.2	**	103	11,593
Economics and social science	16.3		40.5		52.4		39.5		46.5	**	52.4	**	53	5,903
Business and financial studies	15.9		31.4		48.6		32.6		21.2		27.5		179	19,009
Arts and Humanities	12.1		39.4		55.6	**	30.3		31.6	**	44.4	**	120	13,677

(Firms can use more than one discipline)

The Capacity to Connect

Overall, the evidence shows the important role of the firm in initiating contact with HEIs either unilaterally or mutually with HEIs – and this is particularly important for larger firms. To shed light on the capacity to connect and engage, Exhibit 5.5 shows the percentage of firms employing someone whose responsibilities include liaising with HEIs. Overall, 13% of firms employ someone who performs this role, but there is a pronounced positive correlation with firm size, for instance only 8% of micro firms employ someone to liaise with HEIs compared to 54% of large firms. This suggests that larger firms have more connective capacity which facilitates their connections with universities and academics. There is therefore a potential capacity barrier facing smaller businesses that seek to initiate interaction with HEIs.

Exhibit 5.5 Firms employing someone whose responsibilities include liaising with Higher Education Institutes (% of firms)

	%	N (un-weighted)	N (weighted)
All	12.6	2,513	347,333
Micro	8.1	951	161,320
Small	12.7	1,078	146,121
Medium	22.3	252	30,520
Large	54.4	232	9,371
	**		

There are also variations by growth, innovation and sector. Thus Exhibit 5.6 shows that 17% of innovating firms employ someone to liaise with HEIs compared to 9% of non-innovating firms and 18% of fast growth firms employ someone in this role compared to 9% of firms that have slow growth or who are declining.

Exhibit 5.6 Firms employing someone whose responsibilities include liaising with Higher Education Institutes, by innovation activity and growth performance (%)

		%	N (un-weighted)	N (weighted)
All		12.6	2,513	347,333
Innovation				
	Non-innovators	8.8	1,313	189,802
	Innovators	17.3	1,141	149,559
		**		
Growth category				
	Stable/Declining	9.3	977	135,039
	Medium growth	15.2	453	57,353
	Fast growth	17.6	508	73,950
		**		

Similarly Exhibit 5.7 shows that firms in the business services sector are most likely to employ someone in this role (16%) compared to firms in manufacturing (9%), other sectors (9%) and the wholesale/retail sector (7%).

Exhibit 5.7 Firms employing someone whose responsibilities include liaising with Higher Education Institutes (% of firms)

	%	N (un-weighted)	N (weighted)
All	10.4	2,456	338,677
Manufacturing	9.3	498	53,453
Wholesale/Retail	6.8	698	85,555
Business services	15.5	642	95,694
Other	9.1	618	103,975
	**		

Finally Exhibit 5.8 shows the percentage of firms employing someone whose responsibilities include liaising with HEIs by the academic discipline that the business connects with. Overall, businesses that connect with STEM disciplines are more likely to have someone employed in this capacity compared to other disciplines. Whereas the firms that connect with business and financial studies and economics and social science are least likely to employ someone to perform this function.

Exhibit 5.8 Firms employing someone whose responsibilities include liaising with Higher Education Institutes (% of firms)

	%		N (un-weighted)	N (weighted)
All	12.6		2,513	347,333
Discipline				
Engineering and Materials science	43.2	**	249	26,527
Biology, Chemistry, Veterinary science	39.1		101	8,887
Health sciences	65.7	**	41	4,812
Physics, Mathematics	51.4	**	139	14,878
Architecture/ Building/ Planning and Urban design	40.0		110	12,527
Economics and social science	32.6		56	6,394
Business and financial studies	30.8		197	21,986
Arts and Humanities	39.4		126	14,406

Firms can use more than one discipline

These patterns of resource commitment are consistent with the earlier results showing that fast growing innovative and manufacturing and business service firms and those connecting to STEM subjects are all more likely to use the vast majority of the routes to initiate interactions.

Given the extent to which interacting businesses employ specialist liaison staff, it is important to understand their background. The experience of those employed to liaise with HEIs is therefore shown in Exhibit 5.9. Overall, firms tend to employ those with experience in business (93% of firms); compared to those with experience in academia (21%) or experienced in the public sector (13%). It should be noted, however, that, as shown in Exhibit 5.10, innovating firms are twice as likely to employ someone with experience in academia compared to non-innovating firms. This may reflect the need for absorptive capacity within the firm in relation to technical and scientific subjects used as sources of knowledge for innovation.

Exhibit 5.9 The experience of the person employed to liaise with Higher Education Institutions (% of employing firms)

	Experienced in academia	Experienced in business	Experienced in public sector	N (un-weighted)	N (weighted)
All	21.1	92.9	12.5	361	41,043
Micro	19.5	88.5	19.5	64	11,979
Small	25.4	92.9	11.9	122	17,417
Medium	12.5	97.9	6.3	61	6,561
Large	21.6	97.3	8.1	114	5,086

Exhibit 5.10 The experience of the person employed to liaise with Higher Education Institutions, by innovation activity and growth performance (% of employing firms)

	Experienced in academia	Experienced in business	Experienced in public sector	N (un-weighted)	N (weighted)
All	21.1	92.9	12.5	361	41,043
Innovation					
Non-innovators	12.9	92.2	10.3	112	16,085
Innovators	25.6	94.3	12.0	242	24,234
	**				
Growth category					
Stable/Declining	17.9	95.3	10.6	94	11,736
Medium growth	14.5	95.2	11.3	82	8,573
Fast growth	27.0	92.1	3.4	110	12,353

Section 6 The Motivations and Impact of Knowledge Exchange

In this section we focus on those enterprises which reported either a people based or a problem solving or a community based interaction with a higher education institution (HEI) in the three years prior to the survey. We examine the motivations behind those interactions and the impact that the enterprises believe such interactions had on the nature of their business's activity and the kind of research which they undertake. We also look at the way in which impact was assessed by interacting enterprises.

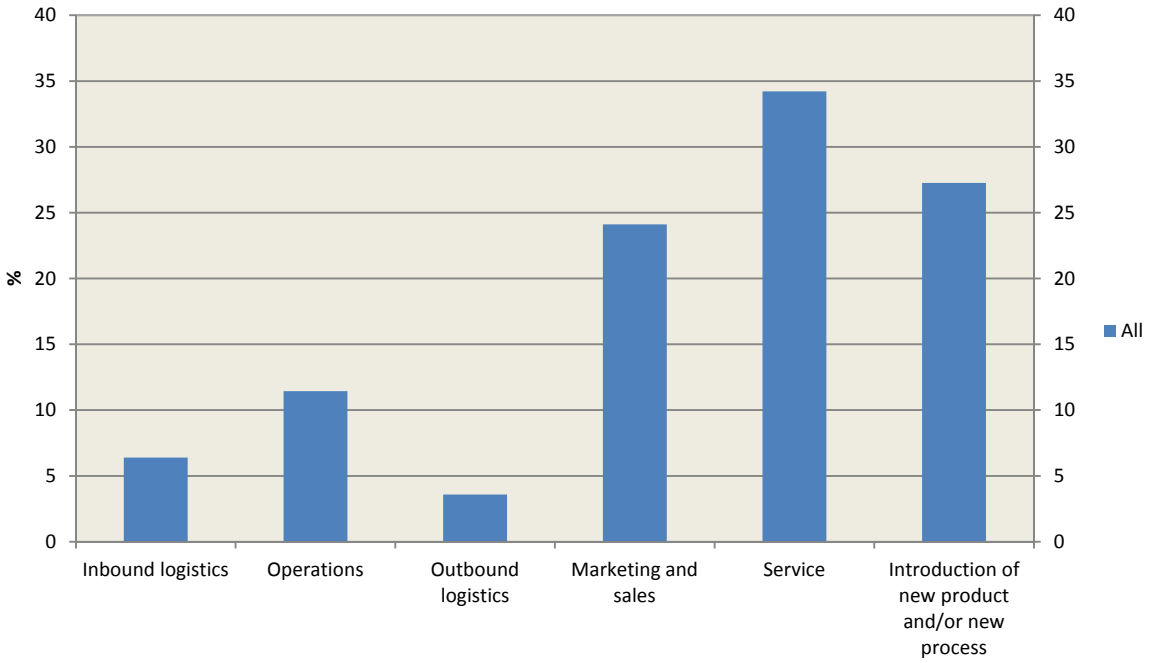
Motivations for Interaction

Interacting firms were asked to identify the primary activities in the value chain of their businesses which motivated their interaction with HEIs. Firms could identify such primary activities in terms of six categories:

- Inbound logistics
- Operations
- Outbound logistics
- Marketing and sales
- Service-related activities
- Introduction of new products and/or processes

Inbound logistics encompasses receiving, storing, inventory control and transportation planning. Operations is defined to include machining, packaging, assembly, equipment maintenance, testing and other activities that transform inputs into the final product. Outbound logistics is defined as activities that get the finished products to the customers, such as warehousing, order fulfilment, transportation and distribution management. Marketing and sales activity includes getting buyers to purchase the product such as channel selection, advertising, promotion, selling, pricing and retail management. Finally, service activities are defined as those that maintain and enhance the product value, such as customer support, repair services, installation, training, spare parts management and upgrading.

Exhibit 6.1 Motives to interact, primary activities (% of interacting firms)

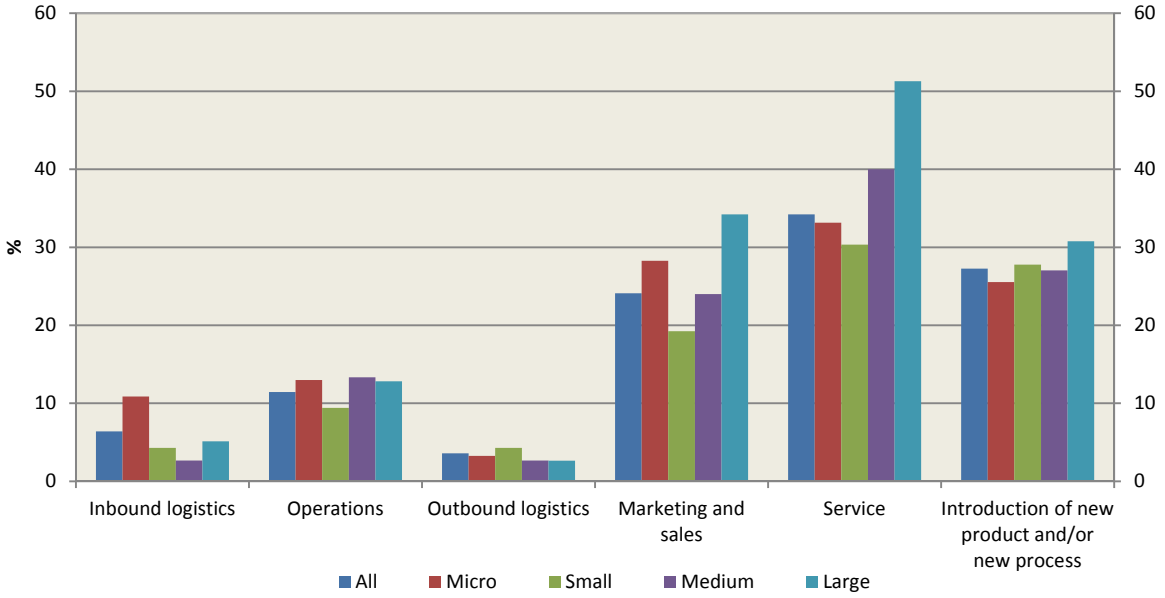


All N (un-weighted)=618; N (weighted)=73,599

Exhibit 6.1 shows the proportion of interacting firms which identified each of the primary activity categories motivating their interaction with HEIs. Firms could identify more than one activity. The most common activity motivating such interactions was in the support of services. This was followed by the introduction of new products and/or new processes and by marketing and sales. The logistics activities were the least likely to be the source of motivation for interaction.

An analysis by size of firm in Exhibit 6.2 reveals that micro-firms were somewhat more likely to report motivations arising from inbound logistics compared to larger size classes, whilst small firms were somewhat less likely to cite operations and marketing and sales as a motivation for interaction. There was little variation across size classes in terms of outbound logistics or the introduction of new products and/or new processes. The largest firms were the most likely to cite marketing and sales service activities and the introduction of new products and/or new processes as factors motivating their interaction.

Exhibit 6.2 Motives to interact, primary activities by firm size (% of interacting firms)



All N (un-weighted)=618; N (weighted)=73,599

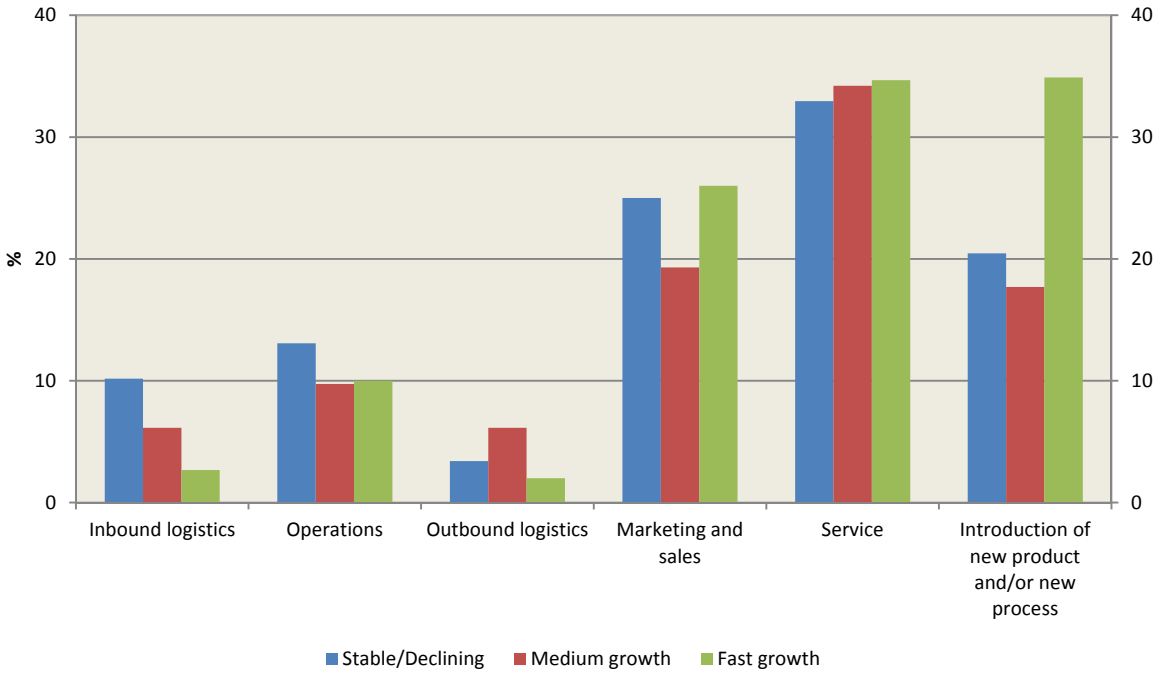
When interacting firms are classified by industry, as shown in Exhibit 6.3, a number of sectoral differences are revealed Marketing and sales as a motivation is highest in business services and in manufacturing whilst business services are the most likely to cite service-related activities as a key motivating factor.

Manufacturing is easily the most significant sector in terms of the extent to which the introduction of new products and/or new processes is the motivating factor with nearly 50% of the respondents citing this as a motivating activity. The manufacturing sector is followed by wholesaling and retailing and business services.

