Characteristics of high-performing research units

A preliminary analysis

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Preface

The Higher Education Funding Council for England (HEFCE) commissioned the Policy Institute at King's and RAND Europe to conduct a preliminary analysis of the characteristics of high-performing research units within UK higher education institutions (HEIs). In particular, the report looks at characteristics shared between research units whose submissions in the Research Excellence Framework (REF) 2014 scored highly in the areas of research and impact, and identifies aspects of characterisation that merit further investigation. It is important to stress from the outset that this report focuses on the broad characteristics of research units or departments and therefore has a wider remit than performance in the REF per se. The report is not a guide to tactical approaches towards performing well in the REF: rather it focuses on strategic approaches to delivering excellent research. The report will be of interest to anyone involved in managing and funding research, facilitating high performance in research and, more broadly, those in the higher education sector.

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This report provides an overview of some of the characteristics of high-performing research units in UK higher education institutions (HEIs). Our focus is to report on characteristics of high performance in research generally and we used the results of the Research Excellence Framework (REF) 2014 as a proxy for 'high performance', with a focus on the top 1.5 per cent of submissions.[1] To determine key characteristics of high research performance, we used a combination of quantitative data analysis across all eligible staff,[2] interviews and a workshop with individuals from high-performing research units, along with a review of existing literature. From our analysis we identified eight observations that are associated with high research performance and warrant further investigation. They are:

A. In high-performing research units more of the staff have PhDs, professorial positions, international experience and externally funded salaries

B. High-performing research units are focused on recruiting the best and retaining them

C. High-performing research units provide training and mentorship programmes to develop staff, while offering rewards for strong performance

D. Staff within high-performing research units display a distinct ethos of social and ethical values

E. The leaders of high-performing research units have earned 'accountable autonomy' within their higher education institution

F. High-performing research units have strategies that are real, living and owned, and more than merely a written document

G. High-performing research units receive more income per researcher than the average research unit

H. High-performing research units enable and encourage researchers to initiate collaborations organically as opposed to using a top down approach

Looking at these observations, it is apparent that they can be mutually reinforcing and interact in positive ways. We have developed a conceptual model that helps explain how these observations may interact (Figure 1).

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1   This represents the sample for interviews and quantitative analysis. When including the research units invited to attend the workshop to validate the findings, our sample covers the top 2.5 per cent of submissions.
2   Eligible staff refers to the whole staff complement of a unit, not just those individuals that were submitted to REF 2014.

Figure 1: Conceptual model for describing characteristics of high-performing research units
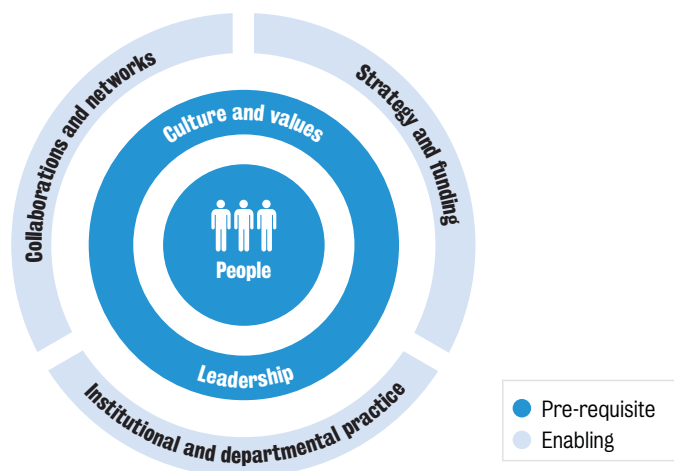
Central to high-performing research units – and the conceptual model in Figure 1 – are two 'prerequisite' characteristics. The first is *People*: this means recruiting and retaining the best. In addition, our analysis suggests that a certain staff mix is associated with high performance, ie staff who are research trained (PhDs), who are senior (professors), who have international experience and whose salaries are funded by external sources. The 'glue' that creates the high-performing research unit is its *research culture, underlying values and leadership*. All the high-performance research units we spoke to had a degree of earned or accountable autonomy – that is they were allowed to get on with what they were doing, partly as it was recognised that they were successful due to their strong leadership and the research culture of the unit.

