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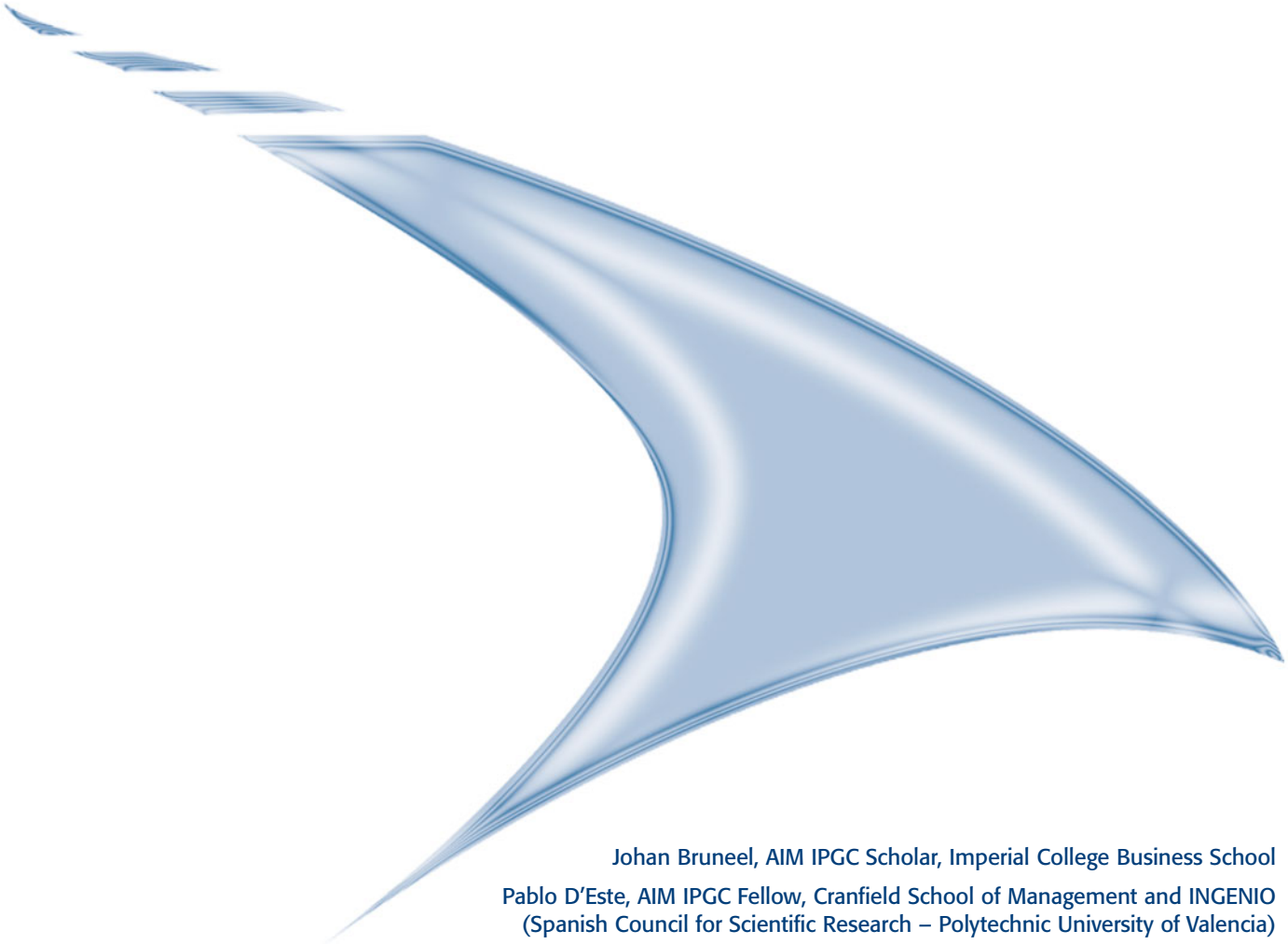
The Search for Talent and Technology

Examining the attitudes of EPSRC industrial collaborators towards universities



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Contents

INTRODUCTION 3

METHOD 5

ANALYSIS 9
- Factors influencing the decision to interact 10
- Extent of the use of outputs from universities 11
- Benefits of interacting with universities 12
- Barriers to interaction 14
- Most important universities for collaboration 17
- Contribution of business to universities 18

POLICY IMPLICATIONS 19
1. The Wealth of Diversity 19
2. Quality of interaction 19
3. Talent and technology 19
4. Increasing barriers 19
5. No shift to short-term benefits 20
6. Impact of Full Economic Costing 20

FUTURE RESEARCH 21

BACKGROUND OF THE STUDY 22
- Innovation and Productivity Grand Challenge 22
- Acknowledgements 22

REFERENCES 23

APPENDIX: 2004 AND 2008 SURVEY INSTRUMENTS 25
- Section A: General information on your company unit 25
- Section B: Type of interactions with university 25
- Section C: Incentives to interact with university 27
- Section D: Outcomes from university-industry interactions 28
- Section E: joint publications and university-industry interactions 29
- Section F: Barriers to interaction with university 30
- Section G: Other general information about your company unit 31
- Section H: Respondent details 32
- Your comments 32

AIM IPGC SURVEY OF INDUSTRY-UNIVERSITY COLLABORATION 33

Introduction

Increasingly universities are seen to be one of the key actors in national innovation systems (Bessant & Venables, 2008; Cosh, Lester, & Hughes, 2006; Etzkowitz, Webster, Gebhardt, & Terra, 2000; Lundvall, Johnson, Andersen, & Dalum, 2002). Firms reach out to universities as a source of knowledge and support for their innovative activities. They use universities as partners in collaborative research projects and as sites for recruiting trained and skilled problem solvers (Perkmann & Walsh, 2007; Salter & Martin, 2001). The movement of many firms towards more open and distributed models of innovation creates substantial opportunities for universities to increase the breadth and depth of their role in the innovation system (Chesbrough, 2003). Moreover, universities themselves have undergone considerable changes in terms of their systems of managing their intellectual property and industrial engagement. Governments have also given greater attention to the nature of interaction between universities and industry, seeking to harness the potential economic value of universities' knowledge and skills for economic development. Given this environment, it is an opportune moment to explore the nature of collaboration between universities and industry in the UK.

This report provides a window on the nature of collaboration by reviewing the results of a survey of industrial collaborators on Engineering and Physical Sciences Research Council (EPSRC) collaborative projects. The survey was undertaken in late 2007 and early 2008 and covers the entire population of firms that have collaborated on EPSRC collaborative research grants since 1999. The survey builds on and extends a previous survey of EPSRC industrial collaborators, conducted in 2004 by the Science Policy Research Unit (SPRU) at the University of Sussex. By combining the two surveys, we are able to compare changes in the nature and attitude of businesses towards their collaborations with universities from 2004 to 2008. We use this information to help understand the general environment for university-industry collaboration in the UK.

Since the EPSRC is the largest UK research council, providing £740 million in research funding in 2007, it represents a good mechanism to gain insight in the nature of university-industry links in the UK. EPSRC funding is concentrated in the engineering and physical sciences, spanning from the nano-level to the planet! EPSRC research projects focus on the development of new scientific and engineering knowledge and each project is judged through the peer review process on its scientific merit. A significant proportion of these projects involve industrial engagement and many of the projects focus not only on developing new knowledge, but also new ways to improve practice in industry.

The sample of businesses examined in this study is, however, not representative of the entire population of UK firms. Indeed, it is only a small share of UK firms that have a collaborative research project with universities. Results from the UK Innovation Surveys have shown that only a modest share of UK firms indicate that they rely on information from universities in their innovative activities (Laursen & Salter, 2004; Tether, 2002). Given this, the population of businesses analysed here are among the leading actors in engaging with the university sector, working closely with universities on common problems and challenges. Moreover, this population includes many firms with their own research activities in direct contrast with the vast majority of UK firms that do no formal Research and Development (R&D). Therefore, the sample of organisations investigated should be seen as firms with high levels of absorptive capacity for university knowledge and have the willingness and desire to overcome the institutional barriers that often confront university-industry collaborations.

