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NCUB
National Centre for Universities and Business

Knowledge Exchange in UK Universities

Results from a Panel of Academics 2005 - 2015

CBR

UNIVERSITY OF CAMBRIDGE

Imperial College Business School

UNIVERSITY OF BATH SCHOOL OF MANAGEMENT

Writen by: Cornelia Lawson, Alan Hughes, Ammon Salter and Michael Kitson with Anna Bullock and Robert B. Hughes


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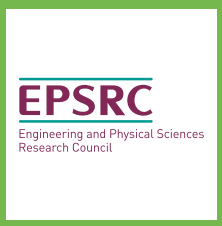
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The final steering group for the project which was responsible for oversight, review and final sign-off of the report, included Jeremy Neathey, ESRC, Ian Viney, MRC, Alex Herbert, HEFCE, Sue Smart, EPSRC, Philip Heads, NERC, Sumi David, AHRC, Dominic Rice, BIS Carolyn Reeve, BIS and Bev Sherbon of MRC. The survey team is extremely grateful to them for their comments, encouragement and support throughout the development of the survey and of this report. The core team also owes a large debt of gratitude to Rosa Fernandez of NCUB who chaired the Steering Group for her sustained and helpful project management and for many valuable comments made during the preparation of this report.

The project team is, of course, hugely indebted to the tens of thousands of academics who responded to the survey.

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Executive Summary

- This report draws upon a unique panel dataset to understand the extent, nature and persistence of academic engagement with external organisations in the UK. The data relate to 4,059 UK-based academics who responded to each of two national surveys covering all academics in all disciplines in all UK Higher Education Institutions. The two surveys were carried out in 2008/9 and 2015. They generated data relating to the three year period prior to each survey. The data thus covers the period 2005 to 2015. It provides a comprehensive and unprecedented opportunity to examine changes in the scale and modes of engagement connecting UK academics with external organisations.

- The survey data identifies 25 separate modes of interaction with external organisations.

- These modes of interaction can be combined into 5 groups of correlated activities. The first group labelled *training* relationships encompasses 4 modes. These are employee training, student placements, joint curriculum development and enterprise education. The second group labelled *meetings, consulting and advice* consists of 7 modes which do not require new original research. It includes attending conferences, standard setting forums, network participation, sitting on advisory boards, consultancy services, invited lectures and informal advice. Group three labelled *joint research* includes 6 modes which are joint research agreements, hosting of personnel, secondment of personnel, contract research, research consortia and joint publications. The fourth group labelled *commercial activities and services* includes 5 modes which are licensing research outputs, patenting and prototyping for external organisations, as well as the creation of new spin-out companies and setting up new physical facilities. Finally group five labelled *public engagement* includes 3 modes which are engagement through school projects, public lectures and public exhibitions.

- Most academics engaged in a very wide range of the 25 individual modes of interaction and persisted in doing so over the two periods captured in the surveys. The results also show that those academics that did not report engagement with external actors in the first survey were also unlikely to report engagement in the second survey. So both engagement and non-engagement are persistent patterns of behaviour.

- In the majority of the 25 individual modes of interaction, activity declined slightly or stayed roughly the same between the two survey periods. However, joint publication, hosting of personnel, sitting on advisory boards and lectures for the community each of which are highly frequently cited modes of interaction in both surveys were all higher in the second survey. The same was true of the much lower frequency activity of enterprise education.

- Taken as a whole these results suggest that for the majority of academics engagement is a recurrent persistent activity, firmly rooted in academic practice across the UK and across a full range of disciplines.

- When the data is analysed using the 5 groups of interaction modes a number of findings emerge. First there was a significant decrease for the *meetings, consulting and advice* group both in the mean number of modes used and in the share of respondents engaging in them. In contrast the *public engagement* group shows a significant increase in users and in the number of modes used between the survey periods.

- If we focus on each of the 5 groups of modes of interaction separately we find considerable persistence within each. This suggests that developing engagement in a group of correlated modes is a learned activity that academics sustain over time. The research also shows that some groups of engagement modes contain more persistent engagement than others. Activities in the *meetings, consulting and advice, joint research* and *public engagement* groups all show highly persistent involvement. Equally non-engagement also persists. Thus for the *commercial activities and services* group only 11% of non-active academics in 2008/9 reported active involvement in 2015.

- The results for the individual groups also show that reduced engagement within a group by some academics is counter-balanced by increased engagement efforts by other academics. The result is that although the level of engagement of individual academics may vary over time, the total level of engagement within each group is fairly constant.

- The multivariate analysis of academic persistence taking all 5 groups together rather than individually shows that the decision to sustain engagement levels is largely explained by past engagement efforts and the research orientation of the individual. Prior experience in engagement and a research orientation towards applied or user oriented basic research are positively related to future engagement. These forces are particularly associated with persistence in the *commercial activities and services* group of modes of interaction.

- Women have a lower propensity to engage through *commercial activities and services* than men, but a higher propensity to engage through *meetings, consulting and advice* and *public engagement.*

- Academic motivations for engagement are related to five areas: *learning* (informing and testing own research), access to *resources* (funding for research, specialist equipment and materials, expertise of external organisations), *teaching* (student placements and teaching content), *financial* (personal income and business opportunities), and to foster the university's outreach *mission*. The survey reveals that learning is the most important motivation for academics, while *financial* benefits were ranked lowest.

- Those academics motivated in their engagement activities by opportunities to learn and gain access to resources are more likely to be persistent in engagement efforts. In contrast, those motivated by promoting outreach are more persistent in their public engagement activities. This suggests that engagement persistence is partly driven by the underlying motivations of academic for engagement and that such motivations may shape the efforts of academics over time to sustain different modes of engagement.

- Academics' decisions to enter and exit engagement with external actors are shaped by overall attitudes to engagement and their perception of the availability of external partners. The perceived lack of external partners increases the likelihood of non-persistence in *training, joint research* and *public engagement* groups while a negative engagement attitude increases the propensity to not persist with modes of interaction in the *meetings, consulting and advice* group.

Section A

Introduction

Universities are frequently viewed as key drivers of economic growth. There has been a continued debate about the extent to which collaboration between the academic and non-academic sectors is a fundamental enabler of this role. Surveying academics about their external interactions contributes to a better understanding of these processes and how policy can intervene to further foster knowledge exchange and disciplinary research.

Between September 2008 and June 2009 the largest ever survey of UK academic engagement with external organisations was undertaken by the Centre for Business Research covering the three year period prior to the survey (2005-2008). This original web-based survey attracted over 21,000 responses (Abreu et al., 2009). In 2015 a new survey was launched that covered the period 2012-2015 and attracted over 18,000 responses (Hughes et al. 2016). These are the two largest research and knowledge exchange surveys ever completed of a national Higher Education System. Both surveys highlighted the multifaceted role of the university and provided evidence of a "third mission" that is inclusive of all publics (public, civic and business) and research areas (humanities, social and natural sciences). The large and representative sample sizes permit the identification of a large panel of academics that responded to both surveys r and form the basis for a robust longitudinal analysis of change within the UK higher education institution (HEI) sector.

The themes covered in both surveys relate to work roles and their recognition by the university, the balance between basic and applied research, the range and breadth of external knowledge exchange interactions and how they are initiated, and the motivations and constraints experienced by academics when engaging in knowledge exchange activities.

Hughes et al. (2016) showed, using a matched sample approach, that engagement levels through most types of activities declined slightly or stayed the same between the two survey periods. The matched sample approach compares samples of respondents from each survey matched by their characteristics at the respective survey dates such as age and seniority alongside discipline and a wide range of other characteristics. This is useful and important for gauging average changes between the survey periods controlling for overall sample changes in those characteristics.

This report in contrast focuses on the persistence in engagement behaviour between the two surveys using the panel of academics who responded to both surveys. Some of their characteristics (e.g. age) will have changed over time for all of the panel members but others may have changed for some but not others (e.g. seniority). This report specifically focuses on these individuals' changes in external engagement. We do this taking into account the institutional context of each panel member, their individual motivations and their perceived constraints. These are key elements for understanding behavioural change and are important for explaining changes in the engagement behaviour of individuals. These considerations are, in particular, directly pertinent to questions of the development of policy incentives designed to alter the patterns of engagement activity at the level of the individual academic; issues that cannot be properly addressed without the kind of panel data analysis presented in this report. To the best of our knowledge this represents the first longitudinal survey data evidence on academics' engagement with external organisations.

Section B

The CBR Academic Surveys 2008/9 and 2015

This section discusses methodological issues related to the two CBR academic surveys. This includes information on sampling and non-response bias.

Coverage, Sampling and Response

The CBR academic surveys of 2008/9 and 2015 were not originally designed to produce a panel survey but rather as a stand-alone survey of the full population of academics in the UK. The sampling frame in each case included all academics active in teaching and/or research in each sample period in all disciplines in all UK HEIs. For each survey lists of academics in all departments and faculties were manually collected from the websites of UK HEI. This email directory provided the sampling frame to which a web-based questionnaire was addressed in each case. Both surveys were conducted online. The 2008/9 survey frame identified 125,900 valid email addresses and received 21,598 valid responses (response rate of 17%). The 2015 survey frame identified 131,088 valid email addresses and received 18,177 responses (response rate of 14%). Exhibit 1 gives an overview over survey responses. Comprehensive non-response analyses were performed on both surveys. A small bias towards older and slightly more engaged academics was found.

Exhibit 1 Academic survey response 2008/9 and 2015 surveys

	2008/9	%	2015	%
Total Sample*	126,120		140,312	
Less:				
No Longer at Institution/Undeliverable	220		8,422	
Not Eligible			802	
	220		9,224	
Total Surveyed Sample	125,900		131,088	
Not Eligible Responses**	867		162	
Complete Responses	21,598		18,177	
Response Rate [complete responses]		17.3		13.9

* The sample consists of all HEIs in England, Scotland, Wales and Northern Ireland.

** Responses were excluded because the survey indicated inactivity through e.g. retirement or the respondents were students or administrative staff and as such not eligible to participate.

Exhibit 2 Sample characterstics 2008/9 and 2015 surveys (% of respondents)