Three 'enabling' characteristics allow people and leadership to thrive and they are depicted in the outer circle in Figure 1. They are: *collaboration and networks*, a coherent *strategy and diverse funding sources*, and supporting *institutional and departmental practices*. From our research it is not clear whether these three criteria are prerequisites for high research performance, or whether they simply enhance such performance.

Based on this analysis we have developed a preliminary predictive linear model and suggest that further work is undertaken to explore and test these observations. For example, the importance of student characteristics, early career researchers and strong professors.

Some of this could be to examine units that are not at the elite end of the performance scale (ie mid-ranking) or institutions that performed better on the impact element than the output assessment in REF. It may also be possible to develop and implement a survey that collects primary data that is focused on some of the observations. This would enable a more nuanced view as to how the observations interact, complement or substitute one another.

Acknowledgements

Glossary

BIS	Department for Business, Innovation & Skills
ECR	Early Career Researcher
FSR	Financial Statistics Return
GPA	Grade Point Average
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HEIF	Higher Education Innovation Funding
HESA	Higher Education Statistics Agency
KTP	Knowledge Transfer Partnerships
PVCR	Pro Vice-Chancellor for Research
QR	Quality-Related
RAE	Research Assessment Exercise
REF	Research Excellence Framework
REF2	REF research outputs
REF4	REF environment data
REF4a	REF research doctoral degrees awarded
REF4b	REF research income
UOA	REF Unit of Assessment

1 | Introduction

1 | Introduction

This report provides an overview of some of the characteristics of high-performing research units in UK higher education institutions (HEIs). In order to identify high-performing research units, we used the results of the output and impact components of the 2014 Research Excellence Framework (REF)[3] as a proxy for 'high performance', and focused on submissions in the top 1.5 per cent.[4] That said it should be stressed from the outset that this report is not a guide to tactical approaches towards performing well in the REF: rather it focuses on strategic approaches to delivering excellent research and therefore has a wider remit than performance in the REF per se.

It is also important to note that our findings show the characteristics of research units that we have deemed as high-performing, rather than focusing on drivers for future performance. A combination of quantitative data analysis, review of existing literature, interviews and a workshop were used to determine key characteristics of high performance.

The remainder of this introductory chapter sets out the purpose of this study, introduces the methods used, describes the structure of the report and summarises some of the key limitations to our analysis.

Purpose of this report

This project, commissioned by the Higher Education Funding Council for England (HEFCE), specifically aimed to:

- Plot the distribution of high-performing submissions from the REF results across all REF Main and Sub-Panels, identifying distribution trends

- Develop a sampling strategy to examine in depth the characteristics of units that produced high-scoring submissions, drawing on REF submissions and additional sectoral data

- Determine what, if any, characteristics are shared between research units that produced high-scoring submissions

- Identify aspects of characterisation that merit further investigation

This report can be used to provide research managers and funders with an overview of strategic approaches to delivering excellent research. Examples of specific practices used by research units in our sample are provided throughout the report in boxes.

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3   The REF is a system for assessing the quality of research in UK HEIs. It replaced the Research Assessment Exercise (RAE), which occurred on a (near) quinquennial basis from 1986 to 2008. REF 2014 was undertaken by the four UK higher education funding bodies, but managed by the REF team based at HEFCE and overseen by the REF Steering Group, consisting of representatives of the four funding bodies. HEIs made submissions to 36 Units of Assessment (UOAs) with submissions being assessed by an expert Sub-Panel within each, working under the guidance of four Main Panels, A to D (see Table 3, Appendix 1). Sub-panels applied a set of generic assessment criteria to produce an overall quality profile for each submission. The results were published on the 18th December 2014. See http://www.ref.ac.uk/ for further information.

4   This represents the sample for interviews and quantitative analysis. When including the research units invited to attend the workshop to validate the findings, our sample covers the top 2.5 per cent of submissions.

Overview of methodological approach

Figure 2 summarises the approach we used for the study and Appendix 2 provides a more detailed account of the methods. To identify key characteristics of high-performing research units we sourced and triangulated evidence through interviews and a workshop with academics from high-performing research units, from quantitative data from Higher Education Statistics Agency (HESA) and REF 2014 submissions, and from existing literature. Below we summarise the various aspects of our approach.