This survey and others like it demonstrate the complex and varied nature of interaction between universities and industry (Abramovsky, Harrison, & Simpson, 2007; Agrawal, 2006; Agrawal & Henderson, 2002; Beise & Stahl, 1999; Cohen, Nelson, & Walsh, 2002; Henderson, Jaffe, & Trajtenberg, 1998; Klevorick, Levin, Nelson, & Winter, 1995; Meyer-Frahmer & Schmoch, 1998; Pavitt, 2001; Salter *et al*., 2001; Steinmueller, 1994). The channels that link universities and industries are diverse and different. Organisations will choose particular channels because they suit their needs and ambitions (D'Este & Patel, 2007; Perkmann *et al*., 2007). Moreover, the nature of the interaction is rarely episodic and firms often have to spend considerable managerial resources on successful work with universities. Collaborating with universities often requires patience and effort on the part of their industrial partners (Dasgupta & David, 1994; Stephan, 1996). For those firms that are willing to make the investment, considerable benefits are likely to flow. However, such benefits must be weighted against the costs of the interaction and the uncertain nature of the benefits.

The nature and type of university-industry interaction also differs by industry and the size of the firm (Arundel & Geuna, 2004; Cohen *et al*., 2002). Previous research has shown the university-industry interaction is greatest, as might be expected, in science-based industries, such as pharmaceuticals (Belderbos, Carree, & Lokshin, 2004). In other sectors, such as construction, the rate of interaction is much lower and often highly concentrated in the hands of the few leading firms (Klevorick *et al*., 1995). Moreover, the size of the organisation has been found to play a key role in influencing the decision to work with universities (Laursen *et al*., 2004). Research has shown that large firms are several times more likely to draw knowledge and information from universities. This is partly because many small firms are highly resource-constrained and therefore lack the managerial time and effort required to develop collaborative arrangements with universities. There are, of course, many small science-based firms that may have formally spun out of universities or university research with strong links to universities. However, the number of these firms in the wider economic system is small and, for most small firms, working with universities is a bridge too far. Moreover, for many small firms, university researchers are working on problems that may be far removed from their concerns and therefore it is unclear that there is a good match between their needs and university researchers.

The industrial sector and its relationship to universities is complex and varied, as is the university sector, which is made up of 184 different Higher Education Institutions in the UK. Each of these institutions has a unique history and a pattern of engagement with practice, shaping sharp differences in attitudes to engagement with industry across universities. Such differences are not restricted to the divide between research intensive and teaching universities, but even among research intensive universities the extent and type of engagement with industry differ sharply – see, for instance, the marked differences towards university ownership of intellectual property between Cambridge and Oxford (Minshall & Wicksteed, 2005).

The context for this study has been the surge of interest in university-industry collaboration in policy and academic communities. In the policy domain, there have been waves of initiatives launched at the national and regional level to help stimulate and support collaboration between UK universities and industry. This includes the University Challenge Fund (UCF), launched in 1998 aimed at providing seed investment to help commercialisation of university IPR; the Science Enterprise Challenge (SEC), launched in 1999, which provides funds for teaching of entrepreneurship to support the commercialisation of science and technology; and the Higher Education Innovation Fund (HEIF), launched in 2001 (as a continuation of a previous programme called HEROBC), which is the largest funding commitment to support university infrastructure oriented to encourage the universities' third stream activities. Now in its fourth round of funding, HEIF is increasingly shifting from a competitive basis for funding allocation to a formula basis, where universities have access to funding on the basis of their demonstrated performance on third stream activities.

At the same time, there have been considerable changes in the university sector. In 2005 the Research Councils introduced Full Economic Costing (FEC), altering the cost of research to both industry and universities. The period of the recent study was also the lead up to the 2008 Research Assessment Exercise. The past five years has also seen significant changes in universities' intellectual property policies, the growth of the range and extent of universities' technology transfer offices' activities as well as a number of new incentives created for academics to commercialise their research. Indeed, as the Lambert Review (2003) pointed out, by 2003 almost 80% of UK universities had at least one dedicated person to technology transfer activities. Moreover, as the more recent Sainsbury Report (2007) shows, technology transfer from UK higher education institutions has observed a dramatic increase in patents granted (the number granted to UK HEIs has more than doubled between 2000-01 and 2005-06), as well as in the income from licensing intellectual property (which has more than tripled within the same period).

Given this context, it is an opportune time to explore what it is that firms gain from working with universities and to examine whether the nature of the collaboration between firms and universities in the UK is changing. This is the goal of this report.

Method

The study was designed to capture industry and university researchers' attitudes to collaboration. The first stage of the work involves a survey of industry, reported here for the first time, and the second stage involves a survey of university researchers, to be conducted in Spring 2009. The goal of the project is to provide greater information about the nature of collaboration between universities and industry and to provide lessons for public policy in this area.

The research builds upon a past research effort, conducted at SPRU in 2004 and sponsored directly by the EPSRC. Using the funding available from the IPGC programme, we have sought to extend this prior work by providing a second wave to the survey as well as attempting to address new questions.

The survey itself was designed to capture business attitudes towards collaboration with universities. To ensure an adequate representation of industrial views to research collaboration, we surveyed all the private, for-profit organisations that were involved in EPSRC collaborative projects. The names of the firms and individuals surveyed were taken directly from the EPSRC's project records. We used this information to create the sample population and to identify individuals to whom to address the survey. The unit of analysis of the survey was the business unit. In the survey, a business unit was defined as "an organisational unit producing goods or services which benefits from a degree of autonomy in decision making, especially for the allocation of its resources." This definition is consistent with UK Innovation Surveys.

The survey questionnaire was based on the original 2004 EPSRC survey. However, several new questions were added to the survey. The results are therefore broadly comparable between the two populations for many of the questions of the survey. We also sought to shorten the survey and to remove questions of low interest for this research project. For example, the past version of the survey focused directly on the nature of co-publications between industry and universities, an issue of concern to the EPSRC at the time of the study. Questions on this issue were removed. A copy of both the 2004 and 2008 surveys are included in Appendix A.

The survey asked questions about the:

- frequency of interaction by types of engagement (Q1);
- importance of different factors influencing decisions to interact with universities (Q3);
- percentage of a firm's innovation projects that made use of outputs from universities (Q4);
- benefits of interacting with universities (Q5); and
- barriers to interacting with universities (Q6).

We added several new questions to the survey. The first of these questions focuses on the level of trust businesses have in their university partners (Q8). This question was drawn with minor modification from the literature on inter-organisational trust (Zaheer, McEvily, & Perrone, 1998). It includes five items to capture various dimensions of trust. Second, we added a question on the nature of knowledge exchanged (Q9). This question draws from attempts to capture the tacit or codified nature of knowledge exchanged between organisations and business units. The item is drawn from Hansen (1999). Third, we asked firms to list their five most important university partners, providing them with a complete list of the 184 Higher Educational Institutions in UK (Q7). We used this information to calculate the most common collaboration partners and to enable us at a later date to explore the role of geographical distance in the nature of collaboration. Finally, from the previous round of the survey, it was clear that many of the collaborators with industry provided resources and services to the research sector. Some of these organisations were small-scale service firms. In order to assess the level of provision of services of the businesses to universities, we developed a new question that covered a range of services that businesses supply to universities (Q2). This question gives us a sense of the two-way exchange between businesses and university researchers.

In addition, the survey asked respondents a series of questions about their organisation: its size, sector, R&D expenditures, share of staff with higher education degrees and ownership.

The final sample included just over 3431 named individuals, covering 3119 different organisations. We sought to ensure a high degree of overlap with the 2004 survey and therefore we included all respondents and non-respondents to this previous round of the survey. We attempted to clean the data by removing organisations from the EPSRC records that were not private businesses. Additionally, we sought to remove double records, closely checking postcodes and individual names. Since the survey population covers the period of industrial collaborators from 1999, many individuals to whom we addressed the survey had left the organisation or the organisation has ceased to exist. In total, we received 178 of 'return to senders' as the people listed the EPSRC data had either moved organisations, retired or passed away. We include all these 'return to senders' in the calculation of our response rate as we are unable to differentiate between 'return to senders' and non-responses.

We sought to ensure that we received responses for more than one individual from the firm. This is to ensure that our results were reliable and truly represented the views of the organisation rather just an individual. To deal with this issue, we included 312 individuals in the sample that came from the same organisation as another individual in the sample.

There were several stages to our data collection. In the first stage, an invitation letter was sent to the individual identified in the EPSRC database in November 2007. This included another letter from the research team inviting the individual to go to a website to complete an electronic version of the survey and a letter from Professor David Delpy, Chief Executive of the EPSRC, endorsing the study. This first stage elicited over 269 responses. In order to improve response rates, we telephoned each contact directly to encourage them to respond. This approach yielded another 176 responses. In the second stage to garner a better response rate, we undertook a second postal survey in February 2008, where this time we also attached a paper copy of the survey. This approach allowed respondents to either fill in an electronic or paper-based version of the survey. The second stage enabled us to capture another 188 responses. In the final stage, we used the email addresses collected from the first telephone contact with the organisation to run an email reminder to the share of the non-respondent population for which we have email information. This approach yielded another 13 responses. In total, we received 646 usable responses from the survey. Given the total population for the survey was 3431, the response rate was just below 20%.