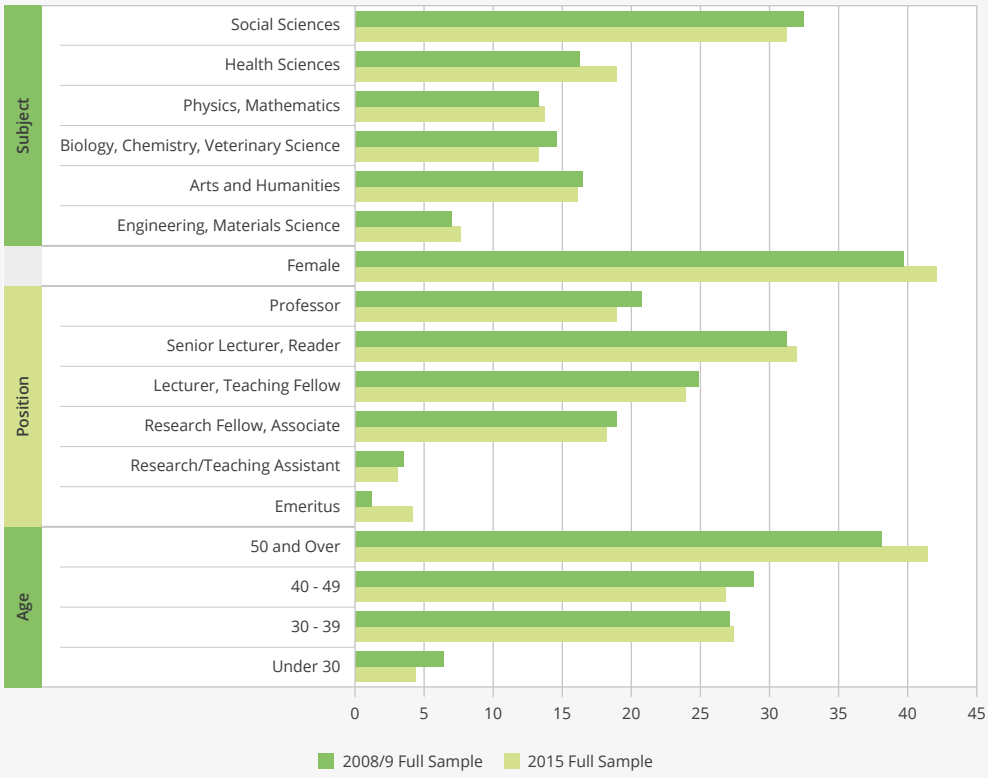


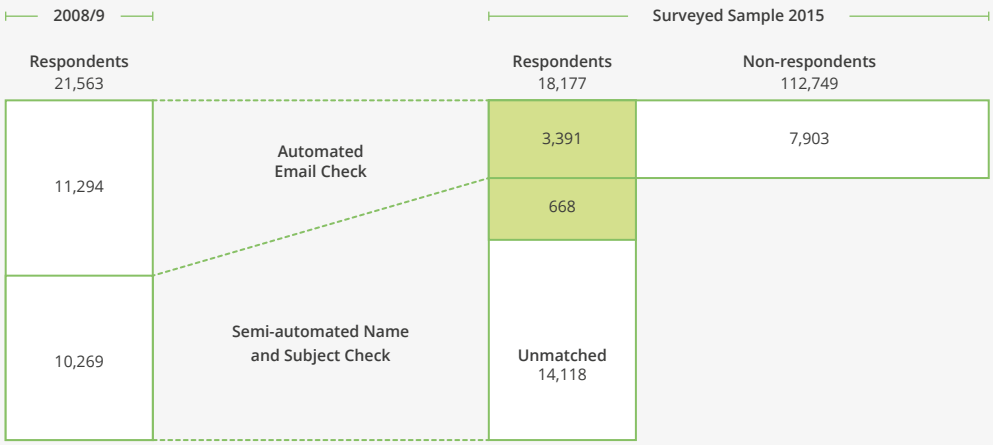
Exhibit 2 shows the distribution of academics in both surveys broken down by disciplinary area, gender, seniority and age. The seniority and subject distribution in 2015 is very similar to 2008/9, however, the share of women has increased by a small amount from 40% in 2008/9 to 42% in 2015. The 2015 sample is also slightly older with a higher share of respondents over the age of 50.

Data Processing and Non-response Analysis

In order to build a panel of academics we had to identify those that answered to both surveys whilst maintaining the confidentiality under which each survey was conducted. This was done in two steps (see Exhibit 3). First, all email addresses collected during the two surveys were standardised[1] and compared. To ensure that email addresses had not been reassigned we also checked for name matches. In total, 11,294 academics that had responded to the 2008/9 survey were contacted in the course of the 2015 survey using the same email address; 3,391 of these replied to the 2015 survey round. Second, to try and deal with problems arising from email address changes caused for example by changing universities we compared the 2008/9 respondents and 2015 respondents based on name and subject area and conducted some manual cross-checking. This process utilised no other data from the two surveys the data from which is kept in separate anonymized files from the contact address data. A new anonymized panel dataset was then created separately from the files containing panel email addresses and names. In this new anonymised dataset we compared the age in both surveys and discarded those matches where the age in 2015 was lower than in 2008/9. Following this process we were able to identify an additional 668 academics that had replied to both surveys. We thus have a total of 4,059 academics in our panel.

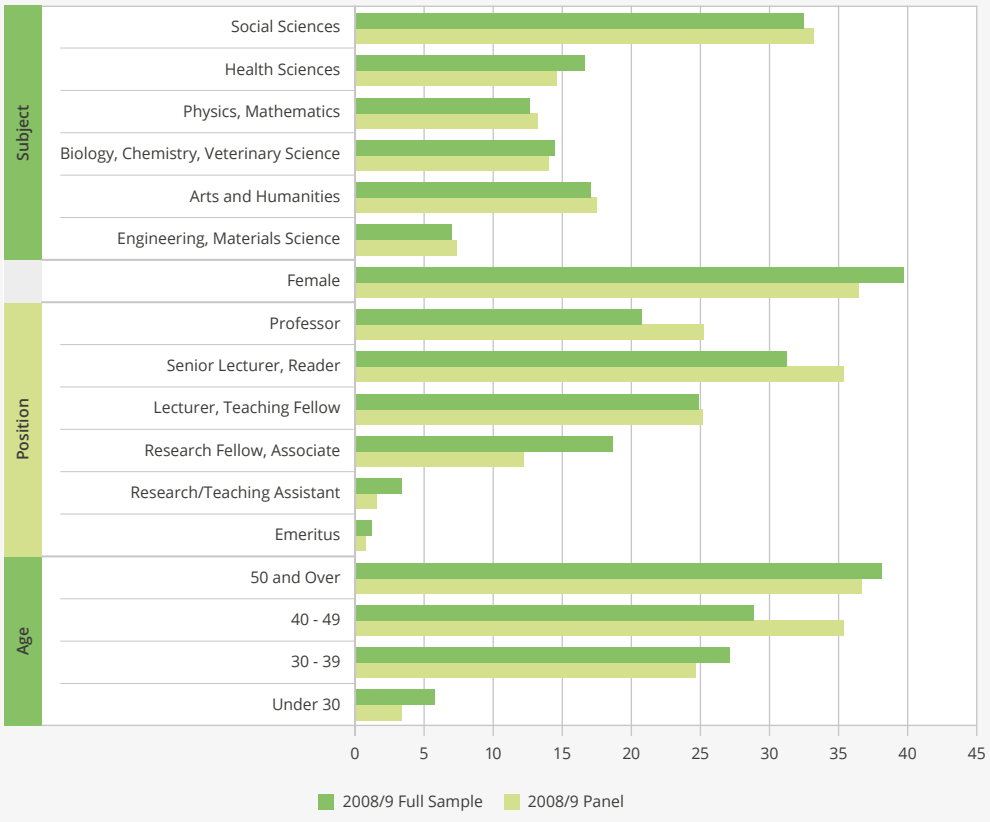
1 Standardisation was necessary where universities have more than one email domain (e.g. le.ac.uk and leicester.ac.uk), use prefixes (e.g. elec.strath.ac.uk), or changed name or merged (e.g. leedsmet.ac.uk became leedsbeckett.ac.uk).

Exhibit 3 Matching procedure 2008/9 and 2015 surveys



The characteristics of the panel respondents in 2008/9 compared to the full 2008/9 respondent sample are provided in Exhibit 4. They show that the panel sample was more likely to be drawn from senior academics and men. These are the groups that are known to be more likely to interact with external organisations. This sample composition means that we may have a bias towards more external engagement within the panel.

Exhibit 4 Sample characterstics 2008/9 full sample and panel (% of respondents)



Changes in the sampling frame populations between the two years meant that not all academics could be surveyed twice. Some had retired or left for other reasons since 2008/9, while some had entered newly into academia. This compounds the potential problems arising from the fact that not all of those contacted in both surveys replied both times. We therefore estimate a selection model to see which 2008/9 respondents are more likely to reply, taking into account whether or not they were included in the second sampling frame.[2] This will help to establish whether there is a non-response bias in our panel. Demographic characteristics should explain the propensity to be contacted while prior engagement experience should increase the propensity to respond. Results are reported in Exhibit 5 and confirm these assumptions.[3]

The results show that those employed in non-tenure track roles (research fellow, assistant or teaching fellow contracts) in 2008/9 are less likely to have been surveyed again compared to professors, senior lecturers or lecturers (75% less likely in the case of research fellows). Also, those that had already retired in 2008/9 are less likely to still be in academia in 2015 and therefore less likely to be in the sample frame for that year. The oldest and youngest groups of academics are less likely to be resurveyed compared to those that were between the ages of 30 to 49 in 2008/9. Older academics may have retired and younger academics may have been in casual employment and left. Exhibit 6 plots the propensity to be resurveyed for different age groups. It shows that those between the ages of 40 and 49 have an almost 60% propensity to be surveyed again.

Other characteristics are also significant. Those that had management responsibility at the time of the first survey or held research council grants[4] are more likely to be contacted again in the second survey. The latter, in particular, is a very strong predictor for having remained in an academic post. In contrast, those that had professional experience outside academia prior to the 2008/9 survey are slightly less likely to still be in the 2015 sample frame population. There are also some minor differences by subject area. Academics in the arts and humanities are more likely to be in both sample frame populations, as are those in physics and mathematics. In contrast, those in health sciences are less likely to be included in both.

Taking into account the probability of being in the second survey frame population, the Stage 2 column in Exhibit 5 looks at the characteristics in 2008/9 influencing whether a response is received in 2015 from those academics surveyed.

The 2008/9 survey asked about external engagement in the previous three years through a variety of channels which were grouped into four categories: commercial, people-based, problem-solving and community-based activities (see Hughes et al., 2016). We find that those involved in more community-based or problem-solving interactions in the three years prior to 2008/9 are more likely to respond to the 2015 survey, however, the effects are very small. For example, those engaged through a high number of different problem-solving activities are about 9% more likely to respond than those with a medium number of different activities. Neither involvement in teaching nor research orientation affect response propensity. We do, however, find that women are slightly less likely than men to respond again. It is notable that the seniority and age effects which influence inclusion in the second survey have little or no effect with regard to their decision to respond to that survey. They are therefore not included in the second stage. Taken as a whole these results suggest that we do not need be too concerned about non-response bias relating to the characteristics examined.

2 Strictly speaking this test is not comprehensive since we cannot analyse individuals who were non-respondents in the second survey but who had changed their institution and hence email address compared to the first survey.

3 Most demographic criteria, such as seniority, age and discipline serve as exclusion restrictions in the first stage as they are expected to determine whether academics have remained in academia and are contactable but not whether they respond again. The exclusion restrictions are supported as none of these variables significantly influence response if included in the second stage.

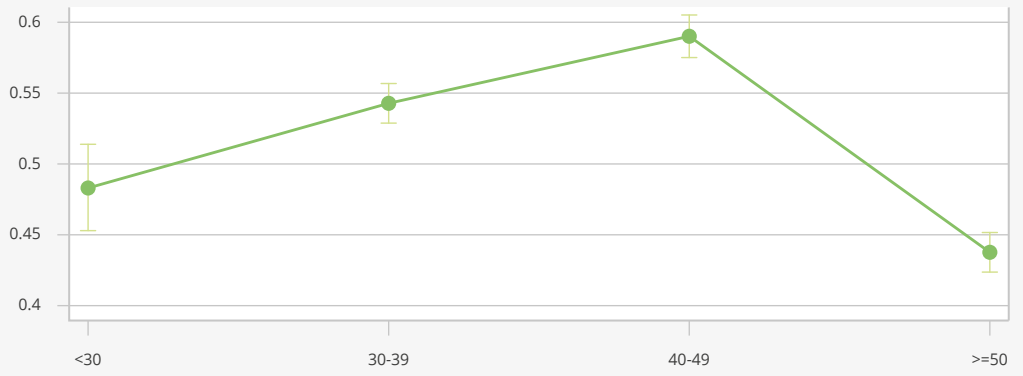
4 Research council funding data was provided by the research councils.