Figure 2: Project schema
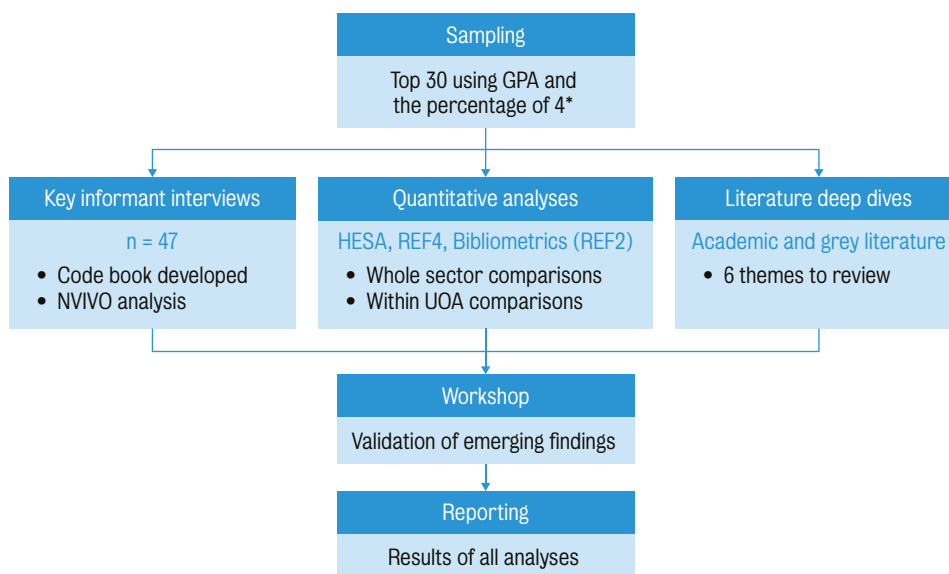
Sampling

We began the study by selecting a sample of high-performing research units based on the results of REF 2014 for research outputs and impacts (not environment).[5,6] To identify a sample population we ranked submissions by two scores:

- The grade point average (GPA) of submissions' combined outputs and impact scores (Figure 3a)[7]

- The percentage of overall submissions scoring 4*, calculated as an average of the percentages of submissions scoring 4* in each of the outputs and impact categories (Figure 3b)[8]

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5   HEIs made submissions to 36 UOAs organised around academic disciplines. A full list of the Main Panels and UOAs can be found in Table 3 (Appendix 1). A submission consists of documented evidence of the outputs, impact and research environment of a UOA.

6   The environment component of REF 2014 submissions (REF5) was not included in determining our sample, as the aim of the study itself was to identify environmental factors of high-performing units beyond those that scored highly in the environment component of the assessment. We therefore focused on identifying high-performing institutions with respect to outputs and impact. Environment templates were read by the interviewers to familiarise themselves with the research environment and context of the interviewee.

7   The grade point average is the average star rating. To calculate this we multiply the percentage of 4* research by 4, the percentage of 3* research by 3, the percentage of 2* research by 2, the percentage of 1 * research by 1, sum these four numbers, and divide by 100. This gives a score between 4 and 0.

8   For outputs, 4* is defined as 'Quality that is world-leading in terms of originality, significance and rigour'. For impacts, 4* is defined as 'Outstanding impacts in terms of their reach and significance'.

Figure 3: Plot of all submissions as (a) output GPA against the impact GPA and (b) percentage of impacts scoring 4* against the percentage of outputs scoring 4*[9]