In order to check the reliability of our sample, we undertook a number of tests of the response population, looking for sources of bias in our sample. First, we compared early and late responders to the survey and found no significant differences in terms of structural features, such as size, sector or R&D intensity as well as attitudes to collaboration. Second, we compared individuals who responded by electronic and paper-based versions of survey and found no significant differences. Finally, we compared the responses of organisations where we had two or more respondents (we had 42 cases of two respondents for the same firm). We found that two respondents from the same organisations' responses were highly correlated, indicating that the responses to the survey reflect general organisational practices rather than individual attitudes. These tests help to provide some confidence that the survey data is reliable.

In Table 1, we examine the composition of the 2004 and 2008 samples by sector. There are notable differences between the pattern of industry responses in the two surveys. The proportion of Business Service firms is greater in the 2008 survey, accounting for 37% of the sample. Moreover, the number of Electronic & Instrument firms was greater in the 2004 sample. Overall however, both surveys provide a similar cross-section of industries, covering the broad expanse of the UK economic base.

Table 1: Sectoral breakdown for the two waves of the survey

Industry	2004	2008
Chemicals & chemicals related	64 (13%)	75 (12%)
Machinery & Metals	54 (11%)	60 (10%)
Electronics & Instruments	74 (16%)	72 (12%)
Transport	17 (4%)	23 (4%)
Utilities & Construction	37 (8%)	54 (9%)
Business Services	136 (29%)	220 (37%)
Not classified elsewhere	93 (20%)	98 (16%)
Total	**475 (100%)**	**602 (100%)**

Table 2 provides on overview of the size distribution of the firms in two waves of the survey. There is little difference between the sizes of the responding firms in the two waves of the survey. Most firms in both surveys are SMEs, representing more than 70% of the sample.

Table 2: Size breakdown for the two waves of the survey

Employment size	2004	2008
1 –50	204 (45%)	252 (45%)
51 – 100	57 (12%)	60 (11%)
101 – 250	72 (16%)	92 (16%)
251 – 500	39 (8%)	46 (8%)
>500	85 (19%)	113 (20%)
Total	**457**	**56**

Analysis

We begin the analysis by exploring the level and nature of interaction between UK businesses and universities. Table 3 presents the percentage of firms who indicated they were involved in a form of interaction with universities and the extent of this interaction. The forms of interaction include: creation of physical facilities; joint research; contract research; consultancy; training of company employees; postgraduate training in companies; conferences; recruitment of graduates and postgraduates; and student placements.

Within the 2008 sample, almost all firms indicated that they have attended conferences with university researchers. Three-quarters of the sample had also recruited recent graduates and postgraduates, and close to two-thirds had sponsored student placements. In addition and as might be expected, a high percentage of firms indicated that they set up a new research agreement with universities. However, many of the other mechanisms of interaction were only cited by less than half of the sample. The least common means of interaction was creating physical facilities, followed by postgraduate training within the company.

There was little difference over time in the use of different mechanisms as there are no significant differences between 2004 and 2008 surveys. However, the 2008 survey population indicates higher levels of engagement in the creation of physical facilities. The increase in engagement of this type may stem from the use of HEIF funding for infrastructure during this period.

Table 3: Degree of engagement across different types of interaction with universities, 2004 and 2008

Types of interaction	**2004** At least once (%)	**2008** At least once (%)
Attendance at conferences	88.8	90.0
Recruitment of graduates	66.6	72.2
Joint research	66.5	65.7
Student placements	58.4	61.9
Contract research	45.6	48.3
Training of company employees	49.2	44.4
Consultancy	42.0	41.5
Postgraduate training	43.6	40.8
Creation of physical facilities	15.5	34.2

Factors influencing the decision to interact

In the survey, we asked respondents to indicate the factors that influence the decision to interact with universities. We included a range of potential factors, some of which were more short term, such as gaining feedback on an existing project, and others were more long term in orientation, such as access to state of the art thinking in science and technology. Respondents were asked to rate the importance of each of these factors on a 1 to 5 Likert scale from 'not at all important' to 'crucial'. Table 5 shows that the most common factor cited as being 'very important' or 'crucial' was access to start of the art research on science and technology, with just under 57% of firms indicating that they turned to universities for this reason. The second most common factor was problem solving capacities and access to research networks. The factor that was least important was outsourcing of R&D activities or to gain feedback from university researchers during a development process. Taken together, these results indicate that firms turn to universities for creative problem solving and access to networks, rather than short-term outsourcing of current problems or long-term visions of future technology.

In general, there were modest differences between the results of the 2004 and 2008 surveys. Businesses cite a high range of factors as being important, indicating a high level of breadth in the way firms view university research. For both the 2004 and 2008 surveys, firms reported an average of three factors as being very important or crucial in influencing their decisions to interact with universities. The analysis of differences between 2004 and 2008 show little change. Although percentage numbers are down slightly for access to 'start of the art research', 'problem solving' and 'R&D facilities', there was no statistical difference between the two waves of the survey. We found no evidence of a significant shift to the use of universities as a short-term vehicle for outsourced R&D.

Table 4: Factors influencing the decision to interact with universities, 2004 and 2008

	2004 % responding 'very important' or 'crucial'	**2008** % responding 'very important' or 'crucial'
Access to state of the art research	66.1	57.3
Access to problem solving	52.1	42.6
Access to R&D facilities	52.1	41.4
Access to a research network	35.8	38.5
Seeking to proprietary knowledge	22.5	32.8
To undertake exploratory research	30.0	30.6
Feedback for development process	24.0	26.6
To build up new research areas	29.7	25.7
Outsourcing R&D activities	21.5	15.2

Extent of the use of outputs from universities

One of the key questions in the survey was about the extent to which firms use outputs from universities. The question focuses on the number of times firms used outputs from universities in their innovation projects. The scale runs from 'Not applicable' to a range of percentages of cases from below 10% to above 91%. The results from the 2008 survey can be seen in Table 5 and they suggest the most frequently used output from universities was publishing, with over 50% of firms indicating that they relied on this output for at least 10% of their innovation projects. The second and third most common outputs were hiring recent graduates and general knowledge from basic research. The least frequent activity was support for problems in late stages of innovation projects, followed by prototypes and designs. When looking at the higher extent of use on innovation projects – the 40% of innovation projects category, the results show that publications, hired graduates and findings from basic research are the most important. Only a small share of firms indicated that they used problem solving close to the market and prototypes and designs from universities in 40% of their innovation projects.

There are some significant differences between the 2004 and 2008 surveys. The overall pattern is similar in terms of the order of output frequencies reported, except findings from basic research have fallen in relative importance between 2004 and 2008. However, in general the level of outputs drawn from universities has fallen, with this fall concentrated in prototypes, real time feedback, consultancy and late stage problem solving. These results are difficult to explain with the current set of information, but suggest that firms are looking at less frequent, but possibly higher value outputs from universities. The results may also be due to a slight change in wording on the 2004 to 2008 surveys, where a 'not applicable' box was added to the scale. The question was also re-worded to include innovation projects as well as R&D projects to capture a broader range of innovative activities, especially in non-R&D active firms.

Table 5: Extent of use of universities in innovation projects, 2004 and 2008

	2004		2008	
	% responding 'above 10%'	% responding 'above 40%'	% responding 'above 10%'	% responding 'above 40%'
Published results	59.2	33.1	50.4	23.2
Hired graduates	49.1	23.4	41.2	16.5
Findings from basic research	53.8	26.5	43.0	14.8
Problem solving at early stages	47.0	23.3	26.5	7.9
Consultancy and advice	46.9	22.7	27.9	7.3
Real time feedback	37.8	19.9	20.0	7.2
Instruments and techniques	38.3	12.2	23.1	6.7
Prototypes or designs	33.0	10.0	18.3	4.1
Problem solving at close to market stages	39.4	16.2	15.4	4.1

Table 6 examines the role of firm size in shaping the use of outputs from universities. Overall and as expected, we find that large firms have a higher percentage of projects that make use of university research. The differences in the 2008 survey between large and small firms are greatest for hired graduates and consultancy and advice. However, the order of outputs used is fairly similar between the two groups of firms, except that hired graduates are less important for small firms than for large firms. In comparison to the 2004 survey, however, we see a significant decline in projects that made use of outputs from universities for both SMEs and large firms. Size appears to play a role here; SMEs in the 2008 survey are much less likely to indicate that a share of their innovative projects rely on universities than the SMEs in the 2004 sample. The major changes are concentrated on the short-term outputs, such as problem solving and real-time feedback. Again, the direct comparability of these two sets of numbers is difficult due to slight changes in the questionnaire. Given this, it must be noted that the 2008 sample contains firms with higher levels of R&D spending and the average number of employees. This indicates that these firms are on average more likely to be able to capture outputs from universities, yet the results from the 2008 survey point in opposite direction.