Exhibit 5 Propensity of 2008/9 respondents to reply to 2015 survey, conditional on being in the 2015 sampling frame population

		Stage 1 Surveyed 2015			Stage 2 Responded 2015		
		Coef.	S.E.		Coef.	S.E.	
Gender	Female	-0.01	0.02		-0.06	0.03	*
Research Orientation$_{09}$	Basic				base		
	User-inspired				-0.02	0.04	
	Applied				-0.05	0.04	
	None				-0.04	0.08	
External Engagement$_{05-08}$	Commercialisation				-0.03	0.03	
	Community-based Intensity				0.05	0.02	**
	Problem-solving Intensity				0.09	0.02	**
	People-based Intensity				0.00	0.02	
Activity$_{09}$	Teaching				0.01	0.05	
Rootedness in Academia	Management Responsibility$_{09}$	0.08	0.02	**			
	Research Council Funding$_{05-08}$	0.30	0.03	**			
	Professional Experience Outside HEI$_{09}$	-0.09	0.02	**			
Position$_{09}$	Professor	base					
	Senior Lecturer/Reader	-0.01	0.03				
	Lecturer	-0.06	0.03				
	Emeritus/Honorary (retired)	-0.23	0.09	*			
	Research Fellow	-0.75	0.04	**			
	Research Assistant	-1.05	0.06	**			
	Teaching Fellow	-0.50	0.07	**			
Age$_{09}$	>50	base					
	40-49	0.38	0.02	**			
	30-39	0.21	0.03	**			
	<30	0.03	0.05				
Discipline$_{09}$	Social Sciences	base					
	Arts and Humanities	0.14	0.03	**			
	Biology, Chemistry, Vet Science	0.01	0.03				
	Engineering, Materials Science	0.07	0.04				
	Health Sciences	-0.11	0.03	**			
	Physics, Mathematics	0.11	0.03	**			
Institution Type$_{09}$	Younger Universities (Est post-1992)	base					
	Top-decile Research Institutions	0.06	0.03	*			
	Older Universities (Est pre-1992)	0.04	0.03				
	Specialist Institutions	-0.04	0.07				
Constant		0.11	0.04	**	-0.71	0.09	**
Region$_{09}$	Joint Significance - chi2 (11)				20.50		**
Log Likelihood					-19140.447		
Number of Observations					20,630		
Number of Uncensored Observations					11,594		
rho					0.1298	0.0621	*

Note: Heckman selection model; ** Statistically significant at the 1% level; * Statistically significant at the 5% level. Subscripts indicate years.

Exhibit 6 Propensity of 2008/9 respondents to be surveyed in 2015 by age group

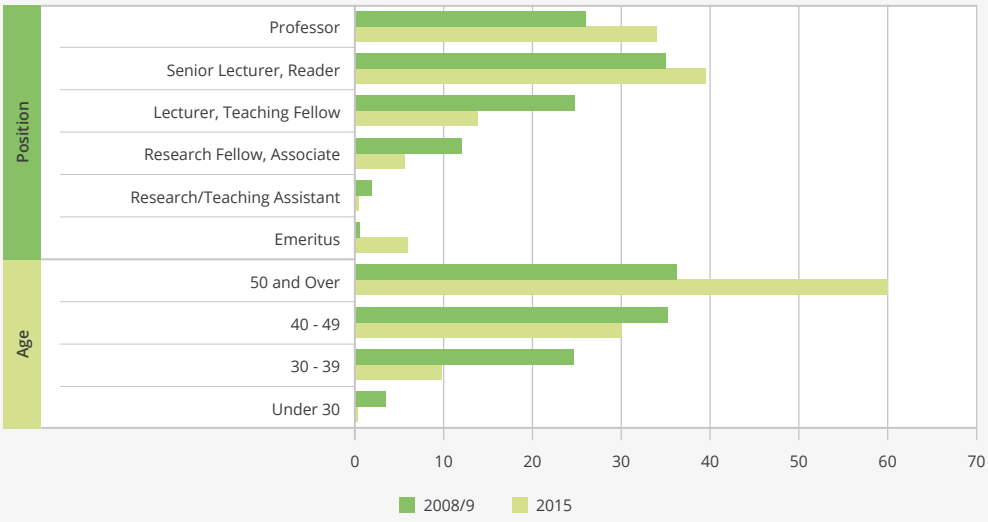


Note: Predictive margins with 95% confidence intervals.

Panel Description

The sample characteristics of the panel in 2008/9 in terms of age, gender, position and subject area were reported in Exhibit 4. Since the 2008/9 survey some respondents have experienced changes in employment and, of course, age; 36% were promoted to a higher academic rank (e.g. from lecturer to senior lecturer) and 16% changed university between 2008/9 and 2015. The share of those securing promotion is higher amongst mobile academics (54%), as many academics will move for career progression. As a result, the share of senior academics in 2015 is much higher than in 2008/9 and the majority of the 2015 panel sample are aged 50 or above (60%). Exhibit 7 reports the sample characteristics of the panel in 2008/9 and 2015.

Exhibit 7 Sample characterstics of panel in 2008/9 and 2015 (% of respondents)



Section C

Introduction to External Engagement

The CBR academic survey covers a wide range of knowledge exchange engagement activities. This includes patenting licensing, spin offs and business start-ups including consultancies. It also includes a wide range of other activities including involvement in training, collaborative and joint research, advisory board membership, meetings and consultations, and community based activities involving the wider public. While patenting, licensing and business start-up have been subject to intense discussion and analysis, the other wider range of activities have been given less attention. The 2008/9 CBR academic survey was the first to demonstrate the great scale of the latter relative to the former. It also showed that this was true for academics in all disciplines and that these activities spanned the public and private sectors. The CBR survey of 2015 expanded the number of engagement activities surveyed, and confirmed the pattern of the earlier survey. In this report we must, of necessity, limit the analysis to those survey items which are covered in both survey rounds.

In total the 2008/9 survey asked about academics' involvement in 25 engagement forms.[5] It enquired about the frequency of involvement only in the case of patenting, licensing and start-ups. We carried out a factor analysis (principal component analysis) to determine potentially underlying common rationales of engagement.[6] As a result we categorised activities into five groups. The first group labelled *training* relationships encompasses the training of company employees and joint student project-supervision and placements. The second group labelled *meetings, consulting and advice* includes informal exchanges with external organisations and advisory agreements that do not require original research. Group three labelled *joint research* includes commissioned research as well as original joint research that can involve research consortia or personnel exchange and can result in joint publications with external partners. The fourth group labelled *commercial activities and services* includes patenting and prototyping for external organisations, as well as the creation of new companies and new physical facilities. Finally group five labelled *public engagement* includes engagement through school projects, and public lectures and exhibitions. The full listing of the 25 forms of engagement and the five groups are shown in Exhibit 8.

Exhibit 8 shows that in the majority of cases activity declined or stayed roughly the same between the two survey periods. Joint publication, hosting of personnel, sitting on advisory boards and lectures for the community each of which are highly frequently cited activities in both years were all however higher in the second survey. For example, 283 more academics gave lectures to the community in 2012-15, an increase of 14% compared to 2005-8. The same was true of the much lower frequency activity of enterprise education, where 68 more academics are now involved.

5 Two additional channels of engagement were surveyed but are excluded here. One is the provision of community sports which does not play an important role for academics and does not correlate well with other activities surveyed. We also exclude responses to a question which asked whether researchers ran a consultancy via their research because of its overlap with a separate question on the provision of consultancy services.

6 Principal component analysis results are reported in Exhibit B1 in Appendix B.

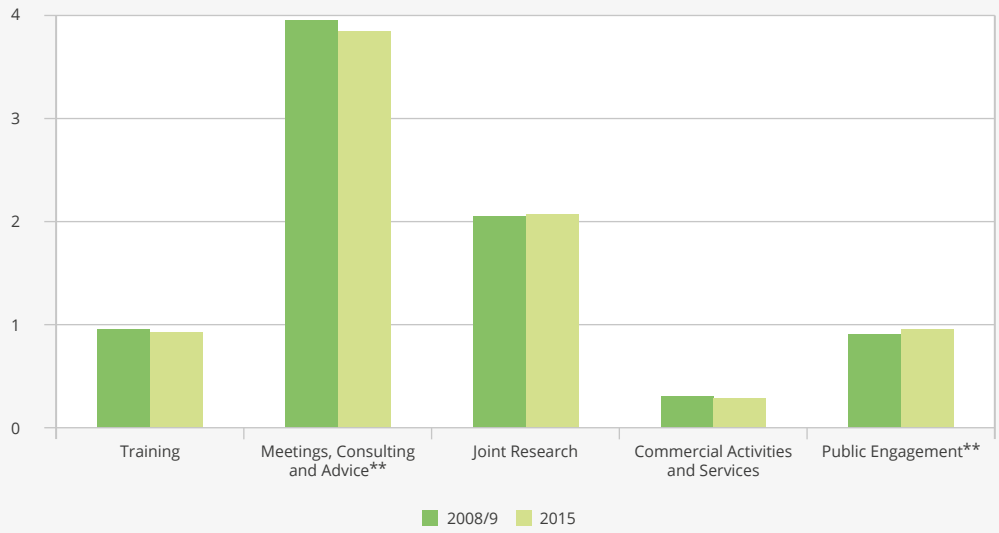
Exhibit 8 Engagement activities (% of respondents)

Group	Engagement Activity Included in Questionnaire	2005-2008	2012-2015	Difference	Diff in No. of Academics
Training	At Least One of the Below	55.1	53.7	-1.5	-60
	Employee Training	30.4	28.7	-1.7 *	-69
	Student Placements	34.1	32.8	-1.3	-51
	Joint Curriculum Development	25.7	23.8	-1.8 *	-75
	Enterprise Education	5.3	7.0	1.7 **	68
Meetings, Consulting and Advice	At Least One of the Below	94.5	92.5	-1.9 **	-79
	Attending Conferences	86.8	81.8	-5.1 **	-205
	Standard Setting Forums	28.8	26.2	-2.5 **	-103
	Participating in Networks	67.5	67.8	0.3	11
	Sitting on Advisory Boards	39.6	42.9	3.3 **	133
	Giving Invited Lectures	67.1	62.9	-4.2 **	-171
	Consultancy Services	44.6	36.8	-3.7 **	-152
	Informal Advice	59.3	55.5	-7.8 **	-317
Joint Research	At Least One of the Below	73.5	73.8	0.3	11
	Joint Publications	46.5	51.7	5.1 **	209
	Hosting of Personnel	28.6	34.3	5.7 **	232
	External Secondment	9.6	10.4	0.8	33
	Joint Research Agreements	50.0	48.3	-1.7	-69
	Contract Research	39.0	32.6	-6.4 **	-258
	Research Consortia	36.8	34.9	-1.8 *	-74
Commercial Activities and Services	At Least One of the Below	21.4	20.6	-0.8	-31
	Setting up Physical Facilities	8.8	9.9	1.1	44
	Prototyping and Testing	9.3	9.4	0.1	5
	Taken Out a Patent	8.4	6.7	-1.7 **	-55
	Licensed Research Outputs to a Company	5.8	4.4	-1.4 **	-46
	Formed a Spin-out Company	4.3	3.9	-0.5	-16
Public Engagement	At Least One of the Below	57.0	61.2	4.2 **	169
	Lectures for the Community	41.5	48.5	7.0 **	283
	Public Exhibitions	13.2	13.5	0.3	11
	School Projects	31.3	30.2	-1.1	-44

Note: Statistically significant difference in the proportions of engaged/non-engaged between the two periods at the 1% (**), 5% (*) level using McNemar's chi-square test.

Exhibit 9 reports the average number of activities that people use in each of the five categories and shows that activities on this basis declined or stayed roughly the same between the two survey periods. We see a statistically significant but very small decrease for *meetings, consulting and advice* activities in the mean number of modes used. In contrast, *public engagement* shows a statistically significant but extremely small increase in the number of modes used between the survey periods. In sum the quantitative significance of the changes is very minor.