Figure 3a

Figure 3b
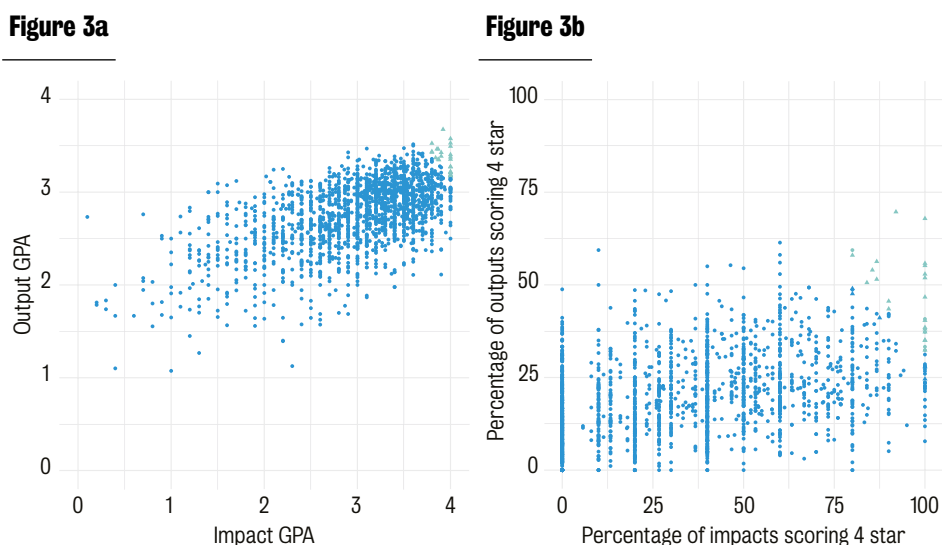
There are a number of different ways of looking at high performance, including the two described above. Due to the overlap in submissions defined as high-performing between the methods, we decided to combine them.

There was an overlap with 20 of the same submissions ranked in the top 25 when comparing across each of these two distributions, and we included these in the high-performance sample along with the remaining five submissions from each ranking. Thus, we selected a total of 30 submissions for inclusion in the sample, equating to the top 1.5 per cent of submissions assessed in REF 2014 (see Table 4, Appendix 2 for a list of high-performing submissions). The selected submissions spanned 19 HEIs (Table 5, Appendix 2) and the submissions were relatively evenly distributed across the Main Panels (eight from Main Panel A, six from Main Panel B, seven from Main Panel C and nine from Main Panel D) (Table 6, Appendix 2). Of the 36 UOAs, 18 were represented in our sample (Table 7, Appendix 2). It is interesting to note that within our sample there was a higher than average rate of return of staff (see Figure 9, Appendix 2).

Interviews

For each of the 30 highest-performing submissions, HEFCE approached the Pro Vice Chancellor for Research (PVCR), or equivalent, inviting them to be involved in the study. Involvement meant taking part in two telephone interviews, one with the UOA lead[10] and one with the PVCR (or equivalent). Of the 19 HEIs approached, 18 agreed to take part. We therefore extended the invitation to the next two highest-performing submissions who both agreed to take part. We had planned on undertaking 49 interviews, but in the end conducted 47, since at one institution, the PVCR was within the department of interest and able to provide both an institutional and a departmental perspective, and at another we could not find a suitable time to interview the PVCR.

In conducting the interviews we sought to explore reasons behind high research performance and, across the sample, to see whether common themes arose, to test

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9   The 25 with the highest average scores for impact and output are coloured in green. This is based on (a) GPAs and (b) scoring 4*.

10 The UOA lead is the individual identified by the HEI to have led the submission for REF 2014. For example this could be the head of school or a senior academic.

against existing data and literature (see interview protocol, Appendix 3). Each interview lasted about 45 minutes and was written up by the interviewer, who also identified five key messages. The project team clustered the emerging themes into topics, as summarised in Box A. These themes were presented to the steering group, and used in the stakeholder workshop described below. From an early iteration of these topics, as well as the interview protocol, we developed an initial code book (see Appendix 4), which we used to code all 47 interview notes using NVivo.[11]

Box A: Key themes associated with high-performing research units

- People
- Leadership, culture and values
- Strategy and funding
- Collaboration and networks
- Institutional and departmental practice

Quantitative data analysis

To supplement our primary analysis we undertook a detailed data review, looking at various characteristics associated with the chosen 30 high-performing submissions to REF 2014. This included different sources such as the HESA staff record linked to the REF return, research doctoral degree data (REF4a), research income data (REF4b) and bibliometric data on research outputs (REF2) submitted by HEIs to REF 2014.[12]

For each characteristic we:

- Tested whether there was a significant difference between our high performance sample and the average of all submissions, by:
  - Testing for an overall difference, comparing each high-performing research unit to the overall average
  - Stratifying the sample and comparing each high-performing research unit to the relevant UOA average
- Calculated correlations between each characteristic and our overall research unit ranking

We carried out both statistical testing and correlation analysis in order to gain greater confidence in our conclusions. Statistical analyses were performed in R.[13] In subsequent chapters we present quantitative data that supports, or contests, the key themes identified from the interviews (for full details of the statistical analysis see Appendix 2). These analyses consider each characteristic, and its relationship to performance, separately. Using the HESA and REF4 data we have also built a preliminary predictive linear model to start to understand how these characteristics as a whole relate to high performance (see Chapter 7).