Table 6. Extent of use of universities in innovation projects by size, 2004 and 2008

	2004 % responding 'above 10%'		2008 % responding 'above 10%'	
	SME	Large firm	SME	Large firm
Hired graduates	47.8	53.1	38.7	50.3
Published results	54.3	70.9	49.9	53.2
Findings from basic research	52.1	58.3	43.3	40.8
Consultancy and advice	45.7	48.7	23.3	39.7
Instruments and techniques	38.3	39.1	21.3	28.7
Problem solving at early stages	47.3	48.7	26.1	28.9
Real time feedback	37.2	40.0	21.0	18.6
Problem solving at close to market stages	38.3	44.4	14.3	18.0
Prototypes or designs	35.1	29.3	17.9	20.4

Benefits of interacting with universities

The benefits that businesses gain from interacting with universities are varied. Some businesses see the benefits of working with universities for their short term, specific needs, such as introducing new products and processes, whereas others have very long term orientation and do not interact with universities for help with an immediate application. It is also possible to see the benefits of working with universities as involving a mixture of long and short-term benefits, such is the multifaceted nature of interaction between universities and industry. In this sense, working with universities can allow organisations to both explore and exploit new technological areas (March, 1991).

The results of the survey suggest that the most important benefit of working with universities is creating long-term links with the university sector. This is followed by the identification and recruitment of employees. In addition, more than a quarter of the sample indicated that improved understanding of phenomena as either being very important or crucial for their organisation. In general, the main benefits are largely long-term in nature and focused on developing underpinning knowledge, methods or instrumentation or getting access to highly skilled problem solvers. This suggests that the main benefits of universities remain related to the talent they provide to the economic system, often embodied in people or methods. In contrast, short-term benefits, such as contributing to new products or process, were only cited as being very important or crucial by 12.5% of the sample. Indeed, all of the lowest scoring items involve commercial motivations, such as capturing intellectual property, reducing costs and speeding up R&D projects.

The comparison of the 2004 and 2008 survey reveals a similar pattern over time. The ranking of benefits is remarkably similar with long-term benefits staying highly important. However, there are some significant differences between the two surveys with respect to the benefits that firms recognise from universities. In almost all cases, the level of benefits cited by firms has declined since 2004. This may suggest that the character of collaboration between universities and industry may have changed during this period. This is consistent with other results for this survey and may reflect erosion in the environment for collaboration between universities and industry in the UK, an issue that we will explore below.

The starkest difference for individual types of benefits can be seen in the creation of long-term knowledge, where almost 14% fewer firms indicated that they gain this benefit from universities between 2004 and 2008. This pattern was similar for 'improved understanding of particular phenomena' and for a variety of more short-term benefits, such as assistance in problem solving and cost reduction. Only a few benefits have increased since 2004. These include the identification and recruitment of employees and the generation of intellectual property.

Although two points of data do not indicate a trend, the results are suggestive of changes in the nature of benefits that firms gain from universities. In general, the level and character of these benefits appears to be declining over time and firms are becoming increasingly focused on using universities as a site for recruitment. On the whole, the willingness to engage university partners in short-term projects is declining at the same time as the longer, less specific benefits of university research are also becoming less important.

Table 7. Benefits of interacting with universities, 2004 and 2008

	2004 % responding 'very important' or 'crucial'	**2008** % responding 'very important' or 'crucial'
Creation of long term links	66.9	52.8
Identification and recruitment of employees	24.8	33.9
Improved understanding of foundations	40.3	26.7
Assistance in problem solving	36.6	24.1
Sources of information for new projects	27.6	23.6
Reducing time for completion of R&D projects	16.2	17.9
Generation of new equipment	19.2	16.8
Generation of intellectual property	9.0	16.0
Generation of procedures or techniques	20.9	16.0
Contribution to successful market introduction	20.6	12.5
Cost reduction in product/process development	10.8	9.3

Table 8 reports the proportion of benefits for SMEs and large firms. The results for the 2008 survey show there are some differences between SMEs and large firms in the types of benefits they see from universities. Large firms indicate higher importance to long-term links, recruitment and assistance with problem solving than small firms. This pattern is not consistent with the 2004 survey, where the differences between large firms and SMEs were less great. Overall, the number of SMEs indicating benefits from universities has fallen across benefit types, except for the generation of IP, since 2004. In contrast, large firms suggest greater importance to recruitment than in 2004 and exhibit similar levels of other benefits.

Table 8: Benefits of interacting with universities by size, 2004 and 2008

	2004 % responding 'very important' or 'crucial'		**2008** % responding 'very important' or 'crucial'	
	SME	Large firm	SME	Large firm
Creation of long term links	65.2	68.3	49.6	61.4
Identification and recruitment of employees	22.1	29.2	29.5	44.9
Improved understanding of foundations	38.5	43.3	23.8	33.3
Assistance in problem solving	36.3	35.8	21.9	30.8
Sources of information for new projects	28.5	24.2	23.0	25.3
Reducing time for completion of R&D projects	16.1	15.8	18.2	19.4
Generation of procedures or techniques	19.5	22.5	15.1	18.5
Generation of intellectual property	9.3	17.5	16.2	15.5
Generation of new equipment	18.0	20.8	18.9	12.8
Cost reduction in product/process development	10.2	10.8	8.8	11.0
Contribution to successful market introduction	18.9	23.3	14.9	7.1

Barriers to interaction

The barriers to interacting with universities involve a range of different norms of incentives and institutional barriers. Discovering new knowledge and establishing priority for these discoveries among peers through publications largely motivates university researchers. Science remains an open system, governed largely by norms set by the scientists themselves. In contrast, industrial research is likely to be specific in orientation and firms are focused on creating private and valuable knowledge that can be used to create products and processes. In this context, industrial firms operate in a very different system where capturing intellectual property, both informal and formal, plays a key role in shaping their external engagement, in general, and work with universities, in particular (Dasgupta *et al*., 1994).

In the survey, we asked firms to rate the importance of different barriers for their organisation's relationship with universities. Taken as a whole, the results show that there remain substantial barriers to interaction between universities and industry. The barriers that were most important were the long-term orientation of universities as well as the lack of suitable government programmes in specific research areas. Over 65% of the sample cited these two barriers as being either very important or crucial. In addition, over 55% of the sample cited regulations and rules, imposed by universities and governments, as concerns over confidentiality, intellectual property and the role of the

Technology Transfer Offices of the universities. The barriers that were seen to be least important were a low profile of the Technology Transfer Office, finding a suitable partner, strong orientation to basic research and lack of mutual understanding.

The comparison between the 2008 and 2004 surveys is highly revealing. Overall, there has been a significant rise in the barriers faced by firms working with universities. In all cases, the importance of different barriers has increased over time. This is true for both barriers related to the orientation of universities and also those related to the government support and rules and regulations. However, the greatest change in terms of cited barriers is the increased importance attached to the Technology Transfer Office and their perceived lack of 'realistic expectations'. Here the number of firms citing this barrier as being very important or crucial increased from 24% to 49%, which is a striking shift in a short space of time. At the same time, there has also been almost a 34% increase in the number of firms indicating that long-term orientation of universities had acted as a barrier to collaboration.

Table 9: Barriers to interaction with universities, 2004 and 2008

	2004 % responding 'agree' or 'strongly agree'	**2008** % responding 'agree' or 'strongly agree'
Long term orientation of university research	31.1	65.4
Lack of suitable gov. programmes to support U-I interactions	51.9	61.4
Potential conflicts with regards to IPR	32.4	55.6
Rules and regulations imposed by Univ. or Government	42.4	52.9
Unrealistic expectations from TTOs	24.0	49.3
Univ. researchers seeking immediate dissemination	22.3	39.8
Lack of information about what university does	27.8	37.4
Difficulty in finding the appropriate partner	19.9	33.5
University oriented towards pure science	22.3	33.4
Mutual lack of understanding about expectations	25.7	33.0
Absence or low profile of TTOs	16.7	28.7
Relevant universities are too far away	7.0	10.0

Table 10 breaks down the importance of barriers by size for each round of the survey. The differences between SMEs and large firms in the 2008 survey are relatively small, with both types of firms indicating that barriers related to orientation, lack of government programmes and conflicts over IPR. The comparison with the 2004 survey reveals more, suggesting the increased number of cited barriers is spread between SMEs and large firms. This indicates that the increasing number of barriers cited over time is not related to the size of firms and could represent a more general pattern of rising barriers, driven by changes in intellectual property policies of universities as well as the long-term orientation of university research.