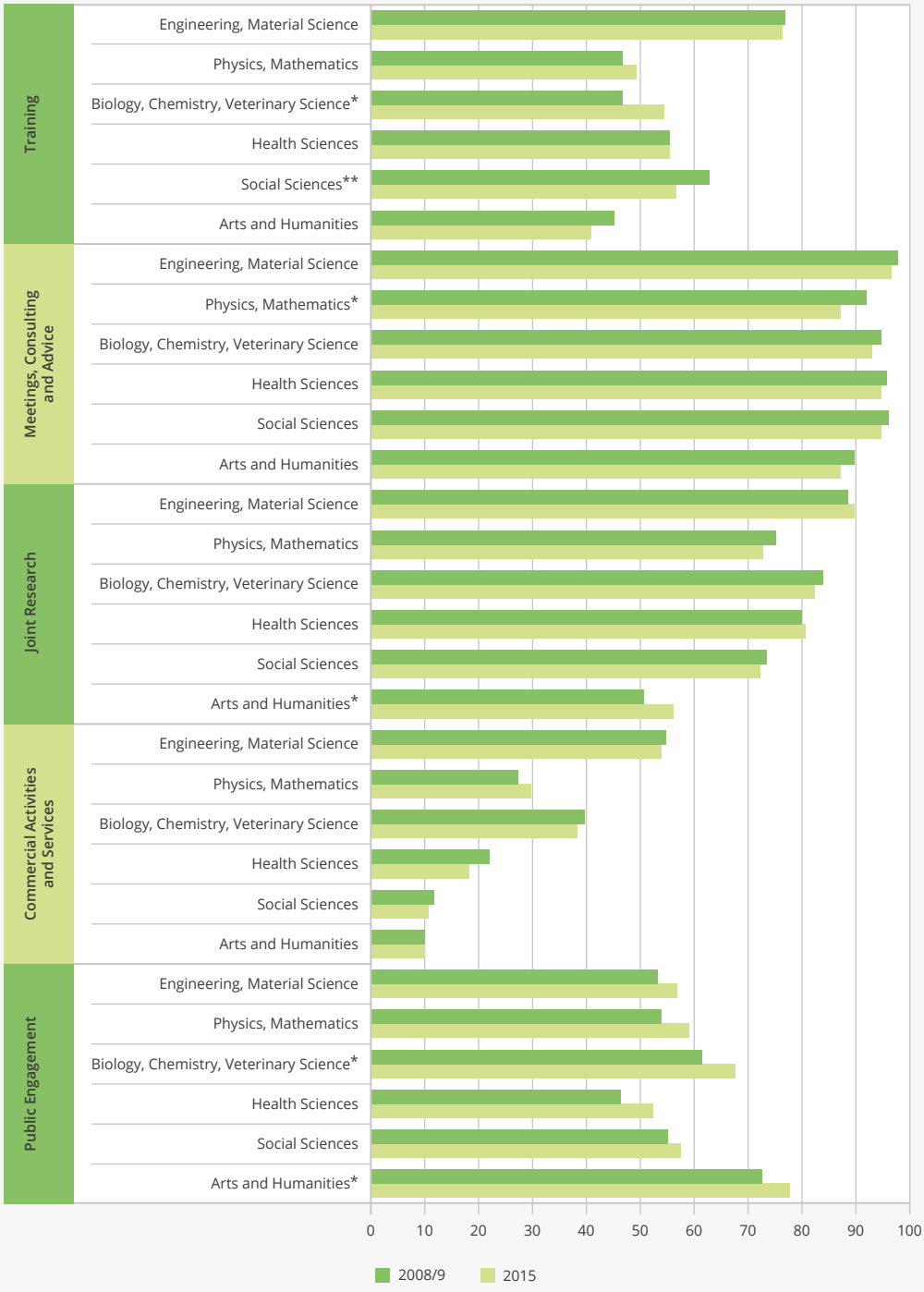
Exhibit 9 Mean number of engagement activities



Note: Differences between the two periods statistically significant at the 1% (**), 5% (*) level using mean comparison test.

Engagement activities did not decline or increase equally across different disciplinary fields. Exhibit 10 reports the share of respondents that interact with external organisations through any of the five different modes in the two periods. It shows that *training* relationships primarily declined in the social sciences and arts and humanities, but increased for academics in biology, chemistry and veterinary science. *Meetings, consulting and advice* interactions declined slightly for academics in all fields, though this decline was statistically significant only in physics and mathematics. Interactions through *joint research* have largely stayed the same. There was, however, a small increase in arts and humanities. *Public engagement* has increased in all fields, and statistically significantly so in arts and humanities and in biology, chemistry and veterinary science.

Exhibit 10 Engagement activities by disciplinary field (% of respondents)



Note: Differences between the two periods statistically significant at the 1% (**), 5% (*) level using mean comparison test.

Section D

Persistence in External Engagement

There is little empirical evidence in the research literature on the dynamics of individual academics' engagement behaviour with external organisations. Most longitudinal engagement indicators have focussed at university or field aggregates and have identified a high and stable share of engagement over the past 15 years (e.g. the Higher Education Business and Community Interaction Survey). Questions that remain unanswered by these indicators are whether it is the same group of academics that engage or whether there is an entry into and exit from engagement activities over the career. The few longitudinal studies available at the level of the individual academic are restricted to a subset of engagement activities (focussing on patents, industry grants and industry co-authorship), disciplines or institutions.[7] Here we are able to look at the patterns of persistence amongst a wide range of different types of engagement activities over time. In particular we can answer questions about the extent of persistence in external engagement at the level of the individual academic, and what drives variations in persistence, exit and entry across individuals, questions that could not be answered to date due to the lack of suitable data (see Perkmann et al., 2013, for a review of the literature on academic engagement).

Sources for persistent behaviour lie within the decision to engage in first place. In other words, the decision to engage with external partners increases the probability to engage in future periods. The reason for this is that contacts have been made and there are thus lower sunk costs; i.e. the academic has gained the experience, skills and network to engage again. In addition there may be certain characteristics that make engagement more likely, including observable characteristics such as disciplinary field, gender or financial resources, and less easily measurable characteristics such as attitude towards engagement, managerial ability or risk taking attitudes.

Engagement Transition Between 2008/9 and 2015

To investigate persistence in external engagement we look at transition probabilities, the chances that individuals either persist in engagement, move into engagement or cease engaging. Exhibit 11 shows that engagement behaviour is persistent but that the level of persistence depends on the type of engagement activity. For example, nearly 71% of academics involved in *training* relationships in the period 2005-8 are still using this activity in the period 2012-15, while 29% stopped their engagement. Also, 67% of those that did not use *training* relationships in the earlier period still do not engage in this way in 2012-15, while 33% started to engage. This also means that the probability to engage through training in the 2012-15 period is twice as high for previously engaged compared to non-engaged individuals. By contrast, in activities involving *meetings, consulting and advice, joint research or public engagement,* continuous engagement is highly persistent (fewer than 6, 16 and 25% respectively stop using these modes). Non-engagement in these areas is less persistent. Thus between 42% and 62% of non-users in 2008/9 report usage of these activities in 2015. This may indicate that hurdles to engage through these channels are small. Still, the propensity to engage in the future is still at least 1.5 times higher for previously engaged compared to previously

7 E.g. Azoulay et al. (2007) using a panel of US life-scientists and using measures of industry-co-authorship and patenting; D'Este et al. (2013) using longitudinal data on industry consultancy and research contracts at universities in Valencia, Spain; Banal-Estanol et al. (2015) using a panel of engineering academics and analysing industry collaboration through UK research council grants.

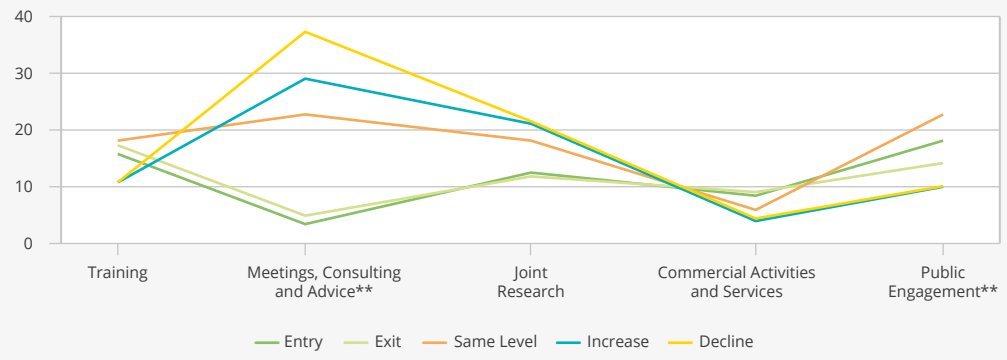
non-engaged individuals. Engagement through *commercial activities and services* appears to be less persistent, with 46% of users in 2008/9 no longer reporting it in 2015. However, non-engagement is even more persistent and only 11% of non-engaged in the first survey start using the activity in the period 2012-15. The propensity to engage is thus more than four times higher for those that were previously engaged, which represents the highest engagement persistency rate of any activity type.

Exhibit 11 Engagement transition probabilities

	% of Engaged That Continue	% of Non-engaged That Enter	Difference (= Persistency Effect)
Training	70.5	33.0	37.6
Meetings, Consulting and Advice	94.3	61.7	32.6
Joint Research	84.1	45.2	39.0
Commercial Activities and Services	54.5	11.4	43.1
Public Engagement	75.9	41.6	34.3

If we compare the share of respondents that enter, exit and continue their external engagement we can make some additional interesting observations. Exhibit 12 shows the share of 2015 survey respondents that entered or left each engagement activity. The graph shows that most of those that stop their engagement are offset by academics that start anew. Moreover, some academics may use fewer or more engagement modes within each of the categories. With the exception of *meetings, consulting and advice,* all decreases in the number of engagement activities by some academics are counterbalanced by increases for other academics.

Exhibit 12 Engagement entry, exit and persistance (% of 2015 respondents)

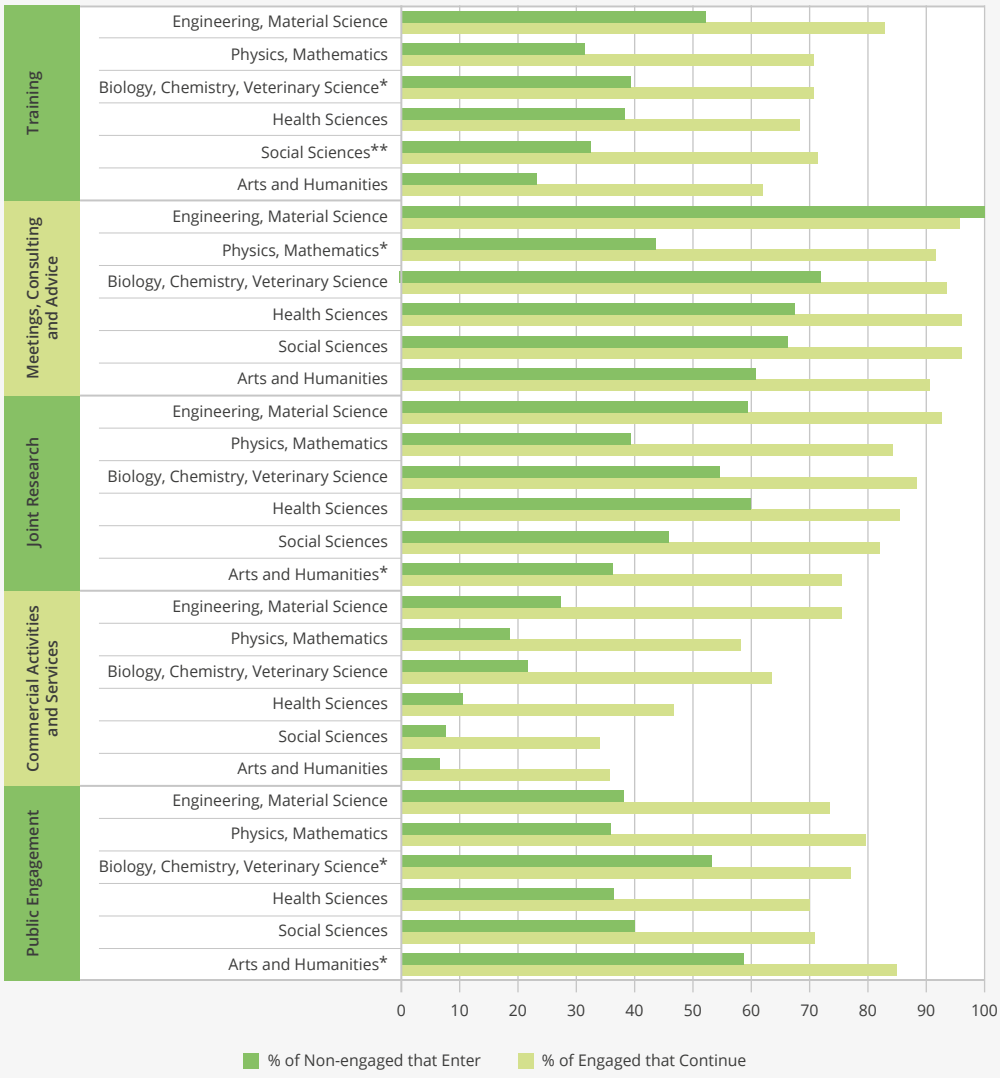


Note: Those that did not engage in either period are not reported. Differences in overall engagement between the two periods statistically significant at the 1% (**), 5% (*) level using mean comparison test.