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11   NVivo is a qualitative data analysis software package that allows the coding of text based information, such as interview notes. Further information is provided in Appendix 4.
12   Data provided by HEFCE, initially compiled for HEFCE (2015).
13   For further information see: https://www.r-project.org (as of 1 September 2015).

Evidence reviews

For the key themes identified from the interviews we undertook rapid evidence reviews of the policy and academic reports, and papers. The purpose of these reviews was to see whether there was any further evidence that either supported or disputed our analysis. These reviews were resource limited (approximately one day was dedicated to reviewing each theme) and thus should not be seen as being systematic or comprehensive, rather they aim to give an overview of literature in this field and provide context to our findings.

Stakeholder workshop

We held a stakeholder workshop on Thursday 23 July 2015 attended by those involved in other high-performing submissions that ranked just below our 'top 30' interview sample, bringing our total sample analysed to the top 2.5 per cent of submissions. We invited representatives (specifically the UOA lead, so to access hands-on knowledge of the department and its processes and ensure no overlap with interviewees where one institution was represented in both samples) from 22 high-performing submissions,[14] covering 18 HEIs (11 who had not previously participated in the study). In all, 18 participants attended (Table 8, Appendix 2). The purpose of the workshop was both to validate our emerging findings and help us unpick and delve deeper into some of the broader emerging topics. Specifically, we asked participants to identify examples around the six themes broadly aligning with those in Box A based on their perspectives and experiences in their respective HEIs. In reporting on these examples we have not identified the HEI involved, but use them to illustrate in more detail the nature of some of the characteristics of high performance.

Synthesis and report outline

In the following chapter we synthesise the results from our four evidence sources – interviews, quantitative data, literature and workshop. In the final chapter we bring the different themes together and present a conceptual model for framing the identified characteristics of high-performing research units. We also present a preliminary linear model which highlights the characteristics and variables that we found to be most significant for demonstrating high performance. Finally, we provide recommendations for areas of further research.

Caveats and limitations of our approach and analysis

There are some limitations to our approach (which is inevitable for preliminary analysis). Probably the most significant is that we have not examined the counter factual – that is for each of the key themes and associated characteristics ideally one would assess their absence from non-high-performing submissions (the bottom 30). We have compared our sample to the average research unit when conducting quantitative analysis, but qualitative analysis with lower performing submissions has significant methodological challenges and was outside the scope of this study. To find our high-performing units we used REF as a proxy for high performance, for which we assume that it is highly likely that a research unit that performed well in REF also performs well generally. Conversely, identifying a good sample for poor performance is challenging, since the reason for poor performance could be due to generally poor research or a poor submission, which cannot be distinguished through our sampling method and could be a particular challenge with new units.

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14   Consisting of the next 20 high-performing submissions in our sample, along with the two submissions who initially declined to partake.

There are a number of limitations of the quantitative data we have used. HESA data is obtained through submissions from HEIs to HESA. Its accuracy therefore depends on the accuracy of the submission; there are a number of known small inaccuracies. HESA are in the process of updating this data, but unfortunately the update was not available for this study. Further details on these known small inaccuracies can be found at https://www.hesa.ac.uk/ref2014.

A range of opinions in the interviews and at the workshop were expressed across the sample. We have broadly attempted to capture the consensus views, but – where appropriate – we also report diverging views.

Interview styles differed according to the member of the team carrying out the interview. In order to minimise the effects of this variation the team met regularly and discussed progress. Interviewers wrote up interview notes as a summary of discussions rather than a verbatim transcript of the conversation and this is one point at which information could have been lost.