Table 10: Barriers to interaction with universities by size, 2004 and 2008

	2004 % responding 'agree' or 'strongly agree'		**2008** % responding 'agree' or 'strongly agree'	
	SME	Large firm	SME	Large firm
Long term orientation of university research	31.5	30.6	67.4	60.8
Lack of suitable gov. progr. to support U-I interactions	51.1	55.3	63.3	59.5
Potential conflicts with regards to IPR	31.9	35.5	55.9	53.2
Unrealistic expectations from TTOs	23.1	28.1	50.3	48.1
Rules and regulations imposed by Univ. or Government	41.9	45.5	57.3	42.4
Lack of information about what university does	27.2	25.4	35.6	40.5
Univ. researchers seeking immediate dissemination	22.3	23.0	41.4	36.7
University oriented towards pure science	24.2	20.3	31.7	35.4
Difficulty in finding the appropriate partner	20.7	15.6	33.9	32.3
Mutual lack of understanding about expectations	24.6	27.3	33.6	31.7
Absence or low profile of TTOs	17.4	13.9	28.6	30.4
Relevant universities are too far away	5.4	10.7	10.5	9.5

These results pose a set of interesting questions about the changing nature of collaboration and how barriers to collaboration are increasing rapidly over a short space of time. The worrying feature of this increase is that it is not simply concentrated in one area, such as the role of the Technology Transfer Offices, but it is spread across different types of barriers. In this respect, the barriers to working with universities are increasing both because of increasing levels of rules and regulations and more active technology transfer activities, but also because university researchers have a long term orientation. Possible explanations for the rising number of barriers may be the combination of the lead up the RAE 2008 and the growth of intellectual property activities of universities during this period. First, the approaching RAE 2008 might have made academics more long term in orientation, focusing on their research outputs. Second, at the same time, the increasingly comprehensive intellectual property strategies of universities may have heightened barriers to interaction. Research has found that some universities overvalue their IP (Clarysse, Wright, Lockett, Mustar, & Knockaert, 2007), which makes negotiations with industry more difficult and this may hinder collaboration with industry (Nelson, 2004). Taken together, these processes could represent the worst of both worlds; increasing barriers because of norms in the science system promoting a focus on long-term research, and rising levels of institutional barriers through rules, regulations and the attempts to capture formal intellectual property by the university.

Most important universities for collaboration

In the 2008 survey, we asked respondents to indicate the five most important universities for their collaboration activities. Table 11 lists the top universities cited. It is clear that the leading research-intensive universities, such as Imperial College London and the University of Cambridge, remain central to the collaboration between EPSRC industrial collaborators and universities. What is interesting is that some leading research universities do not appear in the top ten, such as Oxford and University College London. For example, although Oxford had 292 EPSRC projects worth £163.9 million, it was cited 68 times and University College London with 253 projects worth £142.1 million was only cited 53 times. There are also some surprises on the list given their low levels of research funding relative to other universities, such as Cranfield University and the University of Loughborough. We also calculated the number of times a firm cited a university per million pounds of EPSRC funding. According to this measure, Birmingham and Cranfield had the highest impact, whereas among the top ten Cambridge had the lowest rate of citation per pound.

It must be noted, however, that these results may be strongly influenced by the nature of the sample obtained in the survey. As yet, we have not checked response rates by each university's potential number of industrial partners. It may be that the response rates are biased against some universities, leading to a case where a university has some 300 partners with a response rate of 10% whereas another university had 300 partners but a response rate of 30%. Moreover, the character of ESPRC grants held by each university may influence their likelihood of being cited by industrial firms. For example, a university may hold many EPSRC projects with one or a small number of partners. Therefore the likelihood of obtaining a response from their partners would be lower than a university with a set of projects and a high number of industrial partners. Therefore, these results are suggestive rather than definitive. It must be stated, however, that the question was worded to focus on the contribution of UK universities in general rather than a specific project and firms were able to choose from any of the 184 HEIs. So despite the partial nature of the sample, the responses may reflect more general patterns and attitudes of UK firms toward particular universities as collaboration partners.

Table 11. Ranking of universities by citations by respondents

	Number of times cited	% of respondents that cite this university among the five most frequent collaborators	Number of EPSRC projects1	Value (£ millions) of projects1	Number of cites per £ million of EPSRC funding
Imperial College	166	26.3	413	242.5	0.68
University of Cambridge	127	20.1	290	197.2	0.64
University of Manchester	115	18.2	290	155.5	0.74
University of Nottingham	102	16.1	238	121.2	0.84
University of Southampton	89	14.1	197	134.1	0.66
University of Birmingham	86	13.6	144	83.0	1.04
University of Loughborough	82	13.0	99	84.5	0.97
University of Leeds	81	12.8	198	107.6	0.75
University of Strathclyde	80	12.7	124	80.6	0.99
Cranfield University	75	11.9	59	52.1	1.44

[1]Source: http://gow.epsrc.ac.uk/ListOrganisations.aspx, based on value of all recent or current projects reported by EPSRC.

Contribution of business to universities

One of the new questions posed on the survey relates to the contribution of businesses to universities. The idea of this question was to capture the two-way nature of interactions between universities and industry, and to assess how much and what type of resources businesses are providing to universities. We focused on five sets of resources: ideas for research projects; materials or equipment; specialised software; consultancy services; and funding for research. The main resource cited by businesses was ideas for research, followed by funding for research and materials or equipment. A modest number of firms indicated they provide software or consulting services for universities. Businesses see their contribution to universities as primarily related to idea generation, providing a source of inspiration for future research as well as a source of funding for this research.

Table 12: Proportion of respondents reporting they provided benefits to universities

	SMEs % responding 'very important' or 'crucial'	**Large firms** % responding 'very important' or 'crucial'
Ideas for research projects	41.2	54.8
Funding for research	24.2	39.2
Materials or equipment	26.8	28.3
Consultancy services	19.6	19.3
Specialised software	15.2	15.0

Policy implications

There are several important policy implications arising from this study.

1. The Wealth of Diversity

It is helpful to conceive collaborations between universities and firms as involving a rich blend of mechanisms and motivations. No single factor shapes the relationship between industry and universities. Given this, government efforts to promote collaboration need to reflect the highly differentiated needs and requirements from such a variety of collaboration modes. Attempts to measure and map the performance of UK universities by assessing their levels of commercialisation through patenting and licensing income – as is commonly done – may provide an incomplete picture of the nature of university-industry collaboration. This approach focuses on the least common interactions that bind universities to industry. To date, little attempt has been made to measure and map – systematically and overtime – the broader mechanisms that bring industry together with universities. As a result, many rich and important forms of collaboration are set aside in policy design and evaluation. This survey suggests that forms of collaboration consisting of consulting, student training and joint research are more powerful forms of engagement than formal commercial methods, such as patents. Our lack of attention to these other forms of engagement may misdirect policy efforts, and could potentially lead to significant unanticipated negative consequences for university-industry collaboration, as will be discussed below.

2. Quality of interaction

Most efforts to promote university-industry interaction have focused on increasing raw numbers of firms involved in the process. Although it is true that only a small share of UK firms actually work with universities, there is already considerable interaction taking place within the system. More importantly, these interactions have a considerable impact on UK firms. In this study, almost a quarter of all firms indicated that more than 40% of their innovation projects relied on published research developed by universities. By focusing on raw numbers of collaborators in policy measures, it is possible to underplay the character of the interaction between universities and industry. It would be more useful to measure and monitor the richness of interactions rather than simply counting the quantity of interactions. It is likely that long-term and sustained interactions will lead to fruitful and meaningful exchanges and therefore will have a positive impact. Facilitating repeated and long-lasting exchanges should be one crucial policy goal as well as stimulating firms to collaborate with universities for the first time. One idea for assessing the richness of university-industry collaboration is to develop a Research Council-wide system that monitors the number and scale of industry involvement in publicly funded research projects. Such a system could assess the frequency, breadth and depth of firms' engagement with research projects, providing information on the vitality of the system for both new entrants and for established collaborators. Such an approach would also help to resolve the dangers of an overemphasis on commercialisation measures.

3. Talent and technology

It is clear from the study that firms go to universities for talent and technology and therefore it is important to create mechanisms that support both the use of universities as a source of talent, but also of technology. Mechanisms that support the use of university research as a means for recruiting talent staff are likely to be more useful than mechanisms which focus on recruitment or research alone. We also still lack significant evidence about the movement of skilled problem solvers from universities to industry. Greater attempts to track the flows of university-trained talent through the economic system may provide new insights in the nature and scale of contributions of universities to economic wealth.