Exhibit 6.3 Motives to interact, primary activities by sector (% of interacting firms)

		Inbound logistics	Operations	Outbound logistics	Marketing and sales	Service	Introduction of new product and/or new process	N (un-weighted)	N (weighted)
All		6.3	11.4	3.7	24.1	34.2	27.2	618	73,596
Sector									
	Manufacturing	3.2	17.2	5.3	29.0	16.1	49.5	140	12,934
	Wholesale/Retail	7.7	14.5	6.8	22.9	34.7	31.4	148	16,297
	Business services	0.5	6.2	0.0	29.9	41.5	26.2	219	26,944
	Other	15.9	12.0	6.0	12.0	36.0	9.0	111	17,421
		**	**		**	**	**		

Exhibit 6.4 Motives to interact, primary activities by growth category (% of interacting firms)

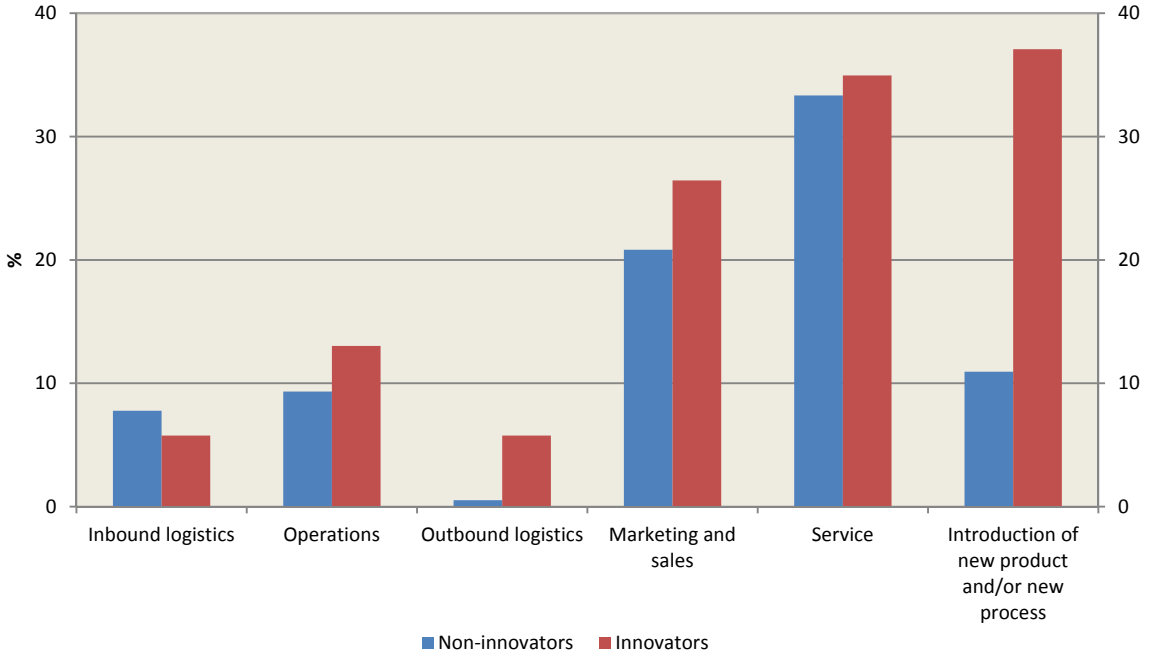


Growth N (un-weighted)=505; N (weighted)=60,909

An analysis of interacting firms by growth rate, shown in Exhibit 6.4, reveals that the introduction of new products and/or new processes is the most important motivating factor along with the support of service activities for fast growing firms. Equally, fast growing firms are more likely to cite this as the reason for their interactions than is the case either for medium growth or for stable and declining firms. Thus, whereas 35% of fast grow firms cite this as the reason for their interaction, the figures are 18% and 20% for medium and stable/declining firms respectively. Medium growth firms are most likely to cite services as the reason for their interaction as is the case for stable and declining firms. The proportion of firms citing service as the motivating factor is fairly stable across each of the three growth cuts with around a third of the interacting firms citing this as a motivation for interaction. The variation in the proportion citing the introduction of new products and/or process as a motivating factor is statistically significantly different across the growth categories. The same is true for the relatively low proportions citing inbound logistics as a motivating factor which is somewhat higher in stable and declining firms than in the rest.

If we divide our interacting firms into those which report making an innovation in product or processes in the past three years and those which do not, another interesting set of patterns emerges which is shown in Exhibit 6.5.

Exhibit 6.5 Motives to interact, primary activities by innovation category (% of interacting firms)



Innovators N (un-weighted)=607; N (weighted)=72,229

As might be expected, the introduction of new products and/or new processes as a motivating factor is far higher in innovators than in non-innovators. In general, innovators are more likely to cite each of the activities as a motivating factor with the exception of inbound logistics. But these differences are rarely statistically significant whereas the difference in patterns in terms of the introduction of new products and/or processes is statistically significant at the 5% level. It thus appears that the interactions citing the introduction of new products and/or new processes are largely the province of innovative firms.

So far we have treated interactions in terms of the higher education institution sector as a whole taking all academic disciplines together. The surveyed firms were also asked to identify which academic disciplines had been most important for their firm in terms of knowledge and/or technological activities in the last three years. Firms were able to identify more than one relevant discipline. A cross-classification of the disciplines and the primary activities which the firms indicated motivated their interaction is shown in Exhibit 6.6.

Exhibit 6.6 Motives to interact, primary activities by discipline (% of interacting firms)

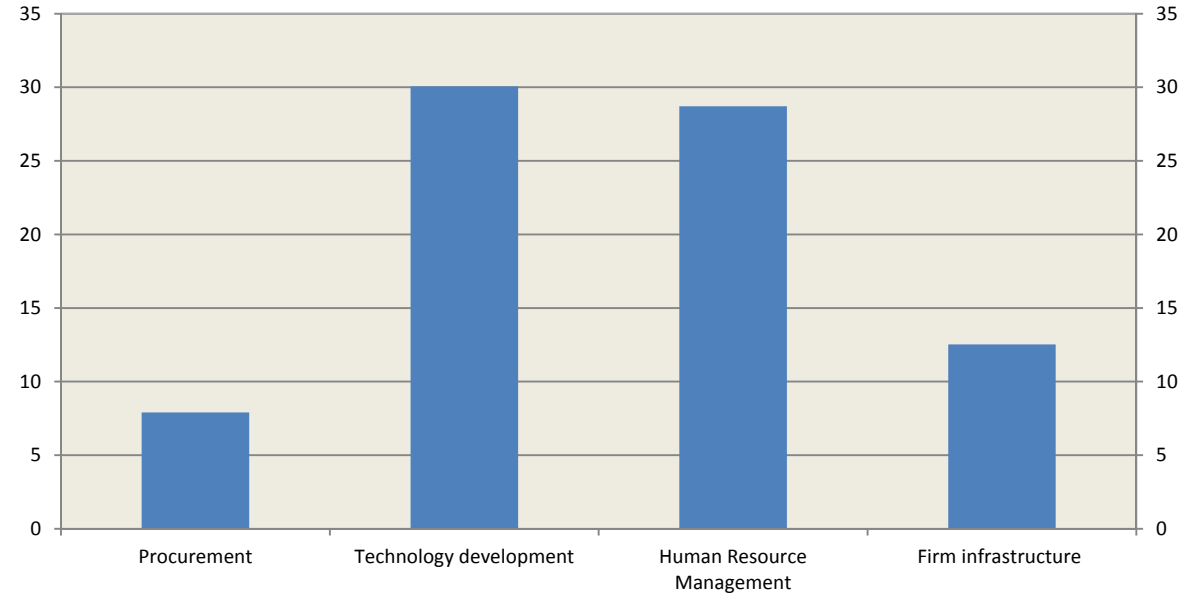
	Inbound logistics		Operations		Outbound logistics		Marketing and sales		Service		Introduction of new product and/or new process		N (un-weighted)	N (weighted)
Discipline (Firms can use more than one discipline)														
Engineering and Materials science	3.0	**	18.9	**	3.6		21.9		32.5		45.0	**	226	23,340
Biology, Chemistry, Veterinary science	5.0		15.0		5.0		22.0		28.8		40.0	**	96	8,253
Health sciences	5.9		14.7		5.9		27.3		47.1		58.8	**	40	4,675
Physics, Mathematics	5.0		13.0		6.0		33.0	**	43.0	**	43.0	**	130	13,857
Architecture/ Building/ Planning and Urban design	5.1		8.8		5.0		20.0		47.5	**	32.5		100	10,995
Economics and social science	2.4		2.4	*	2.4		43.9	**	42.9		47.6	**	51	5,770
Business and financial studies	18.8	**	15.3		9.1	**	38.9	**	39.2		19.6	**	181	19,847
Arts and Humanities	2.2	*	8.6		2.2		44.6	**	50.0	**	26.1		114	12,774

This exhibit shows that the importance of disciplines varies considerably across activities. Firms citing inbound logistics as a factor behind their interactions were much more likely to have been interacting with business and financial studies. Those motivated by operational considerations were more likely to be interacting with a substantial range of science-based disciplines topped by engineering and materials science, but also by interactions with business and financial studies. Business and financial studies were also relatively more important for those concerned with outbound logistics. Marketing and sales were relatively highly linked to economics and social science, business and financial studies and the arts and humanities. In the latter case, 45% of firms concerned with marketing and sales as a primary factor motivating their interaction cited an interaction with arts and humanities disciplines as being important for their firm. Arts and humanities were also the most important in relation to the provision of service activities, although a wide range of disciplines were involved in relation to services as a factor for interaction. As was the case with operations, the introduction of a new product and/or new processes tends to involve more frequent interactions with engineering, materials science, biology, chemistry, veterinary science, and health sciences along with physics and mathematics than the other disciplines. Although even here, economics and social science is well represented. The picture which emerges is of a very wide range of academic disciplinary interactions across the full range of primary business activities.

So far our discussion has focused on the primary activities in the value chain of a firm. We also asked our enterprises to what extent their motivation to interact with higher education institutions had to do with support activities in the value chain of the firm. These included the procurement of raw materials, spare parts, building and machines, technology development in terms of research and development, process alteration, design and re-design, human resource management in terms of recruiting, staff development, education, retention and the compensation of employees and managers, and finally what we termed firm infrastructure (general management, planning management, legal, finance, accounting, public affairs and quality management).

Exhibit 6.7 shows that technology development and human resource management were the dominant support activities around which businesses sought interactions with higher education institutes. Around 30% of interacting firms reporting that these two areas were a source of motivation. Firm infrastructure and procurement were much less important.

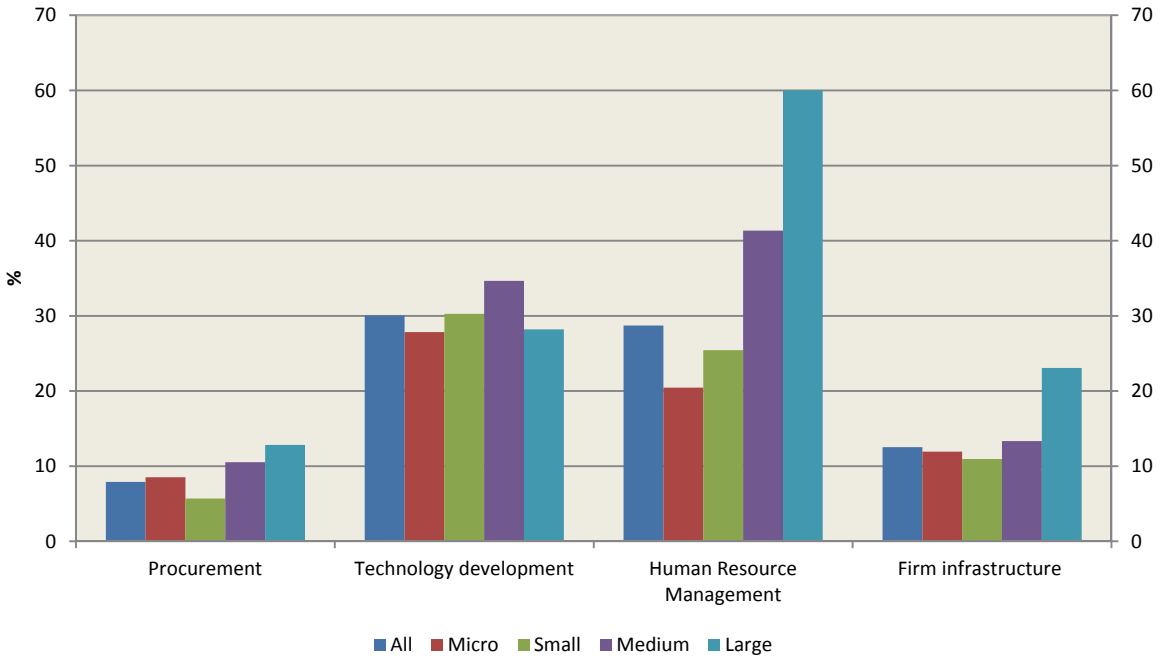
Exhibit 6.7 Motives to interact, support activities (% of interacting firms)



All N (un-weighted)=612; N (weighted)=71,826

Exhibit 6.8 reveals relatively little variation by size of firm. The most striking feature is the extent to which large firms were motivated to interact with HEIs in relation to human resource management issues, where 60% of large firms gave this as a motivation. This difference was not only large quantitatively, but also was statistically significant. The other variations were smaller and not statistically significant.

Exhibit 6.8 Motives to interact, support activities by firm size (% of interacting firms)



All N (un-weighted)=612; N (weighted)= 71,826

When the analysis is broken down by the industrial sector of the firms in Exhibit 6.9, some important differences emerge. For manufacturing over half of the firms cite technology development as a support activity in motivating interactions with HEIs. This is far higher than any other sector. For business services, human resource management is the dominant factor motivating interactions.

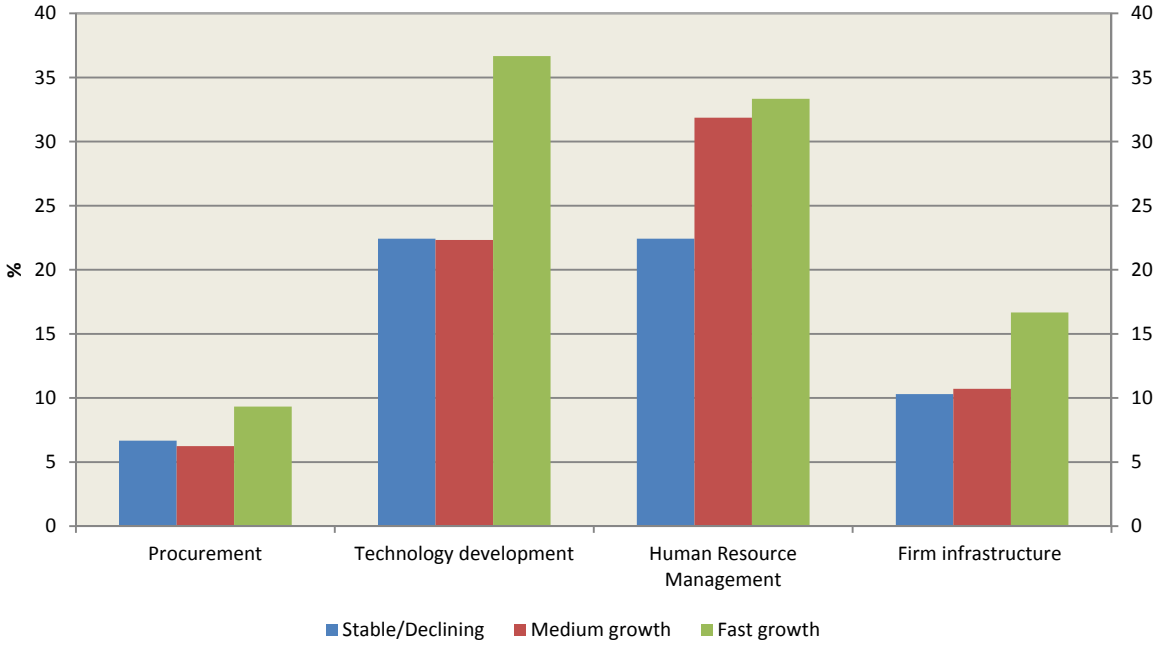
Exhibit 6.9 Motives to interact, secondary activities by sector (% of interacting firms)

	Procurement	Technology development	Human Resource Management	Firm infrastructure	N (un-weighted)	N (weighted)
All	7.9	30.1	28.7	12.4	612	71,824
Sector						
Manufacturing	8.6	55.9	17.2	9.8	138	12,819
Wholesale/Retail	14.7	24.1	15.5	10.3	146	16,069
Business services	6.2	32.5	38.1	17.5	221	26,824
Other	3.0	11.0	34.5	8.0	107	16,112
	**	**	**	**		

Exhibit 6.10 shows that in general fast growing firms are more likely to interact in relation to all support activities, although the difference is particularly marked in relation to technology development. In that area the difference is statistically significant as well as quantitatively

important. In relation to human resource management, both the medium- and fast growth firms feel the need to interact with HEIs more frequently than do stable and declining firms. Once again the relationship was statistically significant.