Transition probabilities may differ by disciplinary field as opportunities may differ. Exhibit 13 confirms that in most cases the propensity to engage in the 2012-15 period is higher for those that were already engaged in the 2005-8 period compared to those that were not regardless of disciplinary field. Notable exception is the engagement through *meetings, consulting and advice* in the case of engineering and material science where there is no difference in propensity. Engagement behaviour is most persistent in physics and mathematics with regard to most of the engagement activities. The only exception is *commercial activities and services,* where engineering and material

science is most persistent. Persistence is defined here as the difference in propensity to engage between the engaged and non-engaged groups. The reason that physics and mathematics has a higher persistence is primarily due to lower entry rates compared to other disciplinary fields. This is perhaps due to differences in the external applicability and technological opportunities of this research or in the demand for engagement with academics in physics and mathematics.

Exhibit 13 Engagement transition probabilities by disciplinary field



Note: Differences in overall engagement between the two periods statistically significant at the 1% (**), 5% (*) level using mean comparison test.

Transition probabilities also depend on the seniority of academic staff. Different career stages come with different opportunities and skills for engagement. Exhibit 14 shows that professors have lower exit and higher entry rates than academics in other positions for most engagement types. This means the propensity to remain engaged increases with seniority in academic rank. The main exception is the entry rate into engagement through *joint research* activities for research fellows, which is higher than that for professors. This may be due to their strong research focus that offers itself to engagement through these activities or through engagement in research funded teams involving more senior leaders.

Exhibit 15 provides some information on engagement persistence by each academic's previous research orientation and teaching duty. It can be seen that engagement through *training* is more stable amongst those that were previously involved in teaching and those that were not involved in research. Those that were primarily involved in applied research have higher entry and lower exit rates in *meetings, consulting and advice* and *joint research* activities compared to those that pursued more basic research lines. Basic research academics and those that do not classify their research as belonging to any of the three research orientations have the highest entry and lowest exit rates in *public engagement.*

Exhibit 14 Engagement transition probabilities by seniority

		Professor	Senior Lecturer/ Reader	Lecturer/ Teaching Fellow	Research Fellow/ Assistant	Retired
Training	% Enter**	36.3	34.1	33.3	27.2	17.8
	% Continue**	70.8	73.1	69.0	53.9	64.3
Meetings, Consulting and Advice	% Enter	70.2	61.4	58.2	77.8	38.5
	% Continue**	96.9	94.7	88.5	92.6	92.7
Joint Research	% Enter**	48.5	46.7	34.7	62.3	42.1
	% Continue**	90.5	80.7	74.2	87.2	81.6
Commercial Activities and Services	% Enter**	14.5	9.5	10.4	16.4	6.2
	% Continue*	60.8	50.2	44.8	46.2	52.8
Public Engagement	% Enter**	47.2	41.1	40.5	32.7	33.3
	% Continue**	79.7	74.2	71.3	69.9	77.0

Note: % enter reported as a share of those that reported non-engagement in 2008/9; % continue reported as a share of those that reported engagement in 2008/9. Statistically significant at the 1% (**), 5% (*) level using Chi-Square test.

Exhibit 15 Engagement transition probabilities by research orientation and teaching

		Research 05-08					Teaching 05-08	
		None	Basic	User-inspired	Applied	Other	No	Yes
Training	% Enter	27.9	23.8	36.9	45.3	22.2**	25.7	33.9*
	% Continue	84.1	58.8	69.7	74.3	65.1**	56.1	71.4**
Meetings, Consulting and Advice	% Enter	59.1	53.3	67.7	82.1	76.5*	57.1	62.3
	% Continue	84.9	88.7	96.4	97.6	93.3*	93.3	94.4
Joint Research	% Enter	24.3	39.2	55.4	63.5	28.9*	50.8	44.8
	% Continue	52.2	74.2	86.8	89.3	70.4**	85.5	84.0
Commercial Activities and Services	% Enter	8.8	8.4	13.4	13.2	8.4**	12.4	11.3
	% Continue	26.9	49.0	57.7	56.2	45.5*	61.9	53.7
Public Engagement	% Enter	29.6	44.9	42.1	39.6	55.9*	37.6	42.1
	% Continue	48.4	80.9	75.5	74.8	84.7*	70.6	76.3

Note: % enter reported as a share of those that reported non-engagement in 2008/9; % continue reported as a share of those that reported engagement in 2008/9. Statistically significant at the 1% (**), 5% (*) level using Chi-Square test.

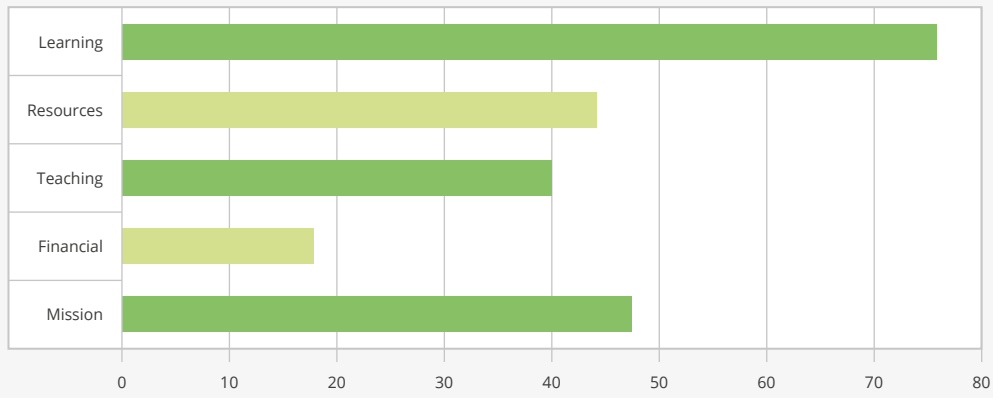
These descriptive findings are confirmed in a multivariate regression analysis that estimates the propensity to interact through the five types of engagement. The analysis is reported in Section A.1 in Appendix A. The results show that engagement activity is primarily driven by past engagement and research orientation. It also confirms that persistence is strongest with regard to *commercial activities and services*. Other predictors, though to a lesser extent, are teaching, disciplinary field, seniority and the receipt of research council funding. Research council funding is negatively associated with *training* relationships and positively with all other types of engagement, but strongest with *joint research*. Women have a lower propensity to engage through *commercial activities and services* than men, but a higher propensity to engage through *meetings, consulting and advice and public engagement*. Age, institution type and regional differences are less pronounced.

Motivations for and Attitudes to Engagement

The persistence of engagement behaviour and the pattern of transition probabilities is influenced by academics' motivations to engage and their confidence in dealing with external sectors. This also includes, amongst others, their general attitude towards external engagement.

The 2008/9 survey asked those that engaged with external sectors to indicate their motivations for doing so on a 5-point Likert scale - where 5 was very important and 1 unimportant. These motivations were grouped into five categories (based on a principal component analysis): *learning* (informing and testing own research), access to *resources* (funding for research, specialist equipment and materials, expertise of external organisations), *teaching* (student placements and teaching content), *financial* (personal income and business opportunities), and to foster the university's outreach *mission*.[8] Motivation measures were recoded to take the value 1 if they were considered as important or very important and the value zero otherwise. Exhibit 16 reports the share of engaged academics in 2008/09 that consider each motivation as important or very important. *Learning* is considered as important by more than 75% of engaged academics. Fostering the university's outreach *mission*, access to *resources* and *teaching* are also important motives for more than 40% of respondents. *Financial* motives are ranked as important by just 18% of respondents.

Exhibit 16 Important motivation for external engagement (% of respondents; 2008/9)



8 Principal component analysis results are reported in Exhibit B2 in Appendix B.

Exhibit 17 reports the exit rates for academics by motivation. Academics that were motivated by *learning* and access to *resources* are less likely to exit from external engagement than those that were not motivated by these. The only exception is *public engagement* for which these motivations do not seem to play any role. Perhaps unsurprisingly, those that were motivated by *teaching* benefits are less likely to exit from *training* activities. *Financial* motives reduce the exit rate for those engaging through *teaching* and *commercial activities and services*. Finally, the goal to fulfil the outreach mission of the university is associated with lower exit rates in *training* and *public engagement*. This comparison shows that persistence in engagement is indeed linked to academics' motives.

Exhibit 17 Exit from engagement by engagement motivation

	Motivations 2005-2008										
	Learning		**Resources**		**Teaching**		**Financial**		**Mission**		**N**
Exit From	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	
Training	32.5	26.3*	30.2	24.4**	35.5	19.4**	29.1	20.4**	29.6	25.4**	1960
Meetings, Consulting and Advice	6.8	2.2**	4.5	1.8**	3.8	2.6	3.0	4.4	3.7	2.8	3035
Joint Research	20.6	11.3**	17.0	9.21**	12.9	13.9	13.4	12.7	13.4	12.9	2562
Commercial Activities and Services	59.7	41.3**	53.0	38.7**	46.4	41.0	48.0	34.3**	44.2	44.3	804
Public Engagement	21.6	23.4	24.5	21.3	24.0	21.8	23.0	22.6	25.5	20.6*	1919

Note: Exit rates are defined as the share of engaged academics in the 2005-8 period that have no engagement in the 2012-15 period. Motivations refer to engagement during the 2005-8 period. Statistically significant at the 1% (**), 5% (*) level using Chi-Square test.