Further information could have been lost through coding. To mitigate this and limit the variations in coding style, two researchers carried out the task. Initially interview notes were double coded by both researchers to ensure consistency in coding. These researchers then agreed a standard of coding practice (with the provision of code definitions to ensure a common understanding of the meaning of their use), and met regularly to discuss areas of uncertainty.

Additionally, in our interviews we found it hard to encourage interviewees towards giving specific details, rather they tended to provide generic statements, such as the need for mentoring. Interviewees also found it hard to distinguish between practices or strategies in place during the last REF submission period that led to high performance, current practices and anticipated future strategies. We do not know if that is a result of people not willing to reveal such information, our inability to elicit that detail in interviews or because the key themes and associated characteristics are inevitably generic. As such, the results presented in the remainder of this report should be seen and treated as exploratory and worthy of further analysis and discussion.

2 | People – department make up and recruitment

2 | People – department make up and recruitment

Many interviewees saw people as *the* prerequisite characteristic of success, with recruiting the best staff seen as key to high performance. In this chapter we look at the departmental make-up in high-performing research units, and the recruitment decisions and processes that led to the observed mix. We first set the scene by drawing on the evidence gathered from our literature reviews, which primarily focuses on departmental size and researcher characteristics, before describing the two observations from our analysis.

We found there to be a great deal of debate in the literature regarding the ideal characteristics of research departments, including department size, critical mass, department composition and individual researcher characteristics. Studies tended to focus on research outputs as measurements of high performance, often measured as productivity (defined as the number of outputs produced and not reflecting the ratio between input and output), as well as quality (defined by bibliometric indicators or performance in research excellence assessments). We identified fewer studies that included measures of high performance through wider societal impact. The majority of studies focused on one specific field, often a particular scientific discipline, so care has to be taken when generalising findings across all fields.

In general, we found that a number of studies correlated size with quality (as defined above) and volume of outputs (Qurashi, 1991; Bosquet & Combes, 2013; Kenna & Berche, 2011; Keena & Berche, 2012); however, results indicate that there are diminishing returns to growth over a certain size (Kenna & Berche, 2011; Keena & Berche, 2012). An analysis of the RAE 1992 results found that while larger departments performed better, once a department had over 40 research-active staff there was only a small gain in quality with greater numbers (Johnston et al, 1995). The size of smaller groups within departments contributes to a critical mass effect, with the number of researchers that an individual is able to communicate with shown to be a dominant driver of research quality (Kenna & Berche, 2011). Quantity and quality share a linear relationship with the size of the group up to a certain size, generally shown to be around eight people, although the number varies depending on the field in question (Quarshi, 1993; von Tunzelmann et al, 2003; Kenna & Berche, 2012). Von Tunzelamnn (2003) suggests that the size of a department may not be of importance if, within it, groups themselves are of the optimal size. Salmi (2009) found that a high concentration of talent and critical mass is important to drive research excellence.

A number of studies have highlighted the importance of researcher characteristics on performance. Bosquet & Combes (2013) found that the diversity of a department in terms of research fields is highly positively correlated with the average quality of publications. Dundar & Lewis (1998) found that research performance was higher in departments with more 'full professors' and 'stars'. Guthrie et al (forthcoming) propose a strategy for funding impactful research. This is an overview of themes emerging from three studies investigating the translation of, and payback from, basic biomedical and clinical research looking specifically at the returns from schizophrenia (Wooding et al, 2013), cardiovascular and stroke (Wooding et al, 2011) and arthritis (Wooding et al, 2005) research. They found that, for impactful research, individual characteristics such as motivation and entrepreneurial attitude are of importance, as well as skills beyond research methods and engagement with wider stakeholders.

Finally, we found a number of models in the literature that attempt to combine characteristics at an individual and a faculty level to explain and predict productivity, using factors such as the highest degree researchers have and their publication habits, research group size, and leadership (Finkelstein, 1984; Cresswell, 1985; Dundar & Lewis, 1998; Teodorescu, 2000; Brocato, 2001; Bland, 2002, 2005). While exact results from these models vary, they generally find that individual-level characteristics are essential for productivity, but the culture of a department, for example feeling that ideas are listened to and having strong leadership, is also of importance (Bland, 2005).