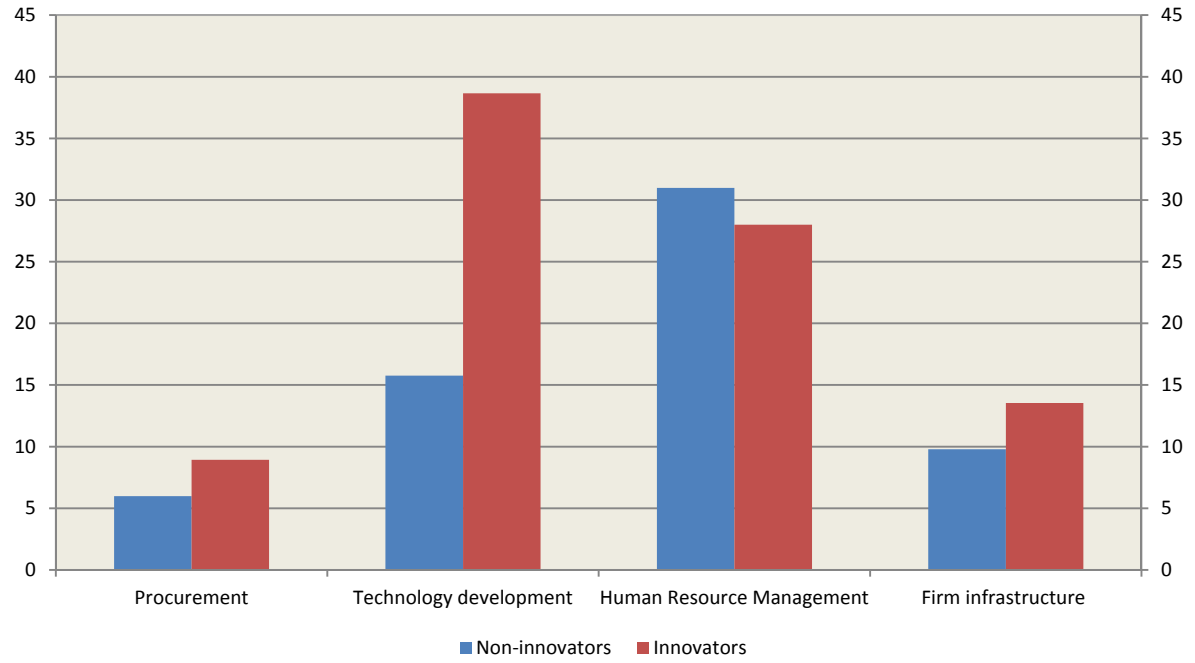
Exhibit 6.10 Motives to interact, secondary activities by growth category (% of interacting firms)



Growth N (un-weighted)=498; N (weighted)=59,218

When we cross cut the data in terms of innovative activity Exhibit 6.11 shows, as might be expected, that technology development is a much more important factor for innovative firms in inspiring their interactions with HEIs. Non-innovators and innovators show a very similar proportion of enterprises requiring support in relation to human resource management.

Exhibit 6.11 Motives to interact, secondary activities by innovation category (% of interacting firms)



Innovators N (un-weighted)=601; N (weighted)=70,510

The firms responding to the survey identified the disciplines which had been important to their firm in terms of knowledge or technological activities in the past three years and also in answer to a separate question reported on which support activities they had relied in motivating their interactions.

The pattern of disciplinary interaction by support activities motivating interaction with HEIs is shown in Exhibit 6.12. As might be expected, firms identifying engineering and materials sciences as a discipline with which they had important interactions had a high proportion citing technology development as a support activity linked to those interactions. In this case 59% of firms having engineering and materials sciences based important interactions cited this as a motivating support activity. Similarly high proportions of 55% and 51% respectively relate to interactions linked to biology, chemistry, veterinary science and the health sciences whilst 46% of those citing physics and mathematics as important disciplines were motivated by technology development in interacting with HEIs. In each case these were the most important motivating support activities for those science-based disciplines. The proportions were both quantitatively and statistically significantly different from the proportion of firms using those disciplines which cited procurement, human resource management or firm infrastructure as a motivating support activity.

Exhibit 6.12 Motives to interact, secondary activities by discipline (% of interacting firms)

	Procurement		Technology development		Human Resource Management		Firm infrastructure		N (un-weighted)	N (weighted)
Discipline (Firms can use more than one discipline)										
Engineering and Materials science	9.8		58.6	**	20.7	**	11.5		229	24,066
Biology, Chemistry, Veterinary science	11.9		55.2	**	19.0	*	16.9		95	8,103
Health sciences	11.4		51.4	**	14.7	*	2.9		41	4,773
Physics, Mathematics	9.1		46.0	**	31.3		16.2		130	13,742
Architecture/ Building/ Planning and Urban design	20.0	**	23.8		39.2	**	15.0		102	11,035
Economics and social science	14.3		19.0		54.8	**	23.8	**	52	5,806
Business and financial studies	9.4		13.9	**	39.4	**	29.2	**	181	19,002
Arts and Humanities	16.5	**	24.4		36.7	*	20.0	**	114	12,545

A rather different pattern applies in the social sciences and the humanities. In this case, the most important support activity motivating interactions amongst firms citing those disciplines as an important source of knowledge or technology is human resource management. This was the case for 55% of those interacting with economics and social sciences, 39% with business and financial studies, and 37% with the arts and humanities. In each case this dimension of support activities was the most frequently cited motivating factor for interacting with these disciplines. Moreover, the difference was both quantitatively and statistically significantly different from interactions linked to procurement, technology development and firm infrastructure. It is important to note, however, that in all cases, firms citing technology development as a motivation for interacting with HEIs did so in relation to reporting a wide range of disciplines with which they had important interactions. Thus 24% of businesses which were motivated to interact with HEIs and cited technology development as a factor had interactions which involved arts and humanities disciplines. The picture which emerges therefore is a business sector with multiple motivations for interaction across the full range of primary and support activities and with interactions which are regarded as important across a very wide range of disciplines.

Success of Interactions

So far we have focused on the motivation for interaction. In this section we turn to the firms' perceptions of the success of the interaction cross classified by the motivation for interaction. The firms were asked to rate success on a scale of 1-5 where completely unsuccessful=1, partially successful=2, moderately successful=3, highly successful=4 and completely successful=5.

Exhibit 6.13 reports the mean scores and the percentages of enterprises reporting at least partial success. If all interactions are taken together around 9 out of 10 firms report at least partial success and the mean score is close to 3 representing moderate success.

Exhibit 6.13 Success of interactions, primary activities: mean scores and % reporting success (interacting firms)

	All collaborating firms for primary activities	Logistics/ Operations	Marketing and sales	Service	Introduction of new product and/or new process
Mean score	2.9	2.9	2.8	2.9	2.9
Partially to completely successful (2-5)	89.1	89.2	90.5	89.7	88.1
Ratings	613*				
N (un-weighted)		102	126	171	161
N (weighted)		9,019	15,060	21,152	16,783

* this is 613 ratings not firms, 1 firm can have multiple ratings

Exhibit 6.14 Success of interactions, support activities: mean scores and % reporting success (interacting firms)

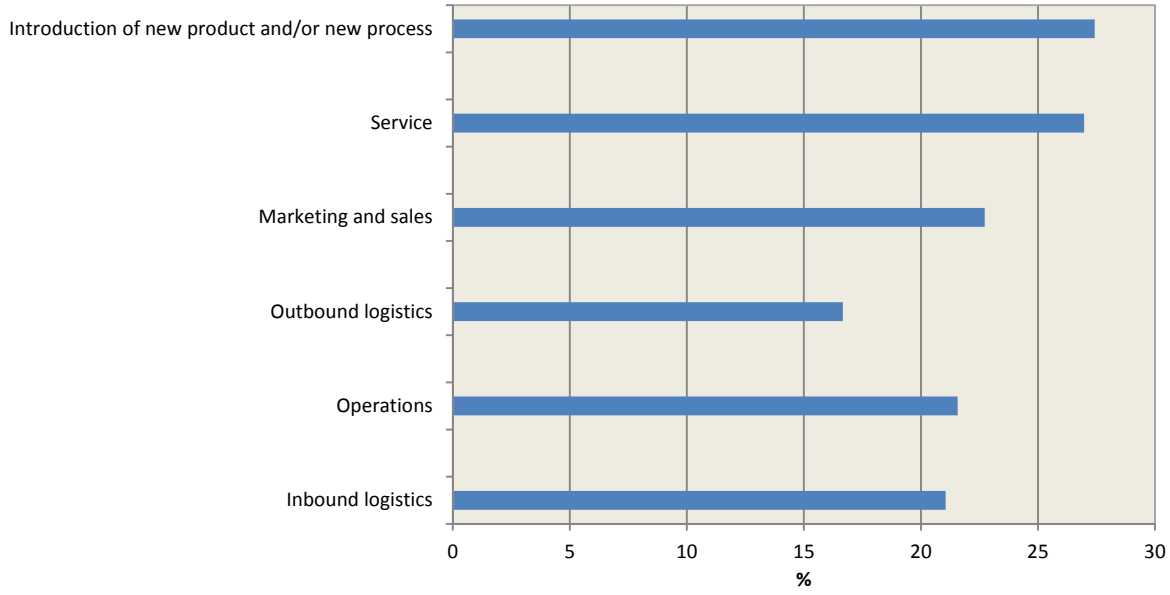
	All collaborating firms for support activities	Procurement	Technology development	Human Resource Management	Firm infrastructure
Mean score	2.9	2.7	2.9	2.8	3
Partially to completely successful (2-5)	90.6	75.7	93.2	90.2	93.4
Ratings	484*				
N (un-weighted)		48	167	167	94
N (weighted)		5,180	18,812	17,752	7,472

* this is 484 ratings not firms, 1 firm can have multiple ratings

Exhibit 6.14 repeats this exercise for support activities with very similar results. For all support activities except procurement, over 90% of respondents report at least partial success with mean scores around 3. In general, the picture which emerges is a very positive one with the vast majority of enterprises reporting at least partial success in their interactions. A slightly tougher test is to focus on those interactions rated as highly or completely successful.

Exhibit 6.15 shows that over a quarter of the cases of interaction met this stringent test in relation to the introduction of new products and/or new processes and in relation to service activities. In relation to marketing, sales, operations and inbound logistics over 20% report highly successful or completely successful interactions. Once again, logistics lags behind.

Exhibit 6.15 Success of interactions, primary activities: % of interacting firms reporting highly or completely successful interactions

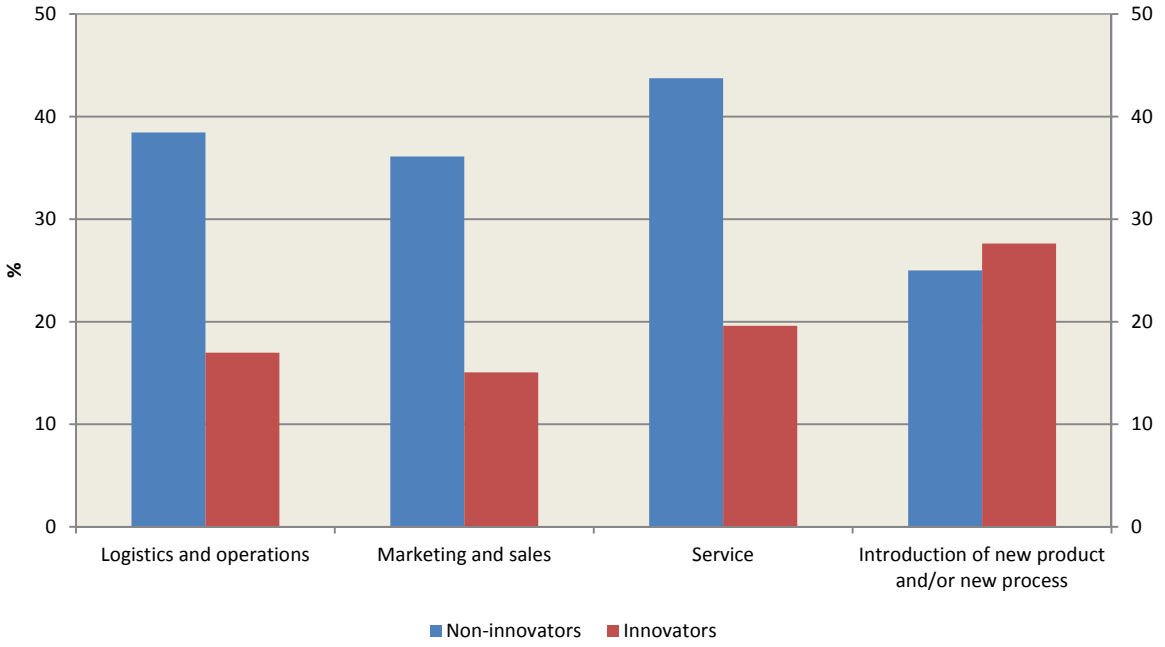


All N (un-weighted)=618; N (weighted)=73,597

We also carried out this more stringent test across firms grouped by innovation activity and growth rate. The results of this are shown in Exhibit 6.16 and 6.17.