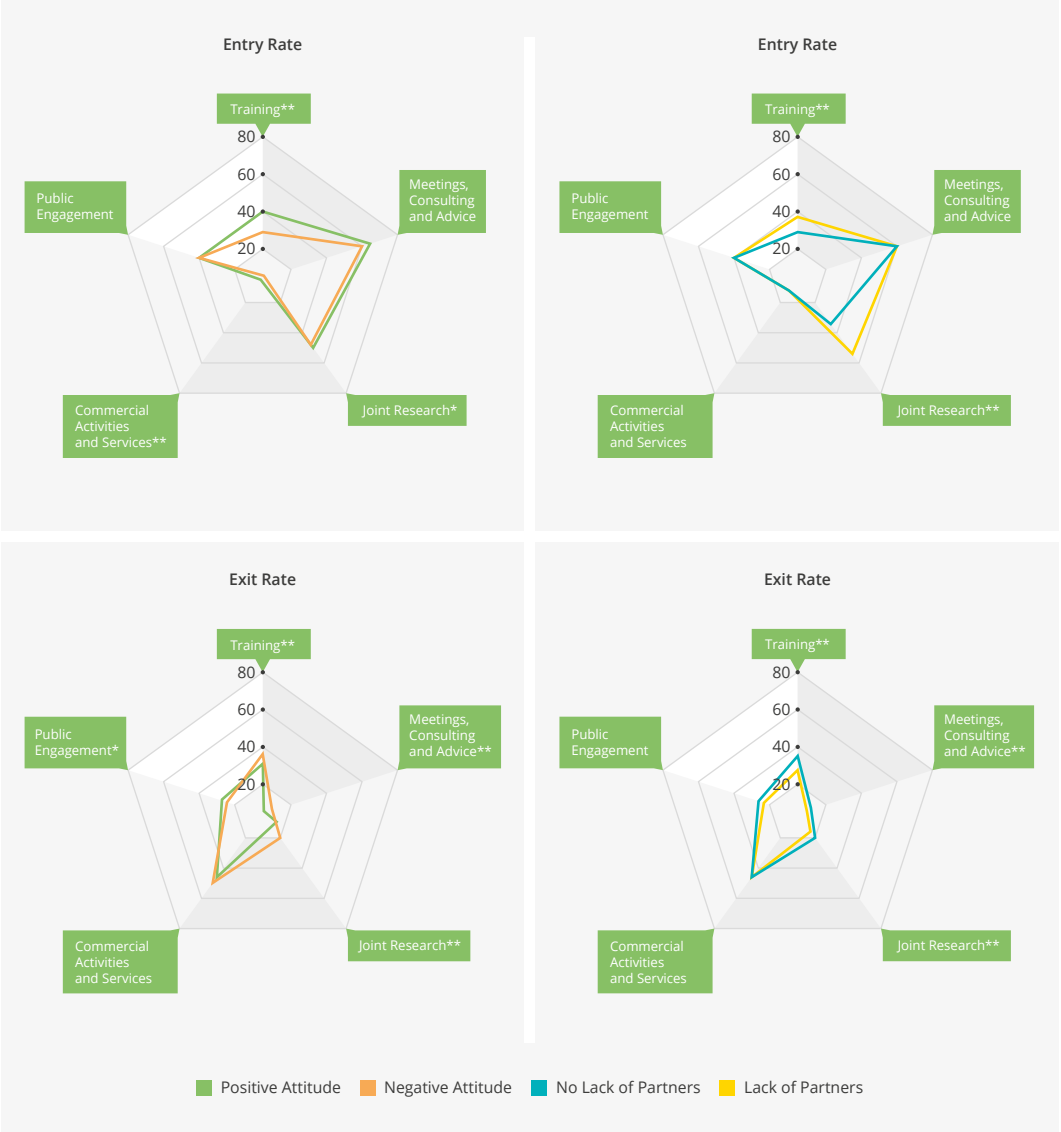
The 2008/9 survey further included a series of questions that allow us to proxy attitudes towards engagement and confidence in engaging with external partners. All survey respondents were asked to indicate the extent to which they agree to a series of statements about university external relationships on a 5-point Likert scale - where 5 is strongly agree and 1 is strongly disagree. Four of these statements were combined into a single measure of the role of the university that takes the value 1 if respondents believe that the university should not be concerned with external relevance and application and zero otherwise.[9] Survey respondents further indicated factors that constrained or prevented interactions with external organisations.

9 The four statements are: 'Academia should focus on basic research and should not be concerned with its actual or potential application'; 'The main purpose of university teaching should be to prepare students for the labour market' (reversed); 'Over the past few years, universities have gone too far in attempting to meet the needs of industry to the detriment of their core teaching and research roles'; 'Over the past few years universities have done too little to increase their relevance to society or contribution to economic development' (reversed).

We devise a measure of lack of confidence that takes the value 1 if academics indicated difficulties in finding partners or claimed a lack of external interest, and zero otherwise.[10] These attitudes may not only affect exit rates but also the entry into engagement.

Exhibit 18 shows the entry and exit rates for academics by attitude to engagement and confidence. Entry rates are significantly lower amongst those with a negative attitude to engagement specifically for relationships involving *training* and *joint research*. They also show higher exit rates with regard to these activities. Academics with low engagement confidence, as indicated by perceived lack of external interest and difficulties in identifying partners, again have lower entry and higher exit rates specifically with regard to *training* and *joint research* relationships.

Exhibit 18 Exit and entry rates by engagement attitude and confidence



Note: Exit rates are defined as the share of engaged academics in the 2005-08 period that have no engagement in the 2012-15 period; entry rates are the share of not-engaged academics in 2012-15 that are engaged in the 2012-15 period. Attitudes are from the 2008/09 survey. Statistically significant at the 1% (**), 5% (*) level using Chi-Square test.

10 The measures relating to barriers are dichotomous. The barriers used here are: 'Difficulty in identifying partners' and 'Lack of interest by external organisations'.

These descriptive findings are partially confirmed in regression analyses that estimate the effect of motivations and attitudes on the propensity to exit from or enter into the five types of engagement. The analyses are reported in Section A.2 in Appendix A. They show that, in line with the descriptive analysis, those motivated by *learning* and *resource* access (which can be considered research related motives) are more likely to continue engagement through *joint research* and *meetings, consulting and advice.* Financial considerations instead decrease engagement through *meetings, consulting and advice* and increase commercial activities and services or training. These results suggest a tension between *financial* and research motives. We find further tensions between research and teaching motives with regard to *joint research*. *Teaching* motives reduce the propensity to exit from *training* activities, but increase the propensity to stop *joint research*. The results thus show that most engagement activities are associated with one dominant type of motive.

Exit and entry propensity are also affected by attitudes towards engagement and lack of partners. The lack of external partners increases exit propensity from *training, joint research* and *public engagement*, while a negative engagement attitude increases the propensity to exit from *meetings, consulting and advice*. We further find that those academics that do not think that the lack of partners limits their research are more likely to enter into engagement through training and joint research. Negative engagement attitudes also reduce the propensity to enter into *training* and *commercial activities and services*.

However, research council income and engagement through other channels are better predictors for the decision to enter or exit. This seems to suggest that opportunities for engagement are more important than attitudes as attitudes are perhaps moulded by opportunities. We have to concede, however, that our measures for attitudes are very simple and perhaps better measures are needed. The 2015 survey asked for more general attitudes regarding the reasons for working in academia. These factors, including measures for research and commercial attitude, are better at explaining exit from and entry into engagement. However, as these attitudes were asked following the engagement period, it is difficult to infer whether these attitudes drive engagement or vice versa.

Section E

Summary

In this report we investigated the persistence of external engagement through training, research and commercialisation based modes of interaction. We specifically looked at exit from and entry into engagement between two survey periods: 2005-08 and 2012-15. We found that engagement propensity is higher amongst those that were previously engaged, suggesting a high level of persistence in engagement. The source for persistence thus lies within the decision to engage in first place. This decision is dependent upon attitudes and opportunities for engagement. For example, research council funding, a positive engagement attitude and other types of engagement increase the likelihood to enter into engagement.

We further find that women have a lower propensity to engage through *commercial activities and services* than men, but a higher propensity to engage through *meetings, consulting and advice and public engagement*. Academics with an applied research orientation are more likely to engage through *joint research* and *meetings, consulting and advice* but not through *public engagement* or *commercial activities and services. Commercial activities* and services are more likely amongst academics in STEM subjects regardless of their individual research orientation. Seniority also contributes to the propensity of engagement.

We further identified five main motivations for external engagement during the 2005-8 period that may explain persistence into 2012-15: *learning* (informing and testing own research), access to *resources* (funding for research, specialist equipment and materials, expertise of external organisations), *teaching* (student placements and teaching content), *financial* (personal income and business opportunities), and to foster the university's outreach *mission*. The survey revealed *learning* to be the most important motivation for academics, while *financial* benefits were ranked lowest. The results show that most engagement activities are linked to one dominant type of motive. E.g. *joint research* activities are only positively associated with research motives (*learning* and *resources*) but negatively with *training* and *financial* motives.

The results support previous cross-sectional findings on types of and motivations for engagement with industry in the UK (D'Este and Patel, 2007, D'Este and Perkmann, 2011; Lam, 2011; Ankrah et al. 2013). It is, however, the first study to offer insights into persistence using a longitudinal framework. This new approach suggests that engagement persistence is partly driven by the underlying motivations of academics for engagement and that such motivations may shape the efforts of academics to sustain different modes of engagement over time.

Section F

Policy implications

There are a range of policy implications that emerge from this analysis:

- Engagement activity is sustained activity, often learned through experience. Fundamentally, past engagement drives future engagement. This has at least three important policy implications. First, training and support for junior academics to learn how to successfully engage with external organisations may help to start academics on a 'pathway to engagement' early on in their careers. As such, more attention may need to be paid to helping to shape academic attitudes and skills in the formative stages of careers to shape future engagement activity.

- Second, those academics that do not engage with external actors are more focussed on basic research and are unlikely to start engaging unless they see an important need to do so. Taken with the results on persistence this suggests that the 'impact agenda' may have little effect on those individuals with a research orientation towards basic research and those with little experience in engagement. This may reflect an appropriate degree of differentiation and of specialisation in the nature of research motivation. Moreover efforts to bring these academics 'off the bench' toward engagement may have limited effect, as the experience and motivation to do so among these individuals is liable to be lacking.

- Third, our analysis suggests that support for those academics that are engaged with external organisations may provide the best means to sustain such engagement efforts in the future, as these are the individuals most likely to persist in engagement. This indicates that support for 'sustained engagers' might yield more influence on behaviour than programmes designed to re-orientate those with little experience in this domain or research motivation to engage in it. In effect, 'Masterclass' programmes to help those with experience in engagement may be more productive than introductory programmes for mid-career academics.

- Although there has been an increasing emphasis on 'impact' in the UK research context through the Research Evaluation Framework 2014 and the RCUK's pathways to impact, these efforts appear to have little direct effect in altering the proportion of academics engaging with external actors or with those who are not doing so. What we cannot say from our data is whether the intensity of these interactions or their quality has changed. Moreover, all academics in our sample were subject to the 'impact agenda' and therefore we lack a counterfactual to explain what would have happened to academic engagement levels in lieu of these efforts. It does suggest, however, that academic engagement with external organisations is rooted in research motivation and practices, and not easily 'movable' through direct external intervention. One interpretation of this result is that the level of academic engagement within the wider UK has been relatively constant since 2005, as a result of the nature of demand and availability of resources in the industrial and public sectors and not withstanding significant changes and in some years worsening of the economic environment for external engagement.

- The effect of the ‘impact agenda’ on academic behaviour may also reflect wider changes in expectations about academic careers and it may be too soon to observe these changes. It could be that the ‘impact agenda’ encourages some academics with a strong engagement orientation to persist in academe when previously they may have exited, as it may encourage universities to reward engagement and impact more effectively in their promotion and hiring practices. Or perhaps the fruits of the ‘impact agenda’ will only be realised in the future when a new cohort of more ‘engaged’ academic populate the wider academic system.

- It should be emphasised again, however, that more engagement is not necessarily a good thing in itself. Different patterns of engagement among academics may reflect a division of labour within the academic system between those doing more basic research and those performing more applied or user-oriented research. In addition, there may be insufficient ‘carrying’ capacity within the public and industrial organisations to sustain richer and deep interactions with academics. It would be unwise to encourage ‘engagement for engagement’s sake’. Policy should focus on encouraging and sustaining engagement where it is appropriate and worthwhile for both academics and external organisations.

Appendix A:

Econometric Analysis

The descriptive analysis of transition rates presented in this report can only present the degree of persistence but does not offer information on the causes of this phenomenon as it does not take into account observed and unobserved characteristics of academics. We therefore estimate a series of models that help to investigate the extent to which persistence is due to academics' individual characteristics or due to dynamic effects of past on future engagement. The empirical analysis takes place in three parts. First, we study the probability of engagement in the 2012-15 period. The expected probability depends on past engagement experience and on some personal, university and subject characteristics. This first step will help to shed light on the determinants of engagement in general and on the role of persistence.

The second part of the analysis looks at the propensity to exit from engagement based on individual level motivations and attitudes for engagement in the previous period and at the propensity of entry into engagement, i.e. it looks at those academics that did not engage in the 2005-8 period.