While the literature points to the importance of department size, critical mass and a focus on general productivity as a measure of success, our own observations relate to the characteristics of staff within departments, and the importance placed on recruiting the best. This is in line with the 2014 report from Economic Insights that identified excellent researchers as the primary driver of research excellence.

Observation A: In high-performing research units more of the staff have PhDs, professorial positions, international experience and externally funded salaries

Based on our analysis of the quantitative data on staff characteristics and PhD cohorts available to us through REF4 and HESA (for further details see Appendix 2), we found that high-performing research units have a higher percentage of eligible staff[15]:

- With PhDs
- Who are professors
- Whose salary is not wholly institution funded
- With non-UK nationality
- Whose previous employment was overseas

In addition, high-performing research units award more research doctoral degrees, both in overall numbers and per eligible researcher. It is important to note that we have not investigated causation and these characteristics should therefore not be interpreted as causative of high performance.

For each characteristic, we tested whether there was a significant difference between our high-performance sample and the average of all submissions, by (1) testing for an overall difference, comparing each high-performing research unit to the overall average; and then stratifying the sample and comparing each high-performing research unit to the relevant UOA average; and (2) calculating correlations between each characteristic and our overall research unit ranking of all units submitted to the REF. Below, we present the results of both these analyses for characteristics where significant results were found (further details on statistical methodology are given in Appendix 2).

Figure 4 shows plots of the characteristics of our high-performing sample against the UOA average for the UOA that the submission belongs to, with shape and colour representing the relevant Main Panel. The black line corresponds to where each point would be if the percentage of eligible staff was the same as the average in the UOA, and it can be seen that most of our high-performing submissions were above this average. Plots are shown for characteristics where the high-performing sample is significantly different from the overall average ($p<0.05$) in both tests (for further details on statistical tests see Appendix 2).

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15   Eligible staff refers to the complement of staff within a unit that met the criteria for submission to the REF (as per REF02.2011 http://www.ref.ac.uk/pubs/2011-02/) , not just those individuals that were submitted to REF 2014.

These analyses consider each characteristic, and its relationship to performance, separately; to start to understand how these characteristics as a whole relate to high-performance we have also built a preliminary predictive linear model (see Chapter 7).

Figure 4: Characteristics for which Mann Whitney U tests comparing our sample against the average are significant: (a) eligible staff with PhDs (b) eligible staff who are professors (c) eligible staff on fixed term contracts (d) eligible staff whose salary is not wholly institution funded (e) eligible staff who are non-UK nationals[16] (f) eligible staff who are early career researchers (g) eligible staff whose previous employment was overseas (h) number of research doctoral degrees awarded and (i) number of research doctoral degrees awarded per head