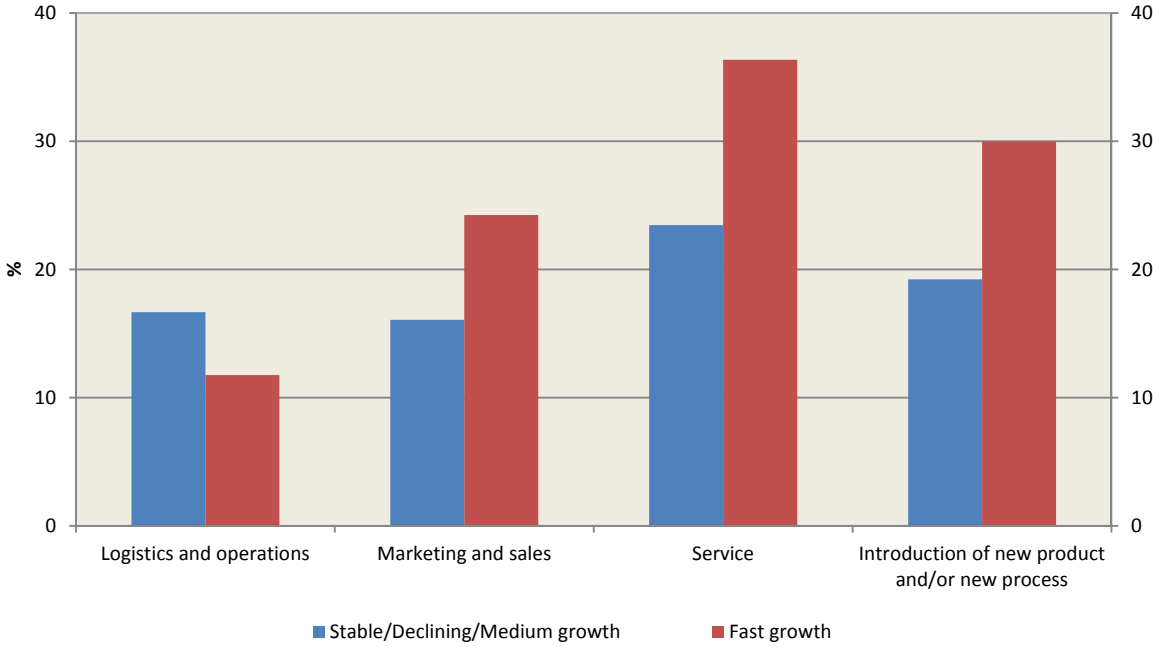
Exhibit 6.16 reveals that innovative firms are less likely to report success in each dimension of activity apart from the introduction of new products and processes. This may reflect the more challenging and riskier nature of the objectives of their interactions (e.g. in relation to designing new operating processes; dealing with new markets and developing new support activities linked to service provision). In contrast Exhibit 6.17 shows that fast growers are more likely to report success in all activity dimensions except logistics. Taking exhibits 6.15 to 6.17 together reveals that in a significant proportion of cases of interaction (around 1 in 4 on average) very high levels of success are achieved.

Exhibit 6.16 Success of interactions, primary activities by innovation category: % of interacting firms reporting highly or completely successful interactions



Innovators N (un-weighted)= 607; N (weighted)= 72,229

Exhibit 6.17 Success of interactions, primary activities by growth category: % of interacting firms reporting highly or completely successful interactions



Growth N (un-weighted)=505; N (weighted)= 60,909

Exhibit 6.18 Impact of interactions by size class (% of interacting firms)

	Led to new projects with HEIs	Strengthened the firm's reputation	Given the business new insights	Led to new contacts in the field	Any one of these effects	Had very little or no impact	N (un-weighted)	N (weighted)
All	10.8	26.6	28.5	23.7	44.2	33.4	614	71,759
Micro	4.0	20.3	22.6	19.2	40.7	33.0	139	24,450
Small	11.8	26.2	27.1	24.0	43.2	33.6	236	31,698
Medium	17.6	37.8	36.5	29.7	50.0	37.3	103	10,258
Large	23.1	38.5	48.7	30.8	56.4	26.3	136	5,353
	**	**	**					

So far we have focused on success cross-classified by specific motivating activities. The surveyed firms were, however, also asked to identify any wider impact that their interactions with higher education institutions had had on the nature of their business more generally, and on the kind of research that they did. Firms were asked specifically whether interaction had led to new projects with higher education institutions, had strengthened the firm's reputation, had given it new business insights, and/or had led to new contacts in the field.

Exhibit 6.18 shows that large firms were more likely to report that their involvement had led to new projects with HEIs. This was the case in 23% of the responding firms. It was also true for 18% of the medium firms. The differences between medium and large firms and the micro and small firms in this respect are both quantitatively and statistically significant. The same was true in relation to strengthening the firm's reputation. This was an impact for 27% of the cases of interaction for the sample as a whole, but for 38% of the medium and 39% interacting involving the large businesses. These businesses were also much more likely to report that they had been given new insights as a result of the involvement. In the case of impacts associated with new contacts in the field, 30% and 31% respectively of medium and large firms reported this impact compared to only 19% and 24% for micro and small firms. All but the last of these differences is statistically significant. If we group all firms together who reported at least one of these impacts, we find that 44% of the sample as a whole identified an impact on one or more of these dimensions. Once again, larger firms were more likely to report one or more of these effects. But even in the case of micro and small firms, over 40% reported an impact.

Exhibit 6.19 cross classifies the impact of the involvement in knowledge exchange interactions against whether the firms were innovators or non-innovators, their growth characteristics and in terms of the discipline with which they reported having important interactions. If we turn first to innovative activity, it is clear the firms which carried out process or product innovation in the previous three years were much more likely to report impacts on each of the various dimensions identified in the exhibit. Thus 51% of the innovators reported one or more positive effects in terms of the establishment of new projects, strengthening the firm's reputation, giving the business new insights or leading to new contacts in the field.

Exhibit 6.19 Impact of interactions by innovation, growth and discipline categories (% of interacting firms)

	Led to new projects with HEIs		Strengthened the firm's reputation		Given the business new insights		Any one of these effects		Had very little or no impact		N (un-weighted)	N (weighted)
All	10.7		26.7		28.5		44.3		33.4		614	71,759
Innovation												
Non-innovators	3.3		20.0		12.8		32.2		37.8		184	24,912
Innovators	14.2	**	30.3	**	36.7	**	50.8	**	30.6		421	45,704
Growth category												
Stable/Declining	9.1		27.4		26.8		40.2		34.1		191	22,703
Medium growth	5.5		22.9		26.6		40.7		29.4		140	15,054
Fast growth	15.9	**	30.5		32.5		51.7	*	34.4		169	20,840
Discipline (Firms can use more than one discipline)												
Engineering and Materials science	19.2	**	35.5	**	41.3	**	57.6	**	34.3		230	23,797
Biology, Chemistry, Veterinary science	32.8	**	48.3	**	45.9	**	66.7	**	27.9		97	8,353
Health sciences	29.4	**	44.1	**	48.6	**	55.9		29.4		40	4,728
Physics, Mathematics	21.2	**	35.6	**	48.5	**	61.5	**	32.7		134	14,323
Architecture/ Building/ Planning and Urban design	10.3		28.2		33.3	**	53.8	*	34.6		101	10,776
Economics and social science	14.0		25.0		46.5	**	51.2		29.5		54	6,019
Business and financial studies	10.4		35.6	**	37.3		53.0	**	32.1		185	18,577
Arts and Humanities	16.3	**	33.7		37.8	**	57.1	**	24.5	**	120	13,581

All of these differences are both quantitatively and statistically significantly different. The leading impact was in terms of giving the business new insights. It is worth noting that even for non-innovators 32% reported an impact on one or more of the dimensions identified. Exhibit 6.19 shows that fast growth firms are more likely to report impacts from their knowledge exchange activities. This is true across each of the dimensions identified. Over 50% of such firms identified at least one of those effects. Gaining new business insights and strengthening the firm's reputation along with leading to new contacts in the field were the dominant forms that the impact took. Even in the case of both stable and declining and medium growth firms, 40% and 41% respectively reported positive impacts on at least one of those dimensions.

Finally, Exhibit 6.19 allows us to consider variations in impact by the disciplines with which the firms interacted. In the case of each discipline a majority of firms interacting with it reported having an impact on one or more of the dimensions identified in the exhibit. In the case of physics and mathematics, 62% of interacting firms who had interactions with them, reported at least one of these effects. In the case of biology, chemistry and veterinary science the relevant percentage was 67%.

There are differences in each discipline in terms of the proportions of firms reporting each type of impacts. These differences are usually both quantitatively and statistically significant. Thus, in the case of involvement in knowledge exchange interactions where engineering and materials sciences were cited as an important interacting discipline, the biggest impacts were found in terms of new business insights, strengthening reputation and leading to new contacts in the field. This was also true in biology, chemistry and veterinary science, health sciences, physics and mathematics and each of the other disciplinary groupings.

In Exhibit 6.20 the dimensions of impact are cross classified by sector. Impacts associated with new projects with HEIs were most likely to be the case in manufacturing firms. The differences between manufacturing and the other sectors were relatively small across the other dimensions. In the case of wholesaling and retailing, strengthening the firm's reputation and leading to new contacts in the field were relatively more important, but the differences were quite small compared to other impacts.

It thus appears to be the case that businesses in different sectors gain in different ways from their interaction with the HEI sector. In all sectors an impact leading to new projects with HEIs is relatively small and most of the gains are in terms of reputation, new insights and new contacts in the field. It thus represents a widening of the range of ways in which businesses can benefit their competitive position.

Exhibit 6.20 Impact of interactions by sector (% of interacting firms)

		Led to new projects with HEIs	Strengthened the firm's reputation	Given the business new insights	Led to new contacts in the field	Any one of these effects	Had very little or no impact	N (un-weighted)	N (weighted)
All		10.7	26.7	28.5	23.7	44.3	33.4	614	71,759
Sector									
	Manufacturing	19.1	34.0	35.1	25.5	47.9	27.7	141	13,007
	Wholesale/Retail	10.2	20.2	18.5	21.0	35.3	35.3	147	16,397
	Business services	10.8	26.3	33.0	27.3	50.0	36.6	218	26,823
	Other	4.0	28.0	26.0	19.0	40.0	30.0	108	15,532
		**		**		*			

Exhibit 6.21 Impact of interactions by size class: overall impact and mode of assessment (% of interacting firms)

	Have the interactions with HEIs, had a significant impact on your firm's activities?	In assessing impact do you use measures related to: Technical objectives	Investment objectives	Wider business objectives	Qualitative information	N (un-weighted)	N (weighted)
All	25.4	33.9	14.5	50.4	35.1	581	70,125
Micro	20.6	31.3	9.6	50.9	32.5	132	23,529
Small	26.0	32.0	16.2	50.5	29.7	227	31,426
Medium	31.5	43.8	19.2	52.1	39.7	99	10,093
Large	33.3	38.2	18.2	45.5	72.7	123	5,077
					**		

Finally, we are able to make some comments on whether interactions as a whole were perceived by the firms as having a significant impact on their activities, whether their assessments related to technical objectives, investment objectives or wider business objectives, and whether in assessing impacts they use qualitative information. Firms could indicate more than one dimension of assessment.

Exhibit 6.21 shows that only a minority of firms registered a significant impact. Medium and large firms were more likely to do this. Thus, 32% and 33% respectively of the firms in these categories reported a significant impact. Measures related to wider business objectives were the most frequently cited. This was followed by qualitative assessment information, technical objectives based assessment and finally by investment objectives based assessment which was relatively infrequent. Qualitative assessment information was used in 73% of large firms. This was far higher than the proportions that reported it as the basis for assessment in micro, small and medium sized firms.

Taken as a whole these results suggest that businesses in a relatively small proportion of cases report significant impacts. In reaching a conclusion about significant impacts, the most important and frequently used bases for assessment relate to wider business objectives and not to narrow technical or investment objectives. Moreover, in a wide range of cases qualitative information is used as an assessment method, especially in larger firms. This emphasis on overall business objectives and on the use of qualitative information is echoed in the detailed case studies undertaken by the authors as a component of the wider project on which this survey was a part (Abreu et al, 2009).

It is possible to cross classify whether or not firms believe that their interactions taken as a whole with HEIs had a significant impact on their activities by innovative behaviour, growth and the intellectual discipline interacted with. Exhibit 6.22 reveals a number of interesting results. Innovators are much more likely than non-innovators to report that interactions had a significant impact on their activities and this is true in relation to each of the dimensions on which impact might be assessed. Thus, even though we saw earlier that innovators were less likely than non-innovators to regard interactions as successful in relation to several specific primary and support activities, they were able to identify wider beneficial impacts than non-innovative firms. This is consistent with our earlier speculation that the result for specific technical or innovation activity cases may reflect inherently riskier or more challenging requirements.

Exhibit 6.22 Impact of interactions by innovation, growth and discipline categories: overall impact and mode of assessment (% of interacting firms)

	Have the interactions with HEIs, had a significant impact on your firm's activities?		In assessing impact do you use measures related to:									
			N (un-weighted)	Technical objectives		Investment objectives		Wider business objectives		Qualitative information		N (un-weighted)	N (weighted)
All	25.4		595	33.9		14.7		50.5		35.2		581	68,494
Innovation													
Non-innovators	9.8		178	15.9		8.5		32.1		25.5		176	22,753
Innovators	33.3	**	408	43.4	**	17.9	**	59.4	**	40.0	**	398	44,896
Growth category													
Stable/Declining	21.7		182	32.7		12.7		48.7		34.0		180	21,629
Medium growth	26.1		139	26.5		14.1		43.4		33.3		132	13,679
Fast growth	27.5		164	39.9	*	17.6		52.0		42.6		162	20,472
Discipline (Firms can use more than one discipline)													
Engineering and Materials science	32.3	**	219	57.2	**	17.5		57.6	**	40.6	*	220	22,929
Biology, Chemistry, Veterinary science	37.7	**	96	60.0	**	23.3	**	68.3	**	48.3	**	94	8,283
Health sciences	54.3	**	40	42.4		21.2		73.5	**	64.7	**	39	4,611
Physics, Mathematics	33.7	**	127	45.5	**	23.8	**	52.5		46.5	**	128	14,011
Architecture/ Building/ Planning and Urban design	30.0		100	45.3	**	13.3		55.4		36.0		98	10,339
Economics and social science	34.9		53	28.6		18.6		67.4	**	50.0	**	52	5,882
Business and financial studies	29.0		178	26.7	**	17.7		61.5	**	46.2	**	175	18,015
Arts and Humanities	31.2		113	26.3	*	11.6		61.1	**	44.2	*	114	13,120

Thus 33% of innovators compared with 10% of non-innovators reported that interactions had had a significant impact on their firms' activities. A further 43% of them reported having assessed the impact in relation to technical objectives, and 59% did so in relation to wider business objectives. Finally, 40% of them used qualitative information in their assessment. Each of these proportions is both quantitatively and statistically significantly higher than is the case for non-innovators. In relation to growth categories, it appears that fast growth companies are more likely to report positive interactions and they do so consistently across all dimensions. However, none of the differences are statistically significant, except in relation to technical objectives where the fast growing companies are moderately statistically significantly more likely to assess impact using technical measures than is the case with stable, declining and medium growth firms.

When we turn to analysis by discipline, it appears that firms that report having an important interaction with health sciences are more likely than other businesses to report a significant impact in their activities as a whole. Thus, 54% of such firms report this to be the case. Variations in this respect across other disciplines in the science, arts and humanities and social sciences are much less marked. As might be expected, technical objectives occur much less frequently as measures of assessing impact in those areas where businesses interact with economics and social science, business and financial studies and arts and humanities. In the case of biology, chemistry and veterinary science, technical objectives are cited in 60% of the responding businesses and in 57% of cases for engineering and materials sciences interactions. Wider business objectives are cited by 60% of firms in interactions involving physical sciences and in economic and social sciences, businesses and financial studies and the arts and humanities.

Qualitative information is used in the majority of cases of businesses interacting with economics and social sciences and health sciences and in most cases the frequency lies within the 40-50% range. Only in the case of architecture, building and planning and urban design do a minority of firms cite the use of qualitative information in assessing impact. In this case the percentage is 36%.

It thus appears that even when impact is assessed in relation to technical objectives, qualitative information plays an important part in the assessment of the overall impact of the interactions that businesses have with the higher education sector. It does not appear to be the case that narrow investment related objectives are important in their analysis. Indeed, in every case measures for assessing impact in relation to meeting the investment objectives of firms is the lowest category of response. In all cases wider business objectives are more frequently asserted than technical objectives. The gap between these two is narrow in engineering and materials sciences and biology, chemistry and veterinary science, but it is much wider in relation to economics and social science, business and financial studies and the arts and humanities. This suggests that in discussions of the way in which the impact of university activities on the business sector might best be measured, it is important to take into account that the firms themselves use criteria which differ across disciplines.