A.1 Propensity to Engage

We estimate scientists' propensity to engage through five different types of activities: *training, meetings, consulting and advice, joint research, commercial activities and services*, and *public engagement*. As a scientist can engage through more than one of the activities, their standard errors are not independent and they are therefore estimated simultaneously. We thus estimate a 5-equation multivariate probit model that can be written as:

$$y_m^* = x_m\beta_m + \varepsilon_m, \quad m = 1, \dots, 5 \tag{1}$$

$$y_m = D(y_m^* > 0), \quad m = 1, \dots, 5 \tag{2}$$

$$\epsilon = (\varepsilon_1, \dots \varepsilon_h)' \sim N(0, \Sigma) \tag{3}$$

where *m* represents the different engagement activities. The variance-covariance matrix ∑ has values of 1 on the diagonal due to normalization, and correlations ρjk = ρkj as off-diagonal elements. The log-likelihood function is then given by:

$$lnL = (\beta_1, \dots \beta_h), \Sigma; y|x = \sum_{i=1}^{N} ln\Phi_5\left((q_{i,1,}x_{i,1}\beta_1, \dots, q_{i,h,}x_{i,h}\beta_h); \Omega\right) \tag{4}$$

where $q_{i,m} = 2y_{i,m} - 1.$

The matrix Ω has values of 1 on the diagonal and $\omega_{j,k} = \omega_{k,j} = q_{i,j}q_{i,k}\rho_{i,k}$ for $j \neq k$ and $j,k = (1,..,h)$ as off-diagonal elements. Φ_h denotes the joint normal distribution of order 5.

The expression for the log-likelihood function can be evaluated numerically through simulation. We employ the Maximum Simulated Likelihood Method using the user-written command *cmp* in Stata (see Roodman 2009).

The multivariate probit not only estimates the propensity of engagement through each of the five modes during the 2012-15 period, but also provides a test of correlation of the error terms for the five types of engagement. A positive significant correlation between two engagement modes suggests that scientists make use of both.

Results of the multivariate probit are reported in Exhibit A1. We can see that prior engagement is positive and significant in all five equations, providing support to the persistence hypothesis. Persistence is strongest with regard to *commercial activities and services*. Prior engagement through other types of engagement is also positive and significant for most of the interaction types. The test of correlation of errors moreover shows the high correlation between interactions through different modes in the current period. The strongest correlation can be seen between engagement through *meetings, consulting and advice* and J*oint research.*

Research orientation and teaching also plays a crucial role in explaining engagement behaviour. Academics' reported research and teaching characteristics in the 2008/9 survey are used as explanatory factors. The results show that those that reported being involved in teaching in the 2008/9 survey have a higher probability to engage through *training* interactions, while research active academics are less likely. Applied researchers are the most likely to interact through *meetings, consulting and advice* and *Joint research* compared to those doing no research or following more basic research lines. *Public engagement* instead is most likely amongst those that do not identify their research as belonging to any of the three research classifications. An additional measure for research activity is receipt of research council funding. Funding is negatively associated with *training* relationships and positively with all other types of engagement. Interestingly, funding during the 2005-8 period covered by the 2008/9 survey is a better predictor for *commercial activities and services*. This may be due to the long-term commitment required for some of these commercial ventures, especially when they involve the running of a company or a longer term relationship with a specific external organisation. Propensity to engage also increases with seniority and is highest for professors. However, research fellows are just as likely to engage through *Joint research, commercial activities and services* and *meetings, consulting and advice* as professors.

Women have a lower propensity to engage through *commercial activities and services* than men, but a higher propensity to engage through *meetings, consulting and advice* and *public engagement*. Age does not play a strong role, but younger academics are somewhat more likely to get involved in *public engagement* activities. With regard to disciplinary fields, we find that those working in engineering and material science or biology, chemistry, veterinary science have a higher probability to engage through *training, joint research* or *commercial activities and services*. Those working in physics and mathematics are still more likely than those in health sciences to engage through *commercial activities and services*. The arts and humanities are the least likely to engage through these modes, however, they are the most likely to do *public engagement*, followed by biology, chemistry and veterinary science. Further, the social sciences, health sciences and engineering and material science have a higher propensity to engage through *meetings, consulting and advice* compared to other disciplines. Institution type and regional differences are less pronounced and jointly insignificant.

Exhibit A1 Multivariate probit model for the determinants of external engagement

	Training$_{12\text{-}15}$		Meetings, Consulting and Advice$_{12\text{-}15}$		Joint Research$_{12\text{-}15}$		Commercial Activities and Services$_{12\text{-}15}$		Public Engagement$_{12\text{-}15}$	
Training$_{05\text{-}08}$	0.724***	(0.046)	0.228***	(0.073)	0.258***	(0.052)	0.138**	(0.057)	0.116**	(0.048)
Meetings, Consulting and Advice$_{05\text{-}08}$	0.230**	(0.107)	0.671***	(0.104)	0.384***	(0.104)	0.279*	(0.155)	0.122	(0.100)
Joint Research$_{05\text{-}08}$	0.213***	(0.056)	0.452***	(0.077)	0.632***	(0.056)	0.173**	(0.077)	0.086	(0.057)
Commercial Activities and Services$_{05\text{-}08}$	0.213***	(0.058)	0.180	(0.111)	0.369***	(0.074)	0.957***	(0.058)	0.135**	(0.059)
Public Engagement$_{05\text{-}08}$	0.183***	(0.045)	0.203***	(0.068)	0.090*	(0.049)	0.226***	(0.054)	0.827***	(0.044)
Research None [base]										
Basic$_{09}$	-0.522***	(0.114)	0.004	(0.142)	0.481***	(0.120)	-0.070	(0.161)	0.517***	(0.119)
User-inspired$_{09}$	-0.275**	(0.113)	0.412***	(0.146)	0.856***	(0.119)	0.144	(0.157)	0.394***	(0.117)
Applied$_{09}$	-0.118	(0.111)	0.587***	(0.147)	1.018***	(0.117)	0.192	(0.155)	0.408***	(0.115)
Other Research$_{09}$	-0.392**	(0.167)	0.409*	(0.223)	0.460***	(0.171)	0.216	(0.229)	0.660***	(0.182)
Teaching Active$_{09}$	0.338***	(0.084)	0.133	(0.119)	0.050	(0.091)	-0.057	(0.089)	0.117	(0.080)
Research Council Funding$_{05\text{-}08}$	-0.017	(0.060)	0.194**	(0.093)	0.048	(0.069)	0.130*	(0.068)	-0.092	(0.061)
Research Council Funding$_{12\text{-}15}$	-0.129**	(0.062)	0.273***	(0.099)	0.343***	(0.074)	0.005	(0.069)	0.233***	(0.064)
Mobile Since 2009	0.016	(0.061)	-0.004	(0.092)	0.113*	(0.069)	-0.011	(0.073)	0.026	(0.060)
Promoted Since 2009	-0.023	(0.050)	0.056	(0.078)	0.136**	(0.056)	0.081	(0.061)	0.103**	(0.051)
Professor^{15} [base]										
Senior Lecturer/Reader$_{15}$	0.000	(0.055)	-0.224**	(0.088)	-0.254***	(0.062)	-0.224***	(0.064)	-0.170***	(0.055)
Lecturer/Teaching Fellow$_{15}$	-0.072	(0.076)	-0.496***	(0.112)	-0.420***	(0.081)	-0.136	(0.091)	-0.191**	(0.075)
Research Fellow/Assistant$_{15}$	-0.263**	(0.112)	-0.223	(0.172)	0.138	(0.123)	0.018	(0.128)	-0.277***	(0.107)
Emeritus / Honorary (retired)$_{15}$	-0.304***	(0.097)	-0.193	(0.135)	-0.099	(0.107)	-0.283**	(0.114)	-0.088	(0.095)
Female	0.017	(0.047)	0.147**	(0.071)	-0.067	(0.051)	-0.252***	(0.058)	0.097**	(0.047)
Age 15 >=50 [base]										
Age 15 <40	0.047	(0.083)	0.061	(0.120)	-0.067	(0.087)	0.065	(0.099)	0.203**	(0.084)
Age 15 40-49	0.069	(0.052)	0.117	(0.084)	0.002	(0.059)	0.039	(0.063)	0.089*	(0.053)
Social Sciences [base]										
Arts and Humanities	-0.181***	(0.068)	-0.207**	(0.094)	-0.143**	(0.071)	0.074	(0.091)	0.499***	(0.071)
Health Sciences	0.007	(0.063)	-0.171	(0.107)	0.175**	(0.074)	0.272***	(0.080)	-0.090	(0.063)
Biology, Chemistry, Vet Science	0.129*	(0.077)	-0.218*	(0.120)	0.252***	(0.089)	0.753***	(0.085)	0.198**	(0.079)
Physics, Mathematics	0.065	(0.072)	-0.381***	(0.100)	0.044	(0.078)	0.604***	(0.084)	0.049	(0.071)
Engineering, Materials Science	0.365***	(0.099)	-0.084	(0.174)	0.332***	(0.120)	0.877***	(0.096)	-0.064	(0.092)
Post-1992 Institutions [base]$_{15}$										
Top-decile Institutions$_{15}$	0.145	(0.160)	0.786*	(0.426)	0.186	(0.206)	0.145	(0.163)	0.136	(0.170)
Other Old Institutions$_{15}$	0.293***	(0.061)	0.077	(0.094)	0.070	(0.067)	0.128*	(0.071)	-0.040	(0.061)
Specialist Institutions$_{15}$	0.124**	(0.051)	-0.009	(0.077)	0.007	(0.056)	-0.076	(0.061)	-0.112**	(0.052)
Constant	-1.043***	(0.204)	-0.016	(0.269)	-1.149***	(0.218)	-1.930***	(0.269)	-1.177***	(0.202)
Joint Sign. of Region Dummies 15 $\chi2(11)$	7.69		17.04		9.40		10.11		8.86	
rho [Training Over Other]			0.466***	(0.050)	0.348***	(0.033)	0.288***	(0.035)	0.173***	(0.029)
rho [Meetings Over Other]					0.734***	(0.053)	0.441***	(0.068)	0.310***	(0.045)
rho [Research Over Other]							0.337***	(0.043)	0.242***	(0.032)
rho [Commercial Over Other]									0.175***	(0.035)
Number of Observations (Clusters)	4045 (143)									
LR $\chi2$	3023.12***									
Log-Likelihood	-8611.957									

Robust standard errors in parentheses; Standard errors clustered at the institution level; Subscripts indicate years; Statistically significant at * p<0.10, ** p<0.05, *** p<0.01

Exhibit A2 Selection probit model for the determinants of exit from external engagement (2nd stage)