4. Increasing barriers

Although UK firms benefit greatly from collaborating with universities, it is also clear that barriers to these interactions are increasing. Between the two waves of the survey, there has been a considerable increase in barriers to interaction, localised mostly in the role of TTOs, long term orientation of university research and the lack of appropriate government funding.

There are several possible explanations for the increasing level of barriers. First, since 2004, UK universities have expanded and professionalised their TTO activities. By 2008, many UK universities had built highly professionalised systems for technology transfer, with extensive capabilities in recognising and capturing formal intellectual property. At the same time, almost half of the respondents of this survey reported that TTOs had unrealistic expectations of the economic value of the research. The desire of universities to capture financial benefits from their research always needs to be balanced with the desire to support firms in their innovative activities. Overall, the TTO activities may have altered the nature of interaction between universities and businesses in the UK. and it is likely that a period of adjustment will be required before the consequences of these changes can be fully assessed. At this stage, it is unclear whether the professionalisation and expansion of TTOs has had a harmful impact on collaboration patterns, but the preliminary results of the survey suggest this outcome may be possible. This raises a key issue for public policy, as it may be necessary to develop potential remedies to these problems before they start to undermine the rich and varied set of interactions that characterise industry-university relations in the UK. Second, the survey covers the period leading up to the RAE 2008 and this was a period associated with considerable effort on the part of university researchers to publish their work before the Dec. 31, 2007 census date. Such efforts may have led some researchers to become more long-term oriented in their research activities and therefore look away from collaboration with industry. Finally, alongside the rise of the TTOs, recent years have seen the development of new and more comprehensive systems of university research management. As part of these changes, universities have created clearer and stricter rules and regulations to govern the research conduct of their staff. The motivations behind these changes are partly to help professionalise research activities of universities and to ensure greater probity in research. The negotiations to launch a collaborative research project increasingly involve four different actors – the university researchers, the company, the university research administration and the technology transfer office – each of which may have different and possibly conflicting agendas. Taken together, these factors may help explain the rise in barriers witnessed in the survey.

5. No shift to short-term benefits

We found little evidence that industrial firms were increasingly outsourcing R&D activities to universities. UK firms look to universities as a source of ideas and talent rather than as a low cost provider of research services. Moreover, the educational benefits of collaboration remain strong.

6. Impact of Full Economic Costing

In written responses to the survey, a small but significant number of respondents indicated the shift towards Full Economic Costing in the university sector was a serious hindrance to collaboration. Greater research is required to understand how FEC has shaped industrial attitudes to working with universities. From our study and for at least a small but vocal minority, FEC was having serious consequences, turning down many firms from collaboration due to the high cost of engaging with university partners.

Future research

The next stage of this project will involve a survey of academics focusing on those individuals who have acted as Principal Investigators on EPSRC grants. Like the survey reported here, it will build upon a previous survey conduced at SPRU in 2004. This survey will allow a comparison of changes in the attitudes of academics with their industrial collaborators.

The collection of survey data on firms' attitudes to working with universities is useful, but often opens up a range of questions that can only be answered by capturing additional data. In the later stages of this project we will seek to match our survey data with financial records of these firms, allowing us to explore how different forms of engagement shape performance. This work will allow us to characterise the types of engagement that have the biggest payoffs for firms as well as to explore the factors that lead some firms to use different forms of engagement with universities. We will also seek to combine our survey data with patent data to explore how the technological base of the firm shapes why and how they collaborate with universities. To date, most research in this area has relied on single sources, such as a survey, and there is a significant potential to build new knowledge about the factors and motivations of firms to collaborate with universities by exploring other information. In addition, we have undertaken a number of interviews with firms collaborating on EPSRC projects.

Background of the study

Innovation and Productivity Grand Challenge

This study is part of a larger programme of research exploring the changing nature of innovation in the UK, called the Innovation and Productivity Grand Challenge. (IPGC). IPGC is a network of five major universities – Cambridge, Liverpool, Loughborough, Cranfield and Imperial College – and the Advanced Institute of Management Research (AIM). As part of IPGC there are a number of complementary projects being undertaken to explore how to get more innovation from knowledge. These projects focus on:

- How the current system for knowledge transfer works and its strengths and weaknesses
- How new firms form from new knowledge
- How existing firms grow through taking new knowledge
- How infrastructure can catalyse or enable innovation from knowledge.

To learn more about IPGC, please visit www.ipgc.ac.uk.

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Appendix: 2004 and 2008 Survey Instruments

Section A: General information on your company unit

A.1 **Is your unit:** (please tick ✓ the correct response)

a. Independent? ☐ b. Part of a larger firm? ☐

If the unit where you work is part of a larger firm, please specify whether this is:

B1. Subsidiary or Division ☐ b2. Head Office ☐ b3. Central R&D Unit ☐

b4. Other (please describe) ☐ : .....

A.2 **If your unit is part of a larger firm, in which country is the Head Office located?:**

.....

A.3 **What is your unit's *main* industrial or commercial activity?:**

.....

Section B: Type of interactions with university

Joint Research projects refer to collaboration agreements between university and industry that involve research work undertaken by both parties / Contract Research refers to research commissioned by industry and undertaken only by university researchers / Consultancy work refers to work commissioned by industry, which does not involve original research (e.g. contracting university researchers to conduct routine tests or to provide advice to industry).

B.1 **How frequently has your unit been engaged in the following types of activity in the calendar years 2002 and 2003?** (Please tick ✓ the appropriate response)

	0 times	1-2 times	3-5 times	6-9 times	10-19 times	≥20 times
1. Creation of physical facilities in collaboration with university researchers (e.g. new laboratory, other buildings on campus)	☐	☐	☐	☐	☐	☐
2. A new joint research agreement (original research work undertaken by both partners)	☐	☐	☐	☐	☐	☐
3. A new contract research agreement (original research work done by University alone)	☐	☐	☐	☐	☐	☐
4. A new consultancy agreement (no original research conducted)	☐	☐	☐	☐	☐	☐
5. Training of company employees (through course enrolment or through temporary personnel exchanges)	☐	☐	☐	☐	☐	☐
6. Postgraduate training in the company (joint supervised PhD)	☐	☐	☐	☐	☐	☐
7. Attendance at conferences with industry & univ. participation	☐	☐	☐	☐	☐	☐
8. Attendance at workshops or networks of univ. & ind. people	☐	☐	☐	☐	☐	☐
9. Recruitment of recently graduated or post-graduated people	☐	☐	☐	☐	☐	☐
10. Forming part of a new R&D Consortium to fund research in university	☐	☐	☐	☐	☐	☐
11. Student placements (undergraduate training in the company)	☐	☐	☐	☐	☐	☐

Appendix: 2004 and 2008 Survey Instruments

Section B: Type of interactions with university (continued)

Region refers to geographic location in the UK (e.g. East Midlands, London, North East, North West, South East, South West, West Midlands, Yorkshire & Humberside, Scotland, Wales or Northern Ireland).

B.2 In connection with Question B.1: in which regions were your unit's university partners located?
(Please tick ✓ ***all*** relevant cases: if several geographical areas are applicable, mark them all)

	Your Region	National (other than your Region)	Other Europe	North America	Other	N/A
1. Creation of physical facilities						
2. Joint Research agreements	☐	☐	☐	☐	☐	☐
3. Contract Research agreements	☐	☐	☐	☐	☐	☐
4. Consultancy agreements	☐	☐	☐	☐	☐	☐
5. Training of company employees	☐	☐	☐	☐	☐	☐
6. Postgraduate training in the company	☐	☐	☐	☐	☐	☐
7. Conferences with ind. & univ. participation	☐	☐	☐	☐	☐	☐
8. Workshops with presence of ind. & univ.	☐	☐	☐	☐	☐	☐
9. Recruitment of newly graduated / post-grad.	☐	☐	☐	☐	☐	☐
10. R&D Consortium to fund research in univ.	☐	☐	☐	☐	☐	☐
11. Student placements	☐	☐	☐	☐	☐	☐

Formal interactions refer to signed agreements or defined contracts between university researchers and industry to undertake activities such as: joint research projects or research commissioned by industry.