Moreover, in all cases qualitative information and wider business objectives are an extremely important part of businesses' own assessment. A narrow focus on technical objectives is not dominant when viewed across the whole range of possible impact assessment criteria, although, as might be expected, it is more important in relation to engineering and the physical sciences more generally.

Finally, we may look at pattern of interactions and assessment of impact by industrial sector. This is done in Exhibit 6.23. The first point to note is that 44% of respondents in manufacturing reported that their interactions taken as a whole had a significant impact on their firms' activities. This was much higher than any other sector. The difference between manufacturing and the others is also statistically significant. Manufacturing enterprises were also more likely to assess impact in relation to technical objectives and wider business objectives and less likely to report the use of qualitative information. The use of qualitative information was much higher in business services than in any other sector. In all sectors, wider business objectives are more frequently cited than technical and investment objectives. As with our discussion of the impact across disciplines, this points to the need to think in a differentiated way across sectors in assessing both the kind of impact that firms expect from their interactions and the way in which they will choose to assess them.

Exhibit 6.23 Impact of interactions by sector: overall impact and mode of assessment (% of interacting firms)

	Have the interactions with HEIs, had a significant impact on your firm's activities?	In assessing impact do you use measures related to:							
		N (weighted)	N (un-weighted)	Technical objectives	Investment objectives	Wider business objectives	Qualitative information	N (un-weighted)	N (weighted)
All	25.4	70,126	595	33.9	14.7	50.5	35.2	581	68,494
Sector									
Manufacturing	44.3	12,292	133	47.1	20.0	57.6	31.8	131	11,756
Wholesale/Retail	17.8	16,354	144	38.8	23.3	51.3	32.8	142	15,985
Business services	22.5	26,400	211	31.7	9.6	51.9	46.0	202	26,116
Other	23.0	15,080	107	23.0	10.0	41.0	22.0	106	14,637
	**			**	**		**		

Section 7 Constraints

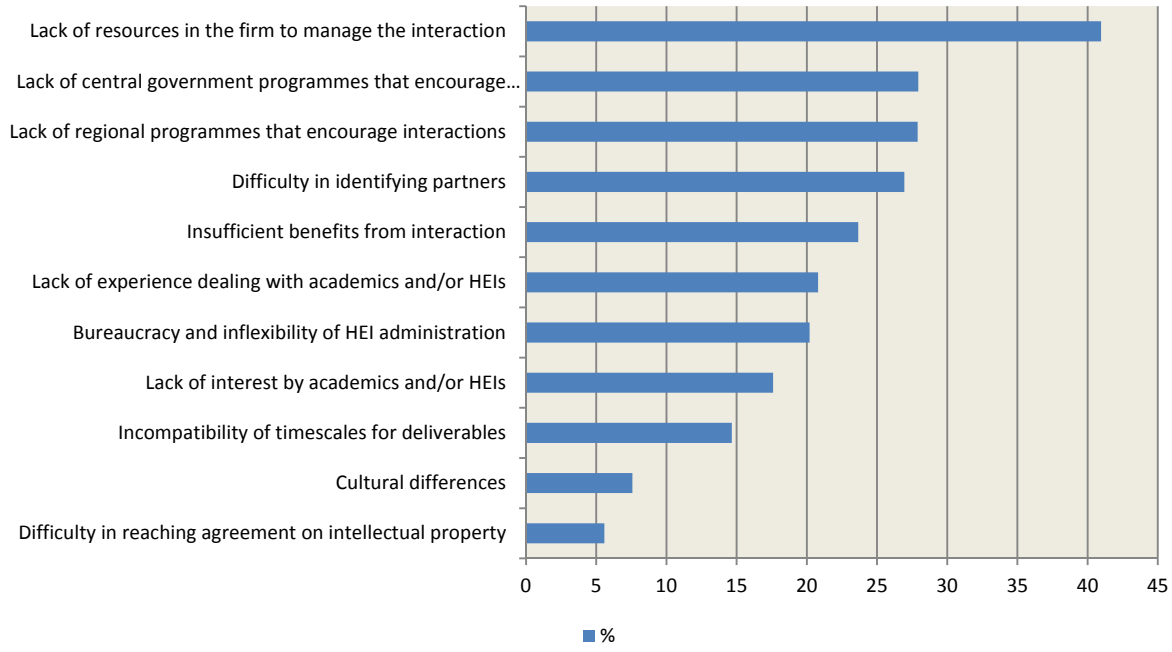
In this section we analyse factors which enterprises report as constraints on interactions with HEIs. Our initial focus is on those firms which interacted in the three years prior to the survey. We consider, for those firms, not only the constraints affecting their interaction activity, but also the extent to which they believe those constraints have changed in the last three years. We then turn to an analysis of the reasons why non-interacting firms have not engaged with HEIs in the last three years.

Constraints reported by Interacting Enterprises

The firms which completed the survey were asked to identify whether or not their interactions had been constrained by a number of factors relating both to their own capabilities and attitudes and to those of the higher education institutions and academics with whom they interacted. They were also asked about possible constraints arising from inadequate policy at regional or national level. The interacting firms were also asked whether a particular constraint which they had experienced had become more or less important over the three years within which their interactions had occurred.

Exhibit 7.1 shows that firms were most likely to report that their interactions had been constrained by a lack of their own resources to manage the interaction. This was reported by 41% of interacting firms. The next most frequent constraints reported were a lack of central and regional government policy to encourage interactions which were reported in 28% of the cases. These constraints were closely followed by difficulty in identifying partners, insufficient benefits from the interaction, lack of experience in dealing with academics and/or HEIs and bureaucratic inflexibility in HEI administrations. It is interesting to note that incompatibility of time scales for deliverables, cultural differences and difficulty in reaching agreement on intellectual property were the least frequently cited constraints. This suggests that arguments based on these particular reasons for incompatibility between business and universities in knowledge exchange are overstated. In the case of difficulty in reaching an agreement on intellectual property, it is important to note, however, that this is likely only to be a perceived constraint in areas where intellectual property is an important part of the interaction. As we have seen in earlier discussions of the nature of business interactions with HEIs, this is likely to be the case only in a small number of interactions. The relatively low proportion reporting constraints from this source could therefore be a reflection of the rather narrow group of enterprises involved in IP related interactions. As a check on this we divided our sample of interacting firms into those who had either acquired patents or licensed from an HEI in the past three years or had collaborated with a spin-out formed by an HEI to exploit research.

Exhibit 7.1 Constraints on interactions with HEIs in the last three years (% of interacting firms)



Non-interacting firms N (un-weighted)=580; N(weighted=69,439

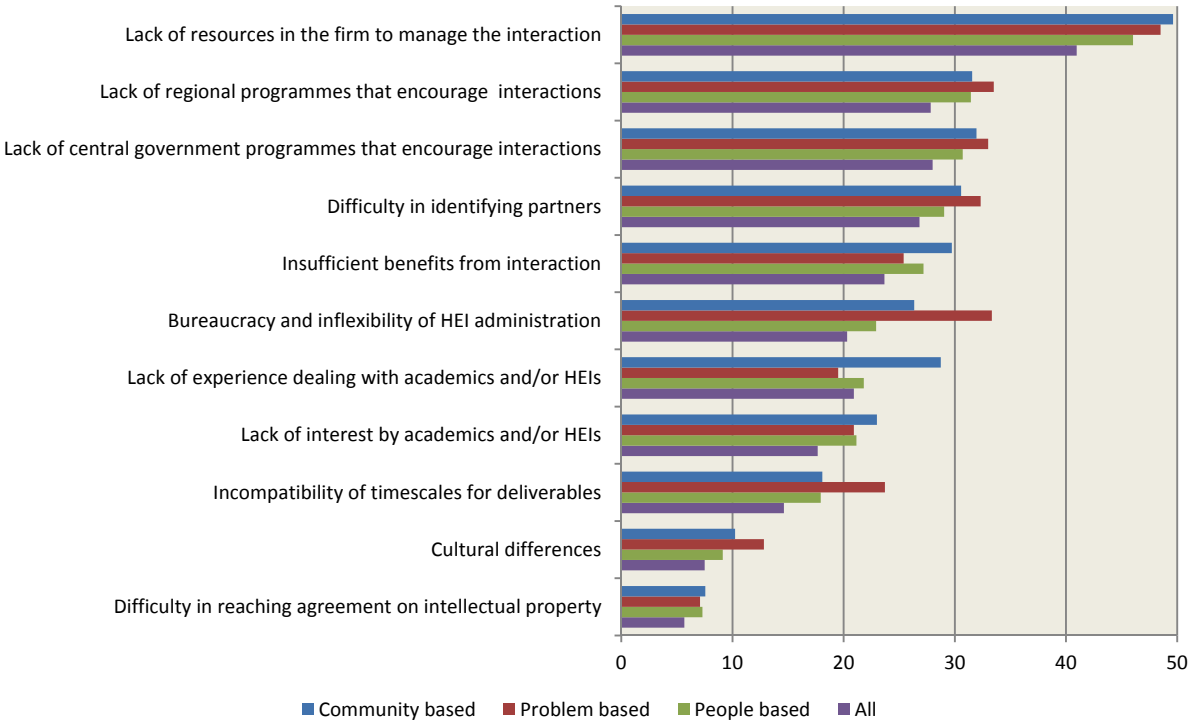
A comparison of the constraint experience of these groups of firms with those interacting firms who had not been so involved is shown in Exhibit 7.2. This confirms that relatively few firms in the sample are involved in these IP linked activities (20 firms had patent or licensing activity and 40 had collaborated with an HEI spin-out). It also confirms, however, that a higher proportion of each of those two groups was likely to report constraints arising from difficulty in reaching agreement on IP compared with enterprises which did not engage in the respective activity. The active groups were also significantly more likely to report cultural differences and incompatible time-scales, HEI bureaucracy and lack of central government policy support. Thus, whilst for the generality of interacting firms culture, time-scales and IP difficulties are rare, they do matter a great deal for firms with specific involvement in IP related activities. Even for these firms, however, lack of internal resources remains in a dominant position as a constraint.

Exhibit 7.2 Constraints on interactions with HEIs in the last three years by IP related activity (% of interacting firms)

		Acquisition of patents and licences owned by HEIs			Collaboration with a spin-out firm formed by an HEI to exploit research		
Category	All	Never	At least once		Never	At least once	
Cultural differences	7.5	7.8	36.4	**	7.9	13.3	
Incompatibility of timescales for deliverables	14.6	15.7	36.4	*	15.5	26.7	
Insufficient benefits from interaction	23.7	27.1	9.1		25.7	41.4	*
Bureaucracy and inflexibility of HEI administration	20.3	21.1	63.6	**	20.9	40.0	**
Lack of interest by academics and/or HEIs	17.7	19.1	36.4		19.5	17.2	
Lack of resources in the firm to manage the interaction	41.0	44.4	54.5		44.0	53.3	
Difficulty in identifying partners	26.8	29.3	54.5	*	29.5	34.5	
Lack of experience dealing with academics and/or HEIs	20.9	23.0	9.1		22.4	27.6	
Difficulty in reaching agreement on intellectual property	5.7	5.3	36.4	**	5.8	10.0	
Lack of central government programmes that encourage interactions	28.0	30.2	72.7	**	30.0	46.7	*
Lack of regional programmes that encourage interactions	27.8	30.6	50.0		29.9	46.7	*
N (un-weighted)	580	500	20		476	44	
N (weighted)	69,439	60,629	1,499		58,014	4,114	

The experience of different kinds of constraints may, more generally, be related to the type of interaction in which a firm is involved. Exhibit 7.3 provides, therefore, an analysis of constraints where firms are grouped by whether they had interaction based on people, problems or community activities.

Exhibit 7.3 Constraints on interactions with HEIs in the last three years by type of interaction (% of interacting firms)



All N (un-weighted)=580; N (weighted)=69,439

Firms may appear in more than one of these groupings. The first point to note is that the pattern of constraints is broadly similar across each group with lack of firm resources at the top and cultural differences and IP at the bottom. Some differences do, nonetheless, emerge. Thus statistically significant *and* quantitatively significant differences emerge in relation to cultural differences, incompatibility of timescales and bureaucracy in HEIs. In these cases those involved in problem solving are more likely to report constraints. Lack of internal resources and lack of experience are relatively more frequently cited by those involved in community based interactions. This latter finding suggests that community based activities may be relatively unfamiliar and may be less readily justified in resource terms than other interactions.

Exhibit 7.4 provides an analysis of constraints by size of firm. In each size class, and particularly amongst large firms, lack of resources in the firm to manage the interaction is the dominant feature. The differences across the size classes are statistically as well as quantitatively significant. Difficulty in identifying partners and lack of government schemes at central and regional level remain highly ranked in each size class. In the case of difficulty of identifying partners, small and large firms report this more frequently than the other size classes, but the differences are not statistically significant. Lack of experience in dealing with academics and/or HEIs is cited as a constraint more frequently by medium and large businesses, and the difference is quantitatively and statistically significantly different from the proportion reporting this as a constraint in micro- and small firms. This is a somewhat surprising result since it implies that given the kind of interactions in which micro- and small businesses are involved in dealing with HEIs, they report fewer constraints. The higher proportions for medium and large firms reporting the constraints may therefore reflect different types of interaction or may be due to these enterprises beginning types of interaction with which they have not previously been involved. This finding requires further analysis to elucidate the factors lying behind the differences.

Exhibit 7.4 Constraints on interactions with HEIs in the last three years by firm size (% of interacting firms)

Category	All	Micro	Small	Medium	Large	
Cultural differences	7.6	7.3	7.0	8.3	10.5	
Incompatibility of timescales for deliverables	14.7	15.2	14.3	16.9	10.5	
Insufficient benefits from interaction	23.7	22.8	23.9	25.0	23.7	
Bureaucracy and inflexibility of HEI administration	20.2	19.8	20.1	19.4	23.7	
Lack of interest by academics and/or HEIs	17.6	13.0	20.6	15.5	26.3	**
Lack of resources in the firm to manage the interaction	41.0	41.5	37.1	41.7	59.5	**
Difficulty in identifying partners	26.9	23.2	30.5	23.6	30.8	
Lack of experience dealing with academics and/or HEIs	20.8	15.2	17.8	33.3	40.5	**
Difficulty in reaching agreement on intellectual property	5.6	5.1	5.1	8.5	5.3	
Lack of central government programmes that encourage interactions	27.9	29.2	29.4	19.7	28.9	
Lack of regional programmes that encourage interactions	27.9	28.1	29.9	19.7	30.8	
N (un-weighted)	580	130	220	100	130	
N (weighted)	69,439	24,765	29,514	9,926	5,234	

Difficulties arising from lack of policy support appear to affect all sizes of firm. The somewhat lower tendency for medium-sized firms to report these as constraints is not statistically significantly different from the proportions reported by other size classes. There are few other differences across size classes which are quantitatively significant and none are statistically significant.

Exhibit 7.5 provides an analysis of constraints for firms grouped in terms of whether or not they carried out an innovation in the three years prior to the survey and their growth characteristics. It appears that innovators are more likely to report constraints than non-innovators. This is the case in each class of constraint. The difference in the percentages reporting difficulty in reaching agreement on IP are neither quantitatively nor statistically significant. All of the other differences are both. It is interesting to note that 49% of the innovating firms reported that they lacked the resources to manage the interaction. The broad rankings of constraints were, however, broadly similar to those reported by non-innovators and by firms as a whole. In particular, cultural differences and incompatibility in time scales remained at the bottom of the list as did difficulty in reaching agreement on IP.