	Exit Training		Exit Meetings, Consulting and Advice		Exit Joint Research		Exit Commercial Activities and Services		Exit Public Engagement	
Learning$_{09}$	-0.023	(0.077)	-0.323***	(0.104)	-0.145*	(0.079)	-0.227	(0.140)	0.179**	(0.085)
Resources$_{09}$	-0.034	(0.063)	-0.274**	(0.119)	-0.209***	(0.071)	-0.121	(0.101)	-0.017	(0.072)
Teaching$_{09}$	-0.339***	(0.066)	-0.011	(0.127)	0.149**	(0.074)	-0.131	(0.105)	-0.104	(0.073)
Financial$_{09}$	-0.161**	(0.078)	0.460***	(0.126)	0.107	(0.088)	-0.227**	(0.106)	0.045	(0.085)
Mission$_{09}$	-0.023	(0.060)	-0.085	(0.103)	-0.034	(0.069)	0.043	(0.099)	-0.162**	(0.067)
Lack of Partners$_{09}$	0.164**	(0.075)	0.137	(0.120)	0.261***	(0.083)	-0.002	(0.115)	0.192**	(0.085)
Negative Engagement Attitude$_{09}$	0.022	(0.064)	0.201**	(0.101)	0.101	(0.072)	-0.002	(0.101)	-0.029	(0.072)
Training$_{05\text{-}08}$			-0.214**	(0.104)	-0.273***	(0.073)	-0.087	(0.112)	-0.091	(0.078)
Meetings, Consulting and Advice$_{05\text{-}08}$	-0.612	(0.531)			-0.279	(0.463)	0.000	(.)	-0.005	(0.318)
Joint Research$_{05\text{-}08}$	-0.180**	(0.091)	-0.226*	(0.123)			-0.361	(0.231)	-0.174*	(0.096)
Commercial activities and Services$_{05\text{-}08}$	-0.196***	(0.073)	-0.119	(0.144)	-0.254***	(0.089)			-0.073	(0.080)
Public Engagement$_{05\text{-}08}$	-0.122*	(0.063)	-0.186*	(0.103)	-0.106	(0.070)	-0.227**	(0.105)		
Mobile Since 2009	0.197**	(0.081)	0.043	(0.137)	-0.056	(0.091)	0.099	(0.144)	0.018	(0.091)
Promoted Since 2009	-0.048	(0.067)	-0.060	(0.115)	-0.030	(0.075)	-0.120	(0.111)	-0.134*	(0.077)
Research Council Funding$_{12\text{-}15}$	0.144*	(0.079)	-0.492***	(0.174)	-0.371***	(0.101)	-0.059	(0.119)	-0.190**	(0.090)
Basic$_{09}$	0.586***	(0.220)	-0.143	(0.232)	-0.360*	(0.215)	-0.335	(0.321)	-0.883***	(0.201)
User-inspired$_{09}$	0.589***	(0.202)	-0.364	(0.232)	-0.594***	(0.226)	-0.394	(0.310)	-0.721***	(0.186)
Applied$_{09}$	0.593***	(0.197)	-0.502**	(0.233)	-0.640***	(0.225)	-0.376	(0.303)	-0.744***	(0.180)
Other$_{09}$	0.505*	(0.290)	-0.482	(0.347)	-0.450	(0.284)	-0.353	(0.503)	-0.835***	(0.292)
Constant	-0.239	(0.569)	-0.987***	(0.288)	0.022	(0.526)	0.907*	(0.503)	0.258	(0.405)
atanh(rho)	0.750***	(0.252)	1.495	(1.309)	0.559***	(0.195)	0.351*	(0.187)	0.413	(0.312)
Number of Observations	3972		3981		3986		3951		3973	
Log-Likelihood	-3368.979		-1032.746		-2657.218		-2156.350		-3462.160	

Robust standard errors in parentheses; Gender, age and discipline controls included in all models; Subscripts indicate years; Statistically significant at * p<0.10, ** p<0.05, *** p<0.01

Exhibit A3 Selection probit model for the determinants of entry into external engagement (2nd stage)

	Entry Training		Entry Meetings, Consulting and Advice		Entry Joint Research		Entry Commercial Activities and Services		Entry Public Engagement	
No lack of Partners$_{09}$	-0.160**	(0.066)	-0.015	(0.190)	-0.445***	(0.086)	-0.032	(0.070)	-0.011	(0.073)
Negative Engagement Attitude$_{09}$	-0.175***	(0.062)	-0.042	(0.196)	0.021	(0.080)	-0.133**	(0.060)	0.024	(0.064)
Training$_{05-08}$			-0.053	(0.296)	0.204**	(0.086)	0.091	(0.063)	0.102	(0.067)
Meetings, Consulting and Advice$_{05-08}$	0.141	(0.107)			0.294***	(0.106)	0.284*	(0.158)	0.052	(0.122)
Joint Research$_{05-08}$	0.159**	(0.069)	0.456	(0.309)			0.185**	(0.075)	0.056	(0.076)
Commercial Activities and Services$_{05-08}$	0.136	(0.085)	0.423	(0.601)	0.353*	(0.195)			0.163*	(0.094)
Public Engagement$_{05-08}$	0.157***	(0.060)	0.149	(0.196)	-0.037	(0.079)	0.171***	(0.061)		
Mobile Since 2009	0.160**	(0.077)	-0.084	(0.262)	0.151	(0.111)	0.051	(0.077)	0.036	(0.083)
Promoted Since 2009	0.061	(0.063)	0.055	(0.189)	0.248***	(0.083)	0.053	(0.064)	0.189***	(0.068)
Research Council Funding$_{12-15}$	-0.077	(0.075)	-0.461	(0.337)	0.271**	(0.121)	-0.004	(0.072)	0.257***	(0.093)
Constant	-1.261***	(0.160)	-0.688	(0.528)	-0.939***	(0.187)	-1.936***	(0.191)	-0.845***	(0.213)
atanh(rho)	0.747***	(0.151)	0.358	(0.222)	0.549***	(0.111)	1.246*	(0.722)	0.269	(0.209)
Number of Observations	3981		3867		3960		4012		3975	
Log-Likelihood	-3391.010		-824.529		-2462.859		-2685.116		-3625.732	

Robust standard errors in parentheses; Gender, age and discipline controls included in all models; Subscripts indicate years; Statistically significant at * p<0.10, ** p<0.05, *** p<0.01

A.2 Propensity to Exit and Enter

We estimate scientists' propensity to exit from engagement through five different types of activities: *training, meetings, consulting and advice, joint research, commercial activities and services*, and *public engagement*. The decision to exit is dependent on being engaged in the 2005-8 period. We therefore estimate models that account for selection into each of the five activities. In the first stage the characteristics of the university (institution type and region), seniority and age in 2008/9, funding in the period 2005-8 and involvement in teaching serve as exclusion restrictions for the selection into engagement. The selection model also considers research orientation, measures for rootedness in academia and disciplinary area. All these are significant predictors for engagement in the 2005-8 period. The selection models perform well for *training, joint research* and *commercial activities and services*.

The propensity to exit is then conditional on the initial selection into engagement. The results of this second stage are reported in Exhibit A2. We find that some motivations for external engagement during the 2005-8 period reduce the propensity to drop out from engagement. Those motivated by learning are less likely to exit from *meetings, consulting and advice*, and *joint research*. They are however more likely to exit from *public engagement*. Those motivated by access to resources are also less likely to stop their engagement through *meetings, consulting and advice*, and *joint research*. *Teaching* motives reduce the propensity to exit from *Training* activities, but increase the propensity to stop *joint research*. Personal income and business motives *(financial)* increase the propensity to remain in *training* and *commercial activities and services* as these activities are the most likely to generate personal income. Exit from public engagement is lowest for those motivated to serve their university's engagement *mission*.

Attitudes towards engagement and lack of partners also affect exit propensity. The lack of external partners increases exit propensity from *training, joint research* and *public engagement*, while a negative engagement attitude increases the propensity to exit from *meetings, consulting and advice*.

Some of the controls are also significant. For example, academics that also interact through other engagement activities in the 2005-8 period are less likely to drop out. Research council funding receipt also increases the propensity to remain actively engaged through *joint research, meetings, consulting and advice*, and *public engagement*. It however reduces to propensity continue engagement through *training*.

The propensity to enter into engagement is estimated using a similar set of selection probits and reported in Exhibit A3. The first stage equations are kept the same as in the exit models. The entry models do not involve motivations, as these were not surveyed for those that had not previously been engaged. The findings show that attitudes in 2008/9 also affect the decision to enter into engagement in the 2012-15 period. We find that those academics that did not think that the lack of partners limited their engagement in the 2005-8 period are more likely to enter into engagement through *training* and *joint research*. Negative engagement attitudes reduce the propensity to enter into *training* and *commercial activities and services*. It further seems that opportunities are more important than attitudes. Those that are already involved through other channels are also more likely to enter. Further, those that receive research council funding have a higher propensity to enter into *joint research* and *public engagement*.

Appendix B

Supplementary Tables

Exhibit B1 Principal component analysis: External engagement activities

Engagement Category	Engagement Activity in Questionnaire	Factor1	Factor2	Factor3	Factor4	Factor5
Training	Employee Training	0.134	0.235	**0.570**	0.069	-0.105
	Student Placements	0.127	0.145	**0.575**	0.056	0.096
	Curriculum Development	0.030	0.185	**0.634**	-0.081	0.070
	Enterprise Education	0.051	-0.051	**0.515**	0.100	0.234
Meetings, Consulting and Advice	Attending Conferences	0.275	**0.534**	-0.024	0.012	-0.003
	Standard Setting Forums	0.138	**0.374**	0.415	-0.036	0.050
	Participating in Networks	0.315	**0.540**	0.141	-0.013	0.086
	Sitting on Advisory Boards	0.150	**0.541**	0.209	0.042	0.160
	Giving Invited Lectures	0.298	**0.636**	0.038	0.029	0.169
	Consultancy Services	0.138	**0.582**	0.236	0.090	0.111
	Informal Advice	0.086	**0.486**	0.365	0.217	-0.095
Joint Research	Joint Publications	**0.729**	0.170	0.025	0.060	0.022
	Hosting of Personnel	**0.549**	0.100	0.296	0.097	0.169
	External Secondment	**0.411**	-0.077	0.246	0.010	0.082
	Joint Research	**0.762**	0.183	0.037	0.088	0.018
	Contract Research	**0.377**	0.330	0.173	0.206	-0.168
	Research Consortia	**0.622**	0.256	0.059	0.126	0.056
Commercial Activities and Services	Setting up Physical Facilities	**0.307**	-0.112	-0.289	**0.304**	0.278
	Prototyping and Testing	0.289	0.039	0.308	**0.381**	0.098
	Taken Out a Patent	1.164	0.009	-0.057	**0.734**	0.021
	Licensed Research Outputs to a Company	0.068	-0.054	0.028	**0.735**	-0.011
	Formed a Spin-out Company	-0.007	0.090	0.074	**0.691**	0.094
Public Engagement	Lectures for the Community	0.048	0.356	-0.048	0.023	**0.635**
	Public Exhibitions	0.121	-0.004	0.030	0.057	**0.658**
	School Projects	-0.020	0.038	0.185	0.044	**0.626**
Rotation Variance of Loadings		2.708	2.509	2.159	1.963	1.558
Proportion of Variance Accounted for		10.83	10.03	8.63	7.85	6.23
Cumulative Proportion of Variance Accounted for		10.83	20.87	29.50	37.35	43.58

Note: Loads of the varimax rotation are reported. Highest factor loadings in bold.

Exhibit B2 Principal component analysis: Motivation for external engagement

		Factor1	Factor2	Factor3	Factor4
Learning	Test the Practical Application of my Research	**0.765**	0.137	0.035	0.252
	Gain Insights in the Area of my Own Research	**0.873**	0.143	0.051	0.006
	Keep Up-to-date with Research in External Organisations	**0.650**	0.362	0.287	-0.004
Resources	Secure Access to Specialist Equipment, Materials or Data	0.187	**0.790**	0.052	0.096
	Secure Access to the Expertise at External Organisation	0.286	**0.769**	0.130	-0.023
	Secure Funding for Research Assistants and Equipment	0.047	**0.554**	0.019	0.528
Teaching	Gain Knowledge About Practical Problems Useful for Teaching	0.264	-0.057	**0.805**	0.029
	Create Student Project and Job Placement Opportunities	-0.022	0.253	**0.765**	0.140
Financial	Source of Personal Income	0.064	-0.110	0.042	**0.792**
	Look for Business Opportunities Linked to my Own Research	0.119	0.204	0.195	**0.778**
Mission	Further my Institution's Outreach Mission	-0.043	0.078	**0.598**	0.206
Rotation Variance of Loadings		1.979	1.819	1.737	1.647
Proportion of Variance Accounted for		17.99	16.54	15.79	14.97
Cumulative Proportion of Variance Accounted for		17.99	34.52	50.31	65.28

Note: Loads of the varimax rotation are reported. Highest factor loadings in bold.

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