B.3 Please indicate the number of formal interactions with university in which your unit has been involved in 2002 and 2003, corresponding to the following time intervals:

Number of formal interactions lasting:

1. Less than 6 months: ..... (if no formal interactions in this category, indicate "0")
2. More than 6 months and less than one year ..... (if no formal interactions in this category, indicate "0")
3. More than 1 year and less than 3 years: ..... (if no formal interactions in this category, indicate "0")
4. Three years or more than 3 years: ..... (if no formal interactions in this category, indicate "0")

Section C: Incentives to interact with university

C.1 Please rank the following reasons for your unit's involvement in interactions with university according to their importance (Please circle a number on the scale)

	Not important 1	2	3	4	Extremely important 5
1. Access to state of the art science & technology (keeping abreast of research done at university)	1	2	3	4	5
2. Access to problem solving capacities from university researchers	1	2	3	4	5
3. Access to a regular research network	1	2	3	4	5
4. Seeking to develop proprietary knowledge (eg filing patent applications)	1	2	3	4	5
5. Access to R&D facilities not available within the company (e.g. University labs)	1	2	3	4	5
6. Lower cost of research undertaken at the university (relative to in-house research)	1	2	3	4	5
7. To build up new research areas within the company	1	2	3	4	5
8. Formal incentive schemes implemented by the company to encourage interactions with university	1	2	3	4	5
9. To undertake highly exploratory research	1	2	3	4	5
10. Access to feedback from university during the development process	1	2	3	4	5
11. Outsourcing research and development activities	1	2	3	4	5
12. Access to specialised skills crucial to the development of close-to-market products	1	2	3	4	5

C.2 From the reasons for your unit's involvement with university in Question C.1, which are the THREE most important? (Please indicate below the number corresponding to three out of the 12 choices in question C.1)*

First:	Second:	Third:

* For example: if you consider reason number 11, in Question C.1, to be the most important, then please write '11' in the first box.

Section D: Outcomes from university-industry interactions

Some of the items in Question D.1 are similar to those listed in Question C.1. Note however that Question D.1 below refers to actual realisation of outcomes, not to expectations.

D.1 Please indicate how important the following benefits resulting from your unit's interactions with university have been over the last five years: (Please circle a number on the scale)

	Not important 1	2	3	4	Extremely important 5
1. Creation of long-term links with University researchers	1	2	3	4	5
2. Improve understanding of foundations of particular phenomena	1	2	3	4	5
3. Source of information suggesting new projects (ideas for new products / processes)	1	2	3	4	5
4. Generation of patents (in products or processes)	1	2	3	4	5
5. Generation of new equipment or instruments (including software)	1	2	3	4	5
6. Generation of new/ improved research procedures or techniques	1	2	3	4	5
7. Assistance in problem solving (e.g. support in the development process)	1	2	3	4	5
8. Peer reviewed publications	1	2	3	4	5
9. Recruitment of university postgraduates (i.e. PhD or Master graduates)	1	2	3	4	5
10. Contribution to the successful market introduction of new products / processes	1	2	3	4	5
11. Training of company personnel by university researchers	1	2	3	4	5
12. Cost reduction in product or process development (e.g. new prototypes)	1	2	3	4	5
13. Reducing the time required for completion of company's R&D projects	1	2	3	4	5

D.2 From the list of benefits from your unit's interactions with university (Question D.1), which are the THREE most important? (Please indicate below the number corresponding to three out of the 13 choices in Question D.1)*

First:	Second:	Third:

* For example: if you consider reason number 11, in Question D.1, to be the most important, then please write '11' in the first box.

D.3 What percentage of R&D projects (undertaken by your company unit) has made use of the following types of "outputs" from university in the years 2002 and 2003?
(Please tick ✓ the appropriate response)

	Below 10%	10-40%	41-60%	61-90%	Over 90%
1. Findings / general knowledge obtained from **basic research** in Univ.	☐	☐	☐	☐	☐
2. **Published** results of university research (e.g. articles in journals)	☐	☐	☐	☐	☐
3. **Prototypes or idea-designs** developed by university researchers	☐	☐	☐	☐	☐
4. **Instruments and techniques** developed by university researchers	☐	☐	☐	☐	☐
5. **Recently hired** graduates or postgraduates	☐	☐	☐	☐	☐
6. **Support for solving problems** at initial stages of R&D projects	☐	☐	☐	☐	☐
7. **Concurrent (real time) feedback** throughout R&D projects	☐	☐	☐	☐	☐
8. **Support for solving problems** at final stages of R&D projects	☐	☐	☐	☐	☐
9. **Consulting and advice services** provided by university researchers	☐	☐	☐	☐	☐

D.4 Please, indicate the extent to which you agree (or disagree) with the following statements:
(Please circle a number on the scale)

	Strongly Disagree 1	2	3	4	Strongly Agree 5
1. New products (or technologies) have been developed and commercialised sooner than expected due to interactions with university	1	2	3	4	5
2. Potential new directions for product or technology development would not have been recognised without interactions with university	1	2	3	4	5
3. Fundamental understanding of the science behind products or technologies developed by the company would not have been achieved without interactions with university	1	2	3	4	5

Section E: Joint publications and university-industry interactions

All questions in this Section refer to publications in scientific journals, co-authored by university and industry researchers.

E.1 In the calendar years 2002 and 2003, did your company unit have any joint publications with university? (Please tick ✓ the appropriate response)

Yes ☐ No ☐

If *Yes*, how many: (Please tick ✓ the appropriate response in the scale)

1 - 2 ☐ 3 - 4 ☐ 5 - 7 ☐ 8 - 10 ☐ 11 - 19 ☐ ≥20 ☐

Note that the number of co-authored publications refers to the two years 2002 and 2003.

Section F: Barriers to interaction with university

F.1 Please indicate the extent to which the following act as constraints to your involvement in interactions with university (Please circle a number on the scale)

	Not at all 1	2	3	4	Very much 5
1. University research is extremely oriented towards pure science	1	2	3	4	5
2. Absence of reward schemes in the company for stimulating joint activities with university	1	2	3	4	5
3. Industrial liaison offices overselling research or having unrealistic expectations	1	2	3	4	5
4. Long term orientation of university research	1	2	3	4	5
5. University researchers seeking immediate dissemination of research outcomes	1	2	3	4	5
6. Potential conflicts with university regarding royalty payments from patents or other intellectual property rights	1	2	3	4	5
7. Difficulty in finding an appropriate university partner	1	2	3	4	5
8. Lack of information about research activities of university departments	1	2	3	4	5
9. Lack of suitable government funding programmes for university – industry joint research in specific areas	1	2	3	4	5
10. Rules and regulations imposed by university or government funding agencies	1	2	3	4	5
11. Mutual lack of understanding about expectations and working priorities	1	2	3	4	5
12. The relevant university departments are (geographically) too far away	1	2	3	4	5
13. Lack of financial support from within the company for cooperation with university	1	2	3	4	5
14. Absence or low profile of industrial liaison offices in the university	1	2	3	4	5

F.2 From the factors that act as constraints to your unit's involvement in interactions with university Question F.1), which are the THREE most important? (Please indicate below the number corresponding to three out of the 14 choices in Question F.1)*

First:	Second:	Third:

* For example: if you consider reason number 11, in Question F.1, to be the most important, then please write '11' in the first box.

Section G: Other general information about your company unit

G.1 General information on your company unit in 2003:

1. Sales turnover in 2003 (in current £): .....
2. Total number of employees in your company unit in 2003 (full time equivalent): .....
3. Amount spent on R&D in your company unit in 2003 (current £): .....
4. R&D personnel in your company unit in 2003 (full time equivalent): .....
5. Did your company unit engage in R&D in the years 2002 and 2003? (please tick ✓ the appropriate response)

   Continuously ☐ Occasionally ☐ Not at all ☐

Note: Amount spent on R&D should cover current (labour costs, acquisition services, materials,…) and capital expenditure (instruments and equipments, land and buildings,…).

G.2 Has your company unit been involved in any patenting activity in 2002 and 2003? (Please tick ✓ the appropriate response)

Yes ☐ No ☐

If *Yes*, please indicate the number of patents your unit has applied for, and the number of patents that has been granted to your unit, during the calendar years 2002 and 2003:

Applied for: ..... Granted: .....

Please do not leave any question blank. If the answer to the question is zero, then please enter "0" in the corresponding space provided above.

G.3 Has your company unit been involved in any patenting activity in 2002 and 2003, resulting from joint activities with university? (Please tick ✓ the appropriate response)

Yes ☐ No ☐

If *Yes*, please indicate how many patents were the result of joint activities with university during the calendar years 2002 and 2003:

Applied for by both the university and the company: ..... Granted: .....

Applied for by the company only: ..... Granted: .....

Please do not leave any question blank. If the answer to the question is zero, then please enter "0" in the corresponding space provided above.

Section H: Respondent details

H.1 Please provide your name, job title, telephone number or e-mail, and the name of your unit:

Name of respondent: .....