The analysis in Exhibit 7.5 in terms of differences across growth categories of firms reveals that, in most cases, fast growth firms experienced higher frequencies of constraint. This was not the case in relation to a lack of experience in dealing with academics and/or HEIs where a lower proportion of fast growth firms reported this as a constraint compared to medium growers and where the differences across the size classes were statistically as well as quantitatively significant. Fast growth firms were the most likely to report difficulty in reaching agreement on IP. Medium and fast growers were also more likely than slow growers to report a lack of regional programmes and central government programmes. In the case of lack of experience and lack of regional programmes, these differences were statistically significant too. Once again, the pattern across constraints in each growth class was similar to that experienced for the sample as a whole.

Exhibit 7.5 Constraints on interactions with HEIs in the last three years by innovation and growth categories (% of interacting firms)

Category	All	Innovation			Growth			
		Non-innovators	Innovators		Stable/ Declining	Medium growth	Fast growth	
Cultural differences	7.5	2.2	11.0	**	5.9	5.8	7.7	
Incompatibility of timescales for deliverables	14.6	9.7	17.8	**	8.2	12.6	18.5	*
Insufficient benefits from interaction	23.7	16.0	28.7	**	22.4	22.3	26.8	
Bureaucracy and inflexibility of HEI administration	20.3	14.0	24.4	**	15.4	17.5	26.1	
Lack of interest by academics and/or HEIs	17.7	10.2	22.4	**	13.0	14.6	23.9	*
Lack of resources in the firm to manage the interaction	41.0	27.3	49.2	**	34.3	41.7	46.1	
Difficulty in identifying partners	26.8	11.2	36.7	**	26.6	28.2	28.9	
Lack of experience dealing with academics and/or HEIs	20.9	13.4	25.9	**	15.4	32.0	20.4	**
Difficulty in reaching agreement on intellectual property	5.7	4.8	6.1		2.4	5.9	11.1	**
Lack of central government programmes that encourage interactions	28.0	21.5	32.3	**	21.6	29.1	31.2	
Lack of regional programmes that encourage interactions	27.8	22.3	31.7	**	20.6	32.7	29.8	**
N (un-weighted)	580	178	399		180	134	162	
N (weighted)	69,439	25,809	42,914		23,417	14,282	19,759	

The sample firms had reported which disciplines had been most important in their interactions. We can therefore cross classify the experience of constraints by the academic discipline with which the firms were concerned. This is shown in Exhibit 7.6. In this exhibit the percentages of firms reporting a constraint in each discipline is tested for significant differences with the number of firms in general reporting that constraint. A number of interesting features emerge from the exhibit. It appears to be the case that firms who report interactions with economics and social sciences, business and financial studies and the arts and humanities are more likely to experience constraints in a number of dimensions than is the case with the sciences, mathematics and architecture, building, planning and urban design. Thus, in relation to the most important constraint (relating to lack of resources in the firm to manage the interaction), the proportions involving economics and social sciences and the arts and humanities are 59% and 60% respectively compared with 41% for enterprises as a whole. Firms interacting with these two disciplines are also much more likely to report constraints arising from a lack of interest by academics and/or higher education institutions and incompatibilities of timescales for deliverables. In

the latter case, the proportion of firms reporting such constraints is almost twice as high in economics and social sciences and arts and humanities as it is for all disciplines together. Even in the case of business and financial studies the percentage is 20% compared to 15% for firms as a whole. In the case of health sciences and architecture, building, planning and urban design, the smaller numbers of firms mean that the differences with all firms are not statistically significant. In relation to difficulty in identifying partners, business and financial studies scores relatively low and this is perhaps a reflection of the closer orientation to business of that aspect of the social sciences compared to economics and social sciences and the arts and humanities. The same is true of lack of experience of dealing with academics and/or HEIs where those interacting with economics and social science are twice as likely to report constraints as enterprises as a whole. The general pattern of the relative importance of factors remains broadly the same, however, across all discipline interactions with lack of resources in the firm to manage the interaction dominating in all cases. In architecture, building, planning and urban design, this factor is matched by constraints arising from a lack of central or regional government. Businesses interacting with architecture, building, planning and urban design are significantly more likely to report this constraint than enterprises in general but only at the 10% level.

It is also possible to examine the pattern of experience of constraints across sectors of business. The results are shown in Exhibit 7.7. The exhibit reveals very few quantitative differences in the percentages of firms reporting different kinds of constraint across the broad industrial sectors identified. None of the relatively small differences in the percentages reporting constraints by sector are statistically significant. The rankings of constrains within each sector is broadly the same as that for enterprises as a whole. It therefore appears that the pattern of constraints on interactions is not related to sectoral business characteristics at the level of aggregation used here.

Exhibit 7.6 Constraints on interactions with HEIs in the last three years by discipline (% of interacting firms)

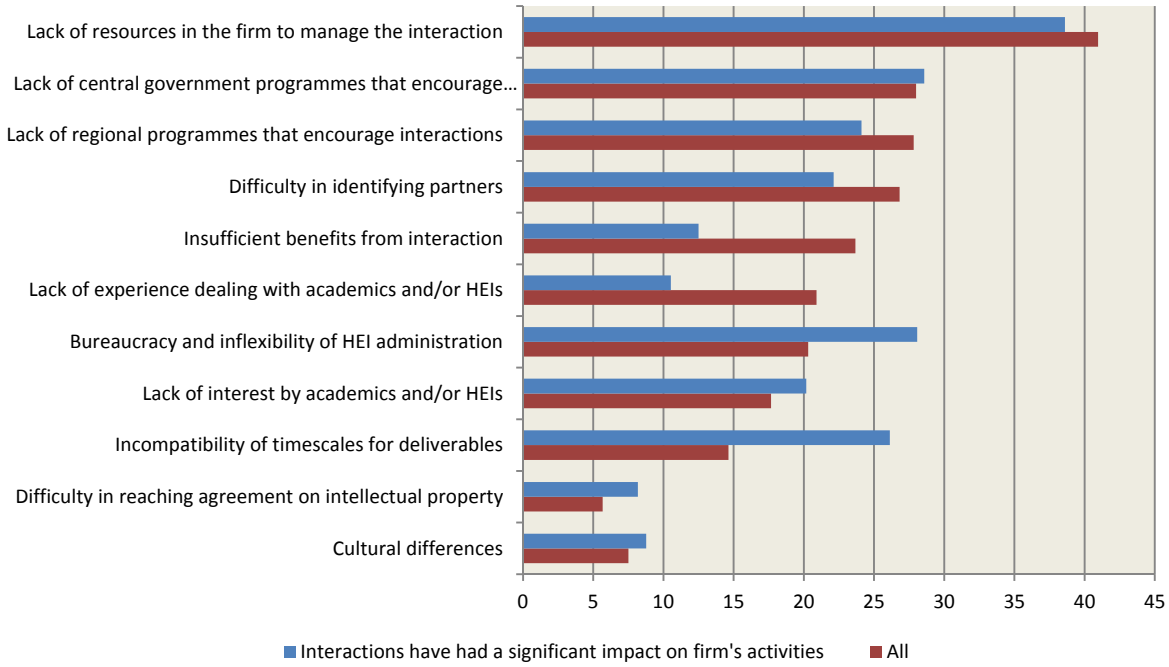
Category	All	Discipline (Firms can use more than one discipline)															
		Engineering and Materials science		Biology, Chemistry, Veterinary science		Health sciences	Physics, Mathematics		Architecture/ Building/ Planning and Urban design		Economics and social science		Business and financial studies		Arts and Humanities		
Cultural differences	7.5	10.9		10.3		9.1	12.1		5.3		14.3		8.0		11.1		
Incompatibility of timescales for deliverables	14.6	15.2		15.8		21.2	18.4		21.1		29.3	**	20.3	**	26.7	**	
Insufficient benefits from interaction	23.7	24.7		35.1	**	15.2	26.3		24.7		40.5	**	17.3	**	30.8		
Bureaucracy and inflexibility of HEI administration	20.3	24.5		26.8		21.2	26.8	*	18.2		29.3		19.6		33.7	**	
Lack of interest by academics and/or HEIs	17.7	17.8		25.0	*	18.2	19.6		15.6		31.7	**	11.6	**	30.3	**	
Lack of resources in the firm to manage the interaction	41.0	40.5		44.6		30.3	44.3		38.2		58.5	**	39.6		59.6	**	
Difficulty in identifying partners	26.8	31.1		34.5		31.3	21.6	*	23.4		38.1		21.7	**	29.2		
Lack of experience dealing with academics and/or HEIs	20.9	15.2	*	22.4		24.2	25.5		15.6		39.0	**	21.7		26.7		
Difficulty in reaching agreement on intellectual property	5.7	6.1		5.4		9.1	5.2		10.4		2.4		2.2	*	2.2		
Lack of central government programmes that encourage interactions	28.0	29.9		33.3		28.6	33.3	*	38.5	*	28.6		29.0		31.9		
Lack of regional programmes that encourage interactions	27.8	31.7		29.8		21.2	28.6		39.0	*	31.0		25.5		31.9		
N (un-weighted)		222		93		38	128		98		51		175		109		
N (weighted)	69,439	22,850		7,970		4,621	13,647		10,586		5,783		19,080		12,410		

Exhibit 7.7 Constraints on interactions with HEIs in the last three years by sector (% of interacting firms)

Category	All	Manufacturing	Wholesale/ Retail	Business services	Other
Cultural differences	7.6	13.3	6.3	9.8	1.0
Incompatibility of timescales for deliverables	14.7	16.7	15.3	13.9	14.0
Insufficient benefits from interaction	23.7	25.3	29.1	28.4	10.0
Bureaucracy and inflexibility of HEI administration	20.2	21.1	25.2	24.2	9.0
Lack of interest by academics and/or HEIs	17.6	18.9	21.8	20.2	9.0
Lack of resources in the firm to manage the interaction	41.0	46.7	44.1	42.6	31.0
Difficulty in identifying partners	26.9	31.1	34.2	30.6	10.0
Lack of experience dealing with academics and/or HEIs	20.8	20.0	23.6	22.5	16.0
Difficulty in reaching agreement on intellectual property	5.6	10.0	7.2	5.4	2.0
Lack of central government programmes that encourage interactions	27.9	27.5	29.7	30.0	24.0
Lack of regional programmes that encourage interactions	27.9	27.2	27.9	32.2	21.0
N (un-weighted)	580	134	134	209	103
N (weighted)	69,439	12,464	15,277	25,444	16,254

It is interesting to ask whether firms reporting successful impacts arising from their interactions were significantly less constrained than interacting firms taken as a whole. Exhibit 7.8 shows that enterprises with positive impacts achieved this despite the fact that a significantly higher percentage of them reported constraints arising from incompatibility of timescales and bureaucratic HEIs. As might be expected these "successfully interacting" firms were significantly less likely to be constrained by insufficient benefits. They also were less likely to report constraints arising from lack of experience. Taken together these results suggest that timescales and bureaucracy matter, but can be overcome and that past experience may help this. Benefits could no doubt be greater still if these constraints were addressed by the interacting parties.

Exhibit 7.8 Constraints on interactions with HEIs in the last three years by impact of interaction (% of interacting firms)



All N (un-weighted)=580; N (weighted)=69,439

So far we have focused on the levels of constraints reported. Constrained firms were also asked to report whether or not constraints had improved, worsened or were unchanged in the past three years. Not all firms reported all constraints, therefore in Exhibit 7.9 we show a change analysis in relation to each specific constraint a firm had reported experiencing.

Exhibit 7.9 Changes in constraints in the past three years (% of constrained enterprises reporting whether constraints had improved, worsened or were unchanged)

Category	Constrained					
	Deteriorated	No change	Improved	Balance	N (un-weighted)	N (weighted)
Cultural differences	34.4	40.6	25.0	-9.4	48	4,533
Incompatibility of timescales for deliverables	9.8	67.2	23.0	13.1	74	8,458
Insufficient benefits from interaction	13.6	79.0	7.4	-6.2	112	11,345
Bureaucracy and inflexibility of HEI administration	26.3	67.1	6.6	-19.7	94	10,513
Lack of interest by academics and/or HEIs	20.0	66.7	13.3	-6.7	78	8,322
Lack of resources in the firm to manage the interaction	15.8	71.9	12.3	-3.4	162	20,227
Difficulty in identifying partners	5.4	87.0	7.6	2.2	110	12,784
Lack of experience dealing with academics and/or HEIs	10.3	73.5	16.2	5.9	81	9,342
Difficulty in reaching agreement on intellectual property	35.3	52.9	11.8	-23.5	31	2,317
Lack of central government programmes that encourage interactions	17.3	76.5	6.1	-11.2	116	13,550
Lack of regional programmes that encourage interactions	13.3	80.6	6.1	-7.1	122	13,513

The exhibit shows the percentage of firms reporting deterioration, the percentage reporting no change and the percentage an improvement in the three years preceding the survey. A fourth column shows the balance between deterioration and improvement and our discussion focuses on that. We note first, however, that, with the exception of cultural differences and difficulty in reaching agreement on intellectual property, in roughly three quarters of the cases firms which were constrained report no change or an improvement. In relation to balances, deterioration is reported in relation to lack of resources in the firm to manage interaction (which we have seen is already the most frequently cited constraint). The negative balance is, however, small. Much greater balances of worsening are reported in relation to difficulty in reaching agreement on intellectual property, and bureaucracy and inflexibility of HEI administration. As we have noted, the first of these is a constraint which is reported by relatively few businesses. The fact that this small number of businesses reports that the situation has worsened, means for this particular group of firms a relatively frequent constraint has got worse over the period. Bureaucracy and inflexibility of HEI administration is, in contrast, relatively frequently cited as a constraint, and also has a deteriorating balance. This raises important questions about the extent to which the increased emphasis in HEIs on the management of knowledge exchange has been associated with worsening rather than improving interactions between HEIs and businesses. The other balances were relatively small. The most quantitatively important positive balance relates to incompatibility of

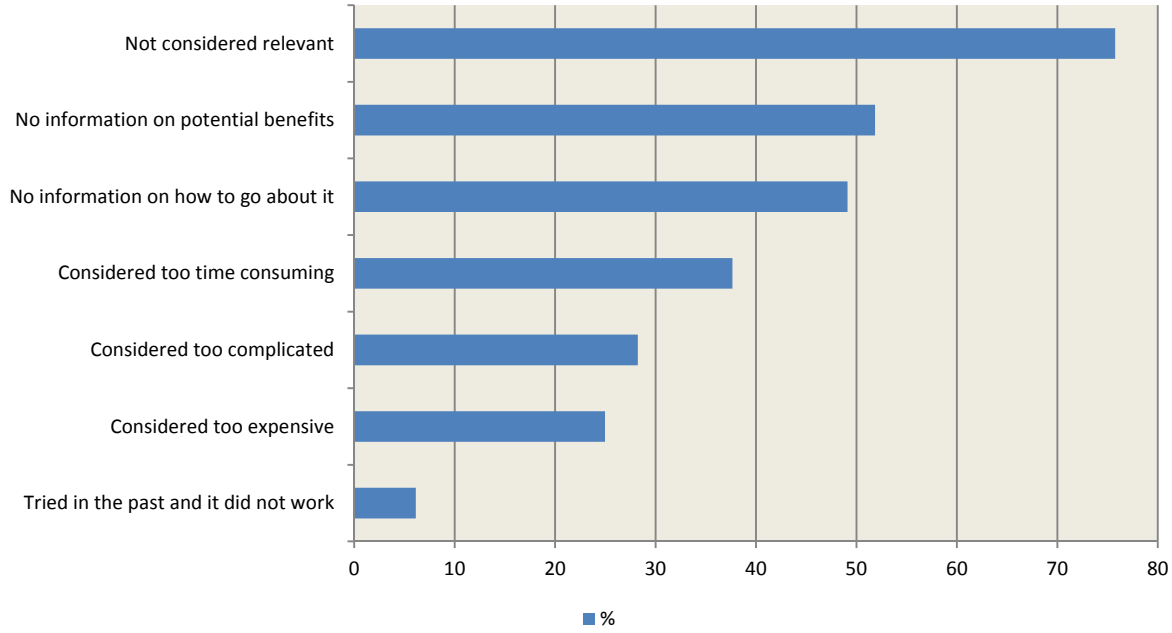
timescales for deliverables which suggests an increased compatibility in this respect over time between enterprises and HEIs which may reflect a positive impact of TTO and knowledge exchange management.

Reasons for not interacting with HEIs

So far we have considered constraints reported by firms that interacted. We now turn to consider the reasons that firms report for not having interacted with HEIs in three years prior to the survey. Businesses were offered seven potential reasons for not interacting. The first two related to a lack of information on potential benefits, or, on how to go about developing interactions. A third reason was associated with the interactions not being considered relevant whilst a fourth was that interactions were considered too expensive. Issues concerned with the time-consuming nature of interactions or their complicated process were offered as two further reasons. The final reason offered was that the interaction had been tried in the past and did not work. Firms could cite more than one reason.

Exhibit 7.10 reports the percentages of firms who indicated each of these reasons for non-interaction. By far the most important reason for not interacting is that the connection is not considered relevant. This was reported by 76% of all non-interacting firms. The next two most important reasons relate to a lack of information on potential benefits, or, on how to go about making the interaction. These two factors were offered by around a half of all the non-interacting firms. Over a third of the non-interacting firms reported that they considered it would be too time-consuming to make the interaction, whilst around a quarter considered it would be too expensive or too complicated. It is important to note that these views were not based to any great extent on having tried such interactions in the past and found that they did not work. An exceptionally small number of firms representing around 6% of the sample gave this as the reason. It does not appear, therefore, that a failure to interact is the result of a bad experience in the past. We should also perhaps not be surprised that such a significant percentage of firms reported that they did not consider the interaction relevant. This is quite consistent with the results reported in Section 3 on the small extent to which businesses in our sample rely on information from the science base as a source of knowledge for innovation. In this respect our results are consistent with a wide variety of related literature which suggests that universities are much less frequent sources of knowledge for innovation than producers in the same line of business, customers and suppliers. (*See for example* Cosh et al., 2006).

Exhibit 7.10 Reasons for not interacting with HEIs (% of non-interacting enterprises)



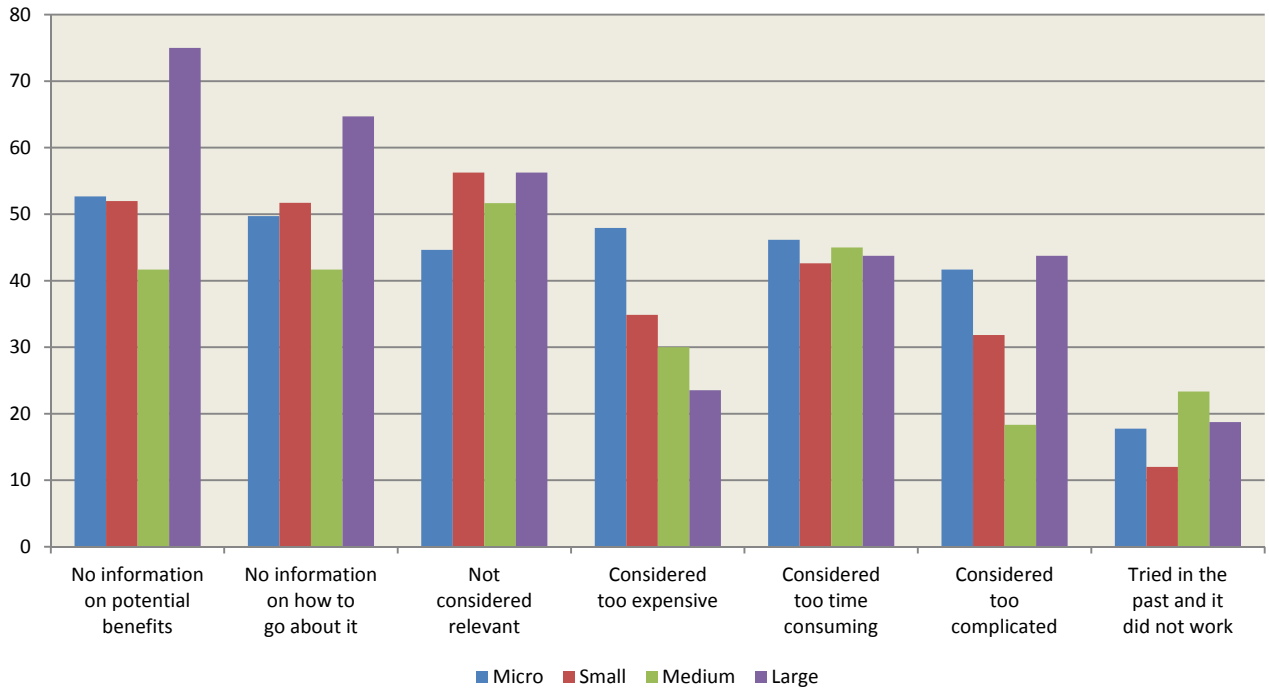
Non-interacting firms N (un-weighted)=1,593; N (weighted)=234,932

Exhibit 7.11 provides an analysis of reasons for not interacting by size of business. If we focus on lack of information on benefits or information on how to go about interacting, it is interesting to note that micro and small firms are the least likely to report these as a problem whilst for large firms 75% report no information on potential benefits and 64% report a lack of information on how to go about it. These differences across size classes are both quantitatively and statistically significant. The micro and small businesses are most likely to report that interactions are not considered relevant.

Taken together, these results present a picture in which it is possible to argue that smaller firms do not consider HEI interactions relevant and perhaps do not then go about finding information on benefits or on how to establish such relationships. They do not therefore report a lack of information in these areas, since they do not seek it as frequently, and do not consider it would be relevant to them. It is also possible that government support services already provide significant information flows in relation to potential benefits and methods of interaction to micro and small firms and that they, therefore, do not see any information gap in those two dimensions. Medium and large firms who have not interacted are more likely to report lack of information on potential benefits and on how to go about interactions despite fewer of them feeling it was not relevant.

Problems to do with the costly nature of interactions in terms of money or time and the complications of the process are somewhat more likely to be reported by micro and small firms than medium and large firms. This pattern would not be surprising given the ability of medium and large firms to spread the cost of interaction across a greater depth of financial and management expertise, but the differences are not statistically significant.

Exhibit 7.11 Reasons for not interacting with HEIs by firm size (% of non-interacting enterprises)



Non-interacting firms N (un-weighted)=1,593; N (weighted)= 234,932

It is possible to analyse the reasons for not interacting by the extent to which the non-interacting firms were innovators and non-innovators and by their growth category. The results of an analysis along these lines are shown in Exhibit 7.12. In general, in each of these potential cross-classifications of non-interacting enterprises, the principal reason remains that the firms did not consider the interaction relevant. Non-innovators were quantitatively and statistically significantly more likely to give this reason than innovators. Similarly, stable and medium growth firms were more likely to offer this reason than was true for fast growers. Innovators and fast growth firms are more likely than other firms to report that they lack of information on potential benefits or on how to go about interactions. This suggests that for this significant group of non-interacting firms, there may be gains to be had by exploring the reasons for the lack of information and the best ways in which it could be addressed.

Exhibit 7.12 Reasons for not interacting with HEIs by innovation and growth categories (%of non-interacting enterprises)

	No information on potential benefits	No information on how to go about it	Not considered relevant	Considered too expensive	Considered too time consuming	Considered too complicated	Tried in the past and it did not work	N (un-weighted)	N (weighted)
All	51.9	49.1	75.8	25.0	37.6	28.3	6.1	1,593	234,580
Innovation									
Non-innovators	48.6	46.0	79.0	26.2	38.0	29.7	6.1	989	145,054
Innovators	58.1	55.4	70.6	23.5	37.8	26.6	6.6	583	86,036
	**	**	**						
Growth category									
Stable/Declining	47.1	45.4	80.0	28.0	40.7	30.8	6.8	690	97,184
Medium growth	56.1	52.9	78.0	24.6	36.7	26.3	6.3	259	35,358
Fast growth	60.2	57.8	67.6	19.6	34.5	25.9	1.9	264	43,366
	**	**	**	**			**		

There are few other quantitatively or statistically significant differences in reasons for non-interaction across the categories analysed in Exhibit 7.12, except that we find stable and declining and medium-sized firms are somewhat more likely to consider interactions as being too expensive. This is consistent with them believing that they will not have future growth prospects which are sufficiently good to exploit the benefits of interaction. The other statistically significant difference is that stable and declining firms and medium growth firms are more likely to have tried an interaction in the past and report that it did not work as a reason for not interacting. However, the percentage of numbers of firms reporting this as a cause of non-interaction is extremely small.

Finally, in Exhibit 7.13, we examine the reasons why non-interacting enterprises did not engage with HEIs cross classified by sector. Once again, interactions not considered relevant is the dominant reason in all sectors and the broad pattern reported earlier for all firms also holds for all sectors. There are, however, for each reason for non-interaction some sectoral differences which are all statistically significant at either the 10% or 5% levels. Thus, we find that the wholesale/retail and business services sectors are more likely to report a lack of information on potential benefits than other sectors. This is also true for lack of information on how to go about interacting. These sectors may therefore be potential targets for information based policy development. Wholesaling and retailing and the “other” sector firms are also more likely to report a lack of relevance as a reason for not interacting. Manufacturing and business services firms are more likely to give the reason that the interaction would be too time-consuming. Manufacturing and “other” sector firms are more likely to report that they tried the activity in the past and it did not work, although here, once again, the percentage of firms reporting this as a reason is always 10% or less.

Exhibit 7.13 Reasons for not interacting with HEIs by sector (% of non-interacting enterprises)

	No information on potential benefits	No information on how to go about it	Not considered relevant	Considered too expensive	Considered too time consuming	Considered too complicated	Tried in the past and it did not work	N (un-weighted)	N (weighted)
All	51.9	49.1	75.7	25.0	37.6	28.3	6.1	1,596	234,932
Sector									
Manufacturing	49.1	46.5	75.8	29.3	44.2	34.2	8.6	319	37,121
Wholesale/Retail	54.4	49.8	78.6	23.6	33.5	26.9	6.5	503	63,991
Business services	55.6	54.5	70.2	21.9	39.8	24.8	2.1	342	58,975
Other	48.0	46.0	77.5	26.0	36.0	29.0	8.0	432	74,845
	*	**	**		**	**	**		

Concluding Remarks

Universities, and the academics within them, are facing increased demands to demonstrate the economic and social value of their research and teaching. Historically, universities have played an important role in supporting economic growth by educating workers and generating ideas. Now this role is not only to the fore – but has to be measured and directed.

The evidence in this report systematically shows a number of dimensions to the widespread extent of engagement between academia and businesses in the UK. First, knowledge exchange includes technology transfer through patents, licences and spin-outs; but it also includes more widespread mechanisms which include people based, problem solving and community orientated activities. Second, businesses connect to academics from all disciplines – not just those in science and engineering. Third, businesses connect for a range of reasons – many not directly concerned with innovation - to improve performance and strategy. Fourth, the main constraints that hinder or limit the knowledge exchange process include insufficient internal capability to manage relationships; problems concerning cultural differences between academics and business and disputes concerning IP are not frequently cited by businesses.

The extent of knowledge exchange in the UK suggests that the notion of an 'ivory tower' is a myth (Hughes and Kitson, 2012). But improving the breadth and depth of knowledge exchange has the potential to generate further economic and social benefits. In particular, improving the 'boundary spanning' function that improves the connectivity of academics with businesses – as well as the public and third sectors – should improve the 'impact' of academic research. As this report has shown, connecting to academia is a particular challenge for many businesses - especially SMEs who frequently lack the internal capacity to engage. Furthermore, an important feature of boundary spanning is to improve the flow of information; as businesses often do not know how to connect with academia or understand the benefits that may follow from such connections.

But there is also a need for caution in embracing the impact agenda. Improving the connectivity between businesses and academia will not have an immediate impact on economic growth as this will take time to emerge. Moreover, there may be limited capacity for substantial increases in knowledge exchange in some areas as academics report increasing pressures on their time to fulfil their various responsibilities. Most importantly, much of the increased focus on the role of universities to improve economic growth could undermine the very foundations on which the success of universities in the UK has been built. Many ideas that do generate economic growth emerge on the shoulders of basic research and the pursuit of fundamental understanding. It is very difficult, if not impossible, to predict how and when basic research will improve the standard of living and the quality of life. Although it is certain that if such research is not undertaken its impact will be zero.

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Annex 1 Survey Management, Database Construction, Response Bias Analysis and Weighting Procedure of the Business Competitiveness and Education Survey

Anna Bullock and Isobel Milner[3]

1. *Sampling Design and the Regional Allocation of the Sample*

The sample size for the survey was calculated to enable us to obtain an accurate estimate of university-business links in each of the 12 regions and nations of the UK. The population of firms for each region was taken from the "UK Business: Activity, Size and Location 2005" report, published by the Office of National Statistics (ONS). We began with a regional allocation to ensure that there would be enough regional variation in the data.

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 (Q16). This question captures a broader range of interactions with universities than a question on universities as co-operation partners for innovation (Q18), which gives a proportion of 0.05. The sample size required to obtain a given level of accuracy increases with the proportion and is highest at 0.50, at which point the variability in the population is at its maximum. We therefore took a conservative approach in using the relatively high value of 0.25 of Q16 rather than the lower value of 0.05 of Q18.

The calculation also uses an acceptable margin of error (or required precision) of 0.05, and the confidence level is set at 95% (implying a z-value of 1.96). The expected response rate was based on previous surveys carried out by the research team at the Centre for Business Research, and was set at 15%.

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:

[3] The sampling design methodology was developed by Maria Abreu and Vadim Grinevich who were respectively Research Fellow and Junior Research Fellow working on the ESRC project of which this survey was a part.

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

where n is the adjusted sample size, and N is the population size.

The required sample size based on these calculations is 22,800 (see Table 1). We decided to increase the total sample to 23,300 firms to provide a margin for other attrition factors due to errors in addresses and other descriptors in the sampling framework database.

Exhibit A1 Required sample size based on regional population estimates

	N	p	Z	Required precision	Required achieved sample before correction	Required achieved sample after correction	Assumed response rate	Required total sample size
London	36867	0.25	1.96	0.05	288	286	0.15	1906
South East	52011	0.25	1.96	0.05	288	287	0.15	1910
South West	29183	0.25	1.96	0.05	288	285	0.15	1902
East of England	33841	0.25	1.96	0.05	288	286	0.15	1905
East Midlands	21862	0.25	1.96	0.05	288	284	0.15	1896
West Midlands	28243	0.25	1.96	0.05	288	285	0.15	1901
Yorkshire and the Humber	25136	0.25	1.96	0.05	288	285	0.15	1899
North East	10455	0.25	1.96	0.05	288	280	0.15	1869
North West	34228	0.25	1.96	0.05	288	286	0.15	1905
Wales	13649	0.25	1.96	0.05	288	282	0.15	1881
Scotland	24228	0.25	1.96	0.05	288	285	0.15	1898
Northern Ireland	9686	0.25	1.96	0.05	288	280	0.15	1866
Total	**319389**					**3411**		**22739**
Rounded up								**22800**

2. *Sampling Design: Allocation across sectors and size classes*

To allow for sectoral and size variations in the sample design we needed to distribute the 23,300 firms in the sampling frames for the 12 regions across 23 sectors and 5 size classes (5-9, 10-49, 50-249, 250-999, 1000+).