Job title of respondent: .....

Telephone number or e-mail of respondent: .....

Name of company unit: .....

Your comments:

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Thank you for your time in completing this questionnaire.

If you would like a copy of the final report of this study, please check the box: ☐

Please, return this questionnaire using the pre-paid envelope provided.

AIM IPGC Survey of Industry-University Collaboration

This survey aims to map patterns of collaboration between industry and universities in the UK. It takes between 10-15 minutes to complete. It focuses on organisations that have collaborated on Engineering and Physical Sciences Research Council (EPSRC) projects. This research is part of the Advanced Institute of Management's Innovation and Productivity Grand Challenge which is funded by the EPSRC and ESRC.

The results will be used to help inform government policy. For the purpose of this survey a business unit is treated as an organisational unit producing goods or services which benefits from a degree of autonomy in decision making, especially for the allocation of its resources.

Thank you for participating. All responses are confidential.

Personal Details

Name: .....

Organisation: .....

Address: .....

Email: .....

1. How **frequently** has your business unit been engaged in the following types of **activity** in the calendar years 2005 and 2006?

	Not during this period	1-2 times	3-5 times	6-9 times	10-19 times	More than 20 times
Creation of **physical facilities** in collaboration with university researchers						
A new joint **research** agreement (original research work undertaken by both partners)						
A new **contract research** agreement (original research work done by university alone)						
A new **consultancy** agreement (no original research conducted)						
Training of company employees (through course enrolment or through temporary personnel changes)						
Postgraduate training in the company (joint supervised PhD)						
Attendance at **conferences** with industry and university participation						
Recruitment of recent graduates or post graduates						
Student **placements** (undergraduate or postgraduate training in the company)						
Other (please describe):						

2. Private organisations often provide resources to universities. Please assess the **importance** of the following types of **resources** provided by your unit.

	Not at all important	Unimportant	Important	Very important	Crucial
Ideas for **research** projects					
Materials or **equipment**					
Specialised **software**					
Consultancy services					
Funding for research					
Other (please describe):					

3. Please assess the **importance** of the following factors in your units' decision to **interact** with universities.

	Not at all important	Unimportant	Important	Very important	Crucial
Access to **state of the art** science and technology					
Access to **problem solving** capacities					
Access to a **research network**					
Seeking to develop **proprietary knowledge**					
Access to **R&D facilities** not available within the company					
To build up **new research areas** within the company					
To undertake **research** of a highly exploratory nature					
Access to **feedback** during the development process					
Outsourcing research and development activities					
Other (please describe):					

4. What **percentage** of your business units' innovation projects, such as R&D, made use of the following types of **"output" from universities** in the period 2005 and 2006?

	Not applicable	Below 10%	10-40%	41-60%	61-90%	Above 91%
Findings or general knowledge obtained from basic research in the university						
Published results of university research (e.g. articles in journals)						
Prototypes or designs developed by university researchers						
Instruments and techniques developed by university researchers						
Recently **hired graduates** or postgraduates						
Support to **solve problems** at early stages of innovation projects						
Concurrent (real time) **feedback** throughout innovation projects						
Support to **solve problems** at late stages of innovation projects						
Consultancy and advice services provided by university researchers						

5. Please assess the **importance** of the following **benefits** that have resulted from your units' interactions with universities over the last five years.

	Not at all important	Unimportant	Important	Very important	Crucial
Creation of **long term** links with university researchers					
Identification and **recruitment** of high calibre employees					
Improved **understanding** of foundations of particular phenomena					
Generation of new **equipment** or instruments (including software)					
Sources of information suggesting new projects and identifying future trends					
Generation of **intellectual property** (patents and or design rights) in products or processes					
Assistance in **problem solving** (e.g. support in the development process)					
Contribution to the successful **market introduction** of new products/processes					
Cost reduction in the product or process development (e.g. new prototypes)					
Reducing the **time** required for the completion of the company's R&D					
Generation of new/improved **research procedures** or techniques					
Other (please describe):					

6. Please indicate your **level of agreement** with the following statements concerning **barriers** to interaction with universities.

	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
University research is extremely orientated towards **pure science**					
Industrial liaison offices tend to oversell research or have **unrealistic expectations**					
Long term **orientation** of university research (concerns over lower sense of urgency of university researchers compared to industry researchers)					
Potential **conflicts** with university regarding royalty payments from patents or other intellectual property rights and concerns about confidentiality					
University researchers seeking immediate **dissemination** of research outcomes					
Difficulty in finding the appropriate university **partner**					
Lack of **information** about what university departments actually do					
Lack of suitable government **funding programmes** for university – industry joint research in specific areas					
Rules and **regulations** imposed by universities or government funding agencies					
The relevant university departments are (geographically) **too far away**					
Mutual lack of **understanding** about expectations and working practices					
Absence or **low profile** of industrial liaison offices in the university					

7. Please list **five universities** which you **collaborate** most frequently with in your innovative activities.

University One	
University Two	
University Three	
University Four	
University Five	

8. Please indicate your **level of agreement** with the following statements about your **relationship** with universities.

	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
During the relationship, our university partners treated our **problems constructively** and with care					
Our university partners may use **opportunities** that arise to profit at our expense					
Based on past experience, we cannot have **complete confidence** in our university partners to keep promises made to us					
We are **hesitant to interact** with our university partners when our needs and requirements are vague					
We **trust** our university partners to treat us fairly					
We **trust** that confidential/proprietary information shared with our university partners will be kept strictly confidential					

9. How would you characterise the **nature of knowledge** that you have **exchanged** with universities? Please indicate your level of agreement with the statements below.

	Strongly disagree	Disagree	Indifferent	Agree	Strongly agree
It was already **well documented**, contained in reports, documents and self-explanatory software					
It could be **easily explained** to others in my organisation in writing (in emails, software code, written reports, manuals, scientific papers etc.)					
It was mainly **personal practical know-how**, tricks of the trade					

10. What is your highest **academic qualification**?

A Level/GCSE	Diploma	BSc/BA	MA/MSc/MBA	Doctoral

11. Is your business **independent**? i.e. not part of a larger firm or a subsidiary/division/head office/central R&D unit.

Yes ☐ No ☐

11b. If your business unit belongs to a larger firm, where is the **head office located**?

11c. If your unit is part of a larger firm, what type of business unit is it? Please select the appropriate response from the list below.

Subsidiary	Head office	Central R&D unit	Other:

12. What is the main **industrial or commercial activity** of your business unit?

13. What was your business unit's **sales turnover** for 2006? (in current £000k)

14. What was your business unit's **total number of employees** in 2006? (full time equivalent)

15. Please estimate (either from management accounting information or using informed estimates) your business unit's **expenditure on R&D** in 2006 as a percentage of your unit's total sales turnover for that year.

0%	1-2%	3-5%	6-10%	11-40%	41-100%

16. Approximately what percentage of the staff in your business unit have higher education degrees?

0-5%	6-10%	11-20%	21-40%	41-60%	61-100%

17. Would you like to receive an Executive Summary of this research?

Yes ☐ No ☐

18. Please add any further comments below

Thank you for your time in completing the survey.

About the Innovation and Productivity Challenge

The main goal of the Innovation and Productivity Grand Challenge is to improve the understanding of how firms create and use knowledge. Recent evidence suggests that the UK is good at producing scientific knowledge. It is ranked second only to the US for academic citations and the UK also ranks fifth in the world for PhDs per unit HERD (Higher Education R&D spend). But the big question remains are UK firms able to *apply* the knowledge as effectively as they create it?

Here the news is mixed. Anecdotal evidence suggests that the UK is good at invention but poor at innovation. The fact is that the UK's innovation from knowledge systems does work. Our research seeks to explore if the current system can be made more efficient at a time when the innovation model is changing.

Now innovation is increasingly about managing flows of knowledge across complex and often global networks as knowledge is often created on a truly international stage new models have been developed.

This raises important questions for the future. How does an effective innovation from knowledge system work in this new system? Who plays the knowledge networking game well and what can we learn from them in order to generate a best practice model? Do we need to create new ways of helping the flow of knowledge through better linkages, bridges and brokers?

These are just some of the topics our researchers are dealing with. Our team comprises a network of five major universities – Cambridge, Liverpool, Loughborough, Cranfield and Imperial College – along with the Advanced Institute of Management, which has links to other UK and international researchers. Our research also benefits from an excellent Advisory Board led by Richard Lambert, Director General of the CBI.

Please contact *ipgc@imperial.ac.uk* for further information about the research.

INNOVATION AND PRODUCTIVITY GRAND CHALLENGE

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