We used the Neyman[4] optimal allocation method to allocate the sample to sectors and size classes within each region. With this method a stratum which is large or has a large within-stratum variance

[4]See for example http://srmo.sagepub.com/view/encyclopedia-of-survey-research-methods/n324.xml

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 vis-à-vis the variance for firms with 10-49 employees taken from the 2004 CBR Small and Medium-Sized Business Survey.

The formula used for the Neyman allocation method was:

$$n_h = \frac{n(N_h S_h)}{\sum_{i=1}^{H} N_i S_i}$$

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 census was taken for firms with more than 1,000 employees because of the low numbers of firms in this category of the business population.

An initial pilot survey was carried out. The pilot survey instrument was sent to 200 firms on 13/6/08. The firms were independent, split by sector into manufacturing and business services and split into two employment sizes: 10-49 and 50-259, giving four groups. Fifty questionnaires were sent to each group. Nine completed questionnaires were returned. As a result the layout of one of the questions was altered, where having the question presented over two columns meant that some respondents had missed options on the right hand column. These 200 firms were drawn before the larger, main sample. When the main sample was received, we checked to see if any of the firms from the pilot stage were included in it. Eleven firms were found in both samples and so were excluded from the main survey.

During the administration of the survey it was discovered that due to an error in supplying the proprietary database names and contacts from the sampling frame database businesses attributed to the North East had in fact been drawn from North West. To correct for this, a further sample of North East firms was drawn and surveyed in early 2009. This additional sample of 1807 firms raised the final sample size to 25015 firms.

3. Survey

The survey was carried out from July 2008 to February 2009.

Exhibit A2 shows the survey response pattern. There were 2,551 responses for an overall response rate of 11.3%. This is an acceptable response for business surveys but lower than the 15% response rate estimated in the sampling design. Since there were only 11 responses from the mining and quarrying sector and 9 from the utilities sector it was decided to exclude these from the analysis to avoid possible small sample biases in grossing up results to population estimates. A further response was also excluded as its survey return made its identity for classification purposes untraceable.

Exhibit A2 HEI Project - Survey response

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 later removed from the final analysis; 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 totals; 1 return was excluded as the identity of the respondent could not be established from the survey return.

Exhibit A3 shows the 2,530 final responses by sector and size and Exhibit A4 by region.

Exhibit A3 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

The response rate of 11.3% meant that regional sample sizes shown in Exhibit A4 are somewhat lower than required by the sample design. However the loss of precision as a result of this is small and the samples are compatible with setting a precision level of .06 as opposed to .05 in Exhibit A1.

Exhibit A4 Region (No. of firms)

	N
Scotland	200
North East	200
Yorkshire and the Humber	221
North West	349*
West Midlands	236
East Midlands	224
East Anglia	195
Wales	193
South West	236
South East	190
London	127
Northern Ireland	159
Total	2530

*See footnote 2 above

4. Response Bias Analysis

Three sets of response bias analysis were undertaken:

1. Responses versus the sampling frame.
2. Responses by response wave.
3. Comparing the CBR survey with CIS4 analysis for potential bias towards replies from innovation active firms.

Response bias analysis versus the sampling frame

Exhibit A5 shows that there is evidence that larger firms were somewhat less likely to respond to the survey than smaller firms. However Table 6 shows that this had no significant effect on the median size of respondents compared to non-respondents.

Exhibit A5 Employment cut (sampling) by response group

Employment	Response		Non response		Absolute difference	% difference	All	
	(%)	*(N)*	(%)	*(N)*			(%)	*(N)*
5-9	39.5	*1,007*	39.9	*7,953*	0.4	1.1	39.9	*8,960*
10-49	42.4	*1,081*	38.5	*7,675*	3.9	9.9	39.0	*8,756*
50-249	8.1	*207*	8.1	*1,623*	0.0	0.4	8.1	*1,830*
250-999	4.9	*124*	5.8	*1,148*	0.9	15.9	5.7	*1,272*
1000+	5.2	*132*	7.7	*1,527*	2.5	33.7	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)

Exhibit A6 Employment size - Mann-Whitney U test

	Median value
Response	12
Non response	12

No statistically significant difference.

Exhibit A7 shows that there is no sectoral bias in the response rate. There is, however, some variation by region with Exhibit A8 revealing somewhat lower response rates from London and higher response rates in the West and East Midlands and the South West.

Exhibit A7 Sector (sampling) by response group

Sector	Response		Non response		Absolute difference	% difference	All	
	(%)	*(N)*	(%)	*(N)*			(%)	*(N)*
Manufacturing	20.3	514	18.5	3,667	1.8	9.5	18.7	4,181
Construction	14.2	360	11.4	2,263	2.8	23.7	11.8	2,623
Wholesale/Retail	28.5	722	26.4	5,217	2.2	8.1	26.6	5,939
Hotels	5.3	135	9.3	1,834	3.9	44.6	8.8	1,969
Transport, Storage and Communications	5.4	137	5.6	1,112	0.2	3.7	5.6	1,249
Business and other services	26.2	663	28.8	5,699	2.6	9.1	28.5	6,362
All	100.0	2,531	100.0	19,792			100.0	22,323

Statistically significantly different at 5%

Exhibit A8 Region by response group

Region	Response		Non response		Absolute difference	% difference	All	
	(%)	*(N)*	(%)	*(N)*			(%)	*(N)*
Scotland	8.0	*203*	7.6	*1,521*	*0.4*	*5.2*	7.7	*1,724*
North East	7.9	*201*	7.2	*1,436*	*0.7*	*9.6*	7.3	*1,637*
Yorkshire and the Humber	8.7	*222*	8.0	*1,588*	*0.7*	*8.6*	8.1	*1,810*
North West	13.8	*352*	14.8	*2,945*	*1.0*	*6.8*	14.7	*3,297*
West Midlands	9.3	*237*	7.8	*1,553*	*1.5*	*18.8*	8.0	*1,790*
East Midlands	8.9	*226*	7.5	*1,503*	*1.4*	*18.2*	7.7	*1,729*
East Anglia	7.7	*196*	7.7	*1,543*	*0.0*	*0.0*	7.7	*1,739*
Wales	7.6	*194*	7.6	*1,522*	*0.0*	*0.0*	7.6	*1,716*
South West	9.3	*237*	7.7	*1,532*	*1.6*	*20.3*	7.9	*1,769*
South East	7.4	*190*	7.8	*1,553*	*0.4*	*5.1*	7.8	*1,743*
London	5.1	*131*	8.6	*1,706*	*3.5*	*42.7*	8.2	*1,837*
Northern Ireland	6.4	*162*	7.6	*1,524*	*1.2*	*16.0*	7.5	*1,686*
All	100.0	*2,551*	100.0	*19,926*			100.0	*22,477*

Statistically significantly different at 5%

Exhibit A9 shows that companies were somewhat more likely to reply and sole proprietors somewhat less likely to reply. Respondents were statistically significantly younger than non-respondents but Exhibit A10 also shows that actual difference in median age was very small.

Exhibit A9 Legal form by response group

Legal form	Response		Non response		Absolute difference	% difference	All	
	(%)	*(N)*	(%)	*(N)*			(%)	*(N)*
Sole proprietor	17.7	*452*	23.1	*4,595*	*5.4*	*24.0*	22.5	*5,047*
Company	66.3	*1,692*	60.8	*12,124*	*5.5*	*8.9*	61.5	*13,816*
Partnership	16.0	*407*	16.1	*3,207*	*0.1*	*0.6*	16.1	*3,614*
All	100.0	*2,551*	100.0	*19,926*			100.0	*22,477*

Statistically significantly different at 5%

Exhibit A10 Year of formation - Mann-Whitney U test

	Median value	Response	Non response
Response	1988		†
Non response	1990		

(†) indicates a 5% statistically significant difference (Mann-Whitney U test)

Response bias analysis by response wave

By comparing successive waves of respondents it is possible to detect possible response biases. Thus if later respondents who require prompting are more like non-respondents then a wave analysis should reveal differences across successive waves. Table 11 confirms our previous finding that the sample is not biased in terms of size since there is no difference between successive waves.

Exhibit A11 Employment size (as measured in the sampling frame) by response wave

Response wave	N	Mean Rank*
1st wave	559	1,312.8
2nd wave	1,219	1,253.1
3rd wave	752	1,250.5
All	2,530	

*Higher value gives higher mean rank

Kruskall-Wallis test: No statistically significant difference

Exhibits A12 and A13 reveal no differences between waves in terms of sector or region, Exhibit A14, however shows that HEI collaborators (defined as having a people based, problem solving or community based interaction with an HEI) were more likely to reply early, although by the final wave two thirds of respondents had no interactions with HEIs.

Exhibit A12 Sector by response wave

	Response wave				
	1st wave	2nd wave	3rd wave	All	N
Manufacturing	19.0	21.1	20.1	20.3	514
Construction	13.1	13.9	15.6	14.2	360
Wholesale/Retail	27.4	28.4	29.5	28.5	721
Hotels	4.3	5.6	5.7	5.3	135
Transport, Storage and Communications	5.0	5.7	5.2	5.4	137
Business and other services	31.3	25.3	23.9	26.2	663
All (%)	100.0	100.0	100.0	100.0	
All (N)	559	1,219	752		2,530

Pearson Chisquare test: No statistically significant difference

Exhibit A13 Region by response wave

	Response wave				
	1st wave	2nd wave	3rd wave	All	N
Scotland	7.2	7.1	9.7	7.9	200
North East	8.1	8.0	7.7	7.9	200
Yorkshire and the Humber	8.8	8.3	9.4	8.7	221
North West	14.3	13.2	14.4	13.8	349
West Midlands	8.4	9.1	10.4	9.3	236
East Midlands	8.6	8.9	8.9	8.9	224
East Anglia	8.8	7.7	6.9	7.7	195
Wales	6.1	8.8	6.9	7.6	193
South West	10.4	9.7	8.0	9.3	236
South East	9.1	7.3	6.6	7.5	190
London	5.0	5.1	4.9	5.0	127
Northern Ireland	5.4	6.8	6.1	6.3	159
All (%)	100.0	100.0	100.0	100.0	
All (N)	559	1,219	752		2,530

Pearson Chisquare test: No statistically significant difference

Exhibit A14 HEI collaborators by response wave

	Response wave				
	1st wave	2nd wave	3rd wave	All	
HEI collaborator answered yes qs: 11-13					
No	55.6	66.0	70.6	65.0	
Yes	44.4	34.0	29.4	35.0	**

Exhibit A15 shows that later waves were less likely to be innovators or to introduce new corporate strategies advanced management techniques or organisational changes. The later waves, however, contained high proportions of non-innovators in these dimensions. We therefore compared the innovativeness of our final sample with that of firms responding to the national innovation survey carried out by ONS. The results are shown in the next section.

Exhibit A15 Innovative activity by response wave

	Response wave				
	1st wave	2nd wave	3rd wave	All	
Q24. Is firm an innovator?					
No	44.7	54.1	58.9	53.4	
Yes	55.3	45.9	41.1	46.6	**
Q25. If an innovator how were innovations developed					
Mainly within firm or group	67.8	68.1	70.3	68.6	
Mainly with other firms	14.2	13.7	10.8	13.1	
Mainly adopted after development by other firms	18.0	18.1	18.9	18.3	n.s.
Q26. Has firm made any major changes in the following areas of business structure? Implementation of a new or significantly changed corporate strategy					
No	62.9	69.6	76.4	70.1	
Yes	37.1	30.4	23.6	29.9	**
Implementation of advanced management techniques such as knowledge management systems etc.					
No	82.4	83.6	85.2	83.8	
Yes	17.6	16.4	14.8	16.2	n.s.
Implementation of major changes to organisational structure such as setting up cross-functional-teams, outsourcing of major business functions					
No	78.8	80.0	83.9	80.9	
Yes	21.2	20.0	16.1	19.1	**
Implementation of changes in marketing concepts or strategies					
No	59.6	64.3	72.1	65.6	
Yes	40.4	35.7	27.9	34.4	**
Q27. Use of sources of information Higher Education Institutions					
Not used	60.9	65.5	66.2	64.7	
Used	39.1	34.5	33.8	35.3	n.s.

Checking for innovation and interaction bias by comparing with CIS

We compared the innovation characteristics of our survey sample with those of the separate sample surveyed by ONS in conducting the harmonised Community Innovation Survey for 2009 (CIS6). For this comparison innovation active firms are defined as essentially those reporting having carried out a product process logistics or business organisational innovation and in the case of ONS firms, those with R&D and/or abandoned or incomplete innovation projects. Exhibit A16 shows that the proportions of innovation active firms are very similar in the two samples so that our process of three prompts appears to have removed any bias arising from the likelihood of innovative active firms replying earlier.

Exhibit A16 Innovation activity

	CIS4 (06-08)	HEI Business Survey	
	Weighted on population of firms	Un-weighted sample	Firm count weighted sample
Per cent innovation active	58	62	59

5. Weighting procedure

Two sets of weights were created, one based on the number of firms in the population and one based on employment. These weights use the distribution of firms in terms of employment size, sector and region. To calculate the proportions of firms in each of these categories, data from the SME Statistics for the UK and Regions 2008 from the Department of Business Innovation and Skills (BIS) website was used.

In order to weight the survey up to population estimates the following groups were used

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

There were 11 completed returns from the mining and quarrying sector and 9 returns from firms in the utilities sector. These were excluded from the final data as it was thought there were too few firms to weight up to represent their sectors.

For the employment weights, the employment distribution by size and sector was calculated from the SME statistics using the sum of the employment totals in the sectors covered in our survey for the employment categories 5 and upwards.

In terms of region, the employment distribution was calculated using the sum of employment in the 'all employers' category minus the employment in the 1-4 employees category for the sectors covered in the survey.

The same method was used to calculate the distribution for the number of firms, using the equivalent data in the number of enterprises column on the SME statistics.

The distributions by size, sector and region calculated from the SME statistics are as follows.

Exhibit A17 HEI Business Survey Sample profile and Weighting Proportions

	Sample profile %	Firm count weighting %	Employment adjusted weighting %
Sector totals			
Manufacturing	20.3	15.8	18.6
Construction	14.2	12.7	7.1
Wholesale/ Retail	28.5	25.3	27.8
Hotels	5.3	12.4	9.8
Transport, storage and communications	5.4	5.4	9.4
Real estate, renting and business services	26.2	28.3	27.2
	100	100	100
Employment totals			
5-9	39.5	52.6	8.6
10-49	42.5	39.4	18.0
50-249	8.0	6.5	15.5
250+	10.0	1.5	57.9
	100	100	100
Region totals			
Scotland	7.9	7.2	7.0
North east	7.9	3.1	2.6
Yorkshire & the Humber	8.7	8.1	8.7
North West	13.8	10.7	9.3
West Midlands	9.3	8.7	8.4
East Midlands	8.9	7.2	7.8
East	7.7	9.6	11.2
Wales	7.6	4.1	2.8
South West	9.3	9.0	6.4
South East	7.5	14.6	14.0
London	5.0	14.5	19.7
Northern Ireland	6.3	3.4	2.3
	100	100	100

A rim weighting program (Ccount) was then used to calculate two sets of weights, for the number of firms and employment, to match the above proportions by size, sector and region.

UK~IRC Cambridge
University of Cambridge
Top Floor
Judge Business School
Building
Trumpington Street
Cambridge CB2 1AG

UK~IRC London
Imperial College Business School
Tanaka Building
South Kensington Campus
London
SW7 2AZ

Email: enquiries@ukirc.ac.uk
www.ukirc.ac.uk

uk-irc
UK-INNOVATION
RESEARCH CENTRE

NCUB
National Centre for Universities and Business

CBR

BIS
Department for Business Innovation & Skills

E·S·R·C
ECONOMIC & SOCIAL RESEARCH COUNCIL

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