Figure 4a

Figure 4b

Figure 4c

Figure 4d

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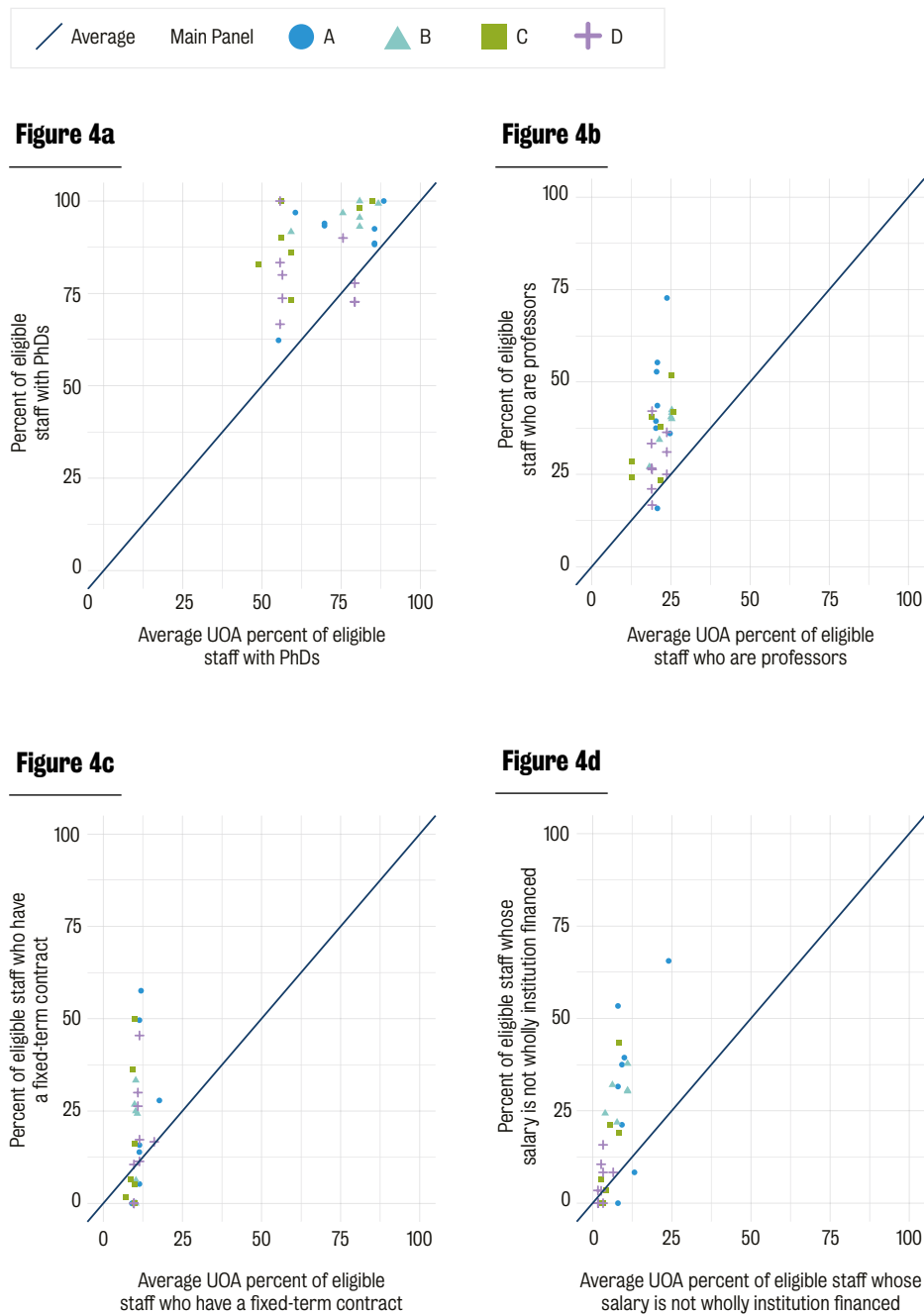
16   Individuals were considered to be international if their legal nationality is not British. Details on the HESA variable of nationality can be found at (as of 1 September 2015): https://www.hesa.ac.uk/index.php?option=com_studrec&task=show_file&mnl=13025&href=a%5e_%5eNATION.html

Figure 4e

Percent of eligible staff who are non-UK nationals (y-axis)
Average UOA percent of eligible staff who are non-UK nationals (x-axis)

Figure 4f

Percent of eligible staff who are early career researchers (y-axis)
Average UOA percent of eligible staff who are early career researchers (x-axis)

Figure 4g

Percent of eligible staff whose previous employment was overseas (y-axis)
Average UOA percent of eligible staff whose previous employment was overseas (x-axis)

Figure 4h

Number of research doctoral degrees awarded (y-axis)
Average UOA number of research doctoral degrees awarded (x-axis)

Figure 4i

Number of research doctoral degrees awarded per head (y-axis)
Average UOA number of research doctoral degrees awarded per head (x-axis)

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Table 1 shows instances where we found significant correlations, and rank correlations, of specific characteristics with the overall research unit ranking of all units submitted to REF (ranked from 1 to 1,911, so that the smaller the number the higher the ranking of the research unit). The correlations are negative, indicating that the characteristic is larger for research units higher up the ranking and smaller for those lower in the ranking.

Table 1: Significant correlations between characteristics and overall research unit ranking

Characteristic	Pearson correlation	Kendall tau-b correlation
Percentage of staff with PhDs	-0.334	-0.190
Percentage of professors	-0.391	-0.297
Percentage of staff who are wholly institution funded	-0.307	-0.276
Percentage of staff with non-UK nationality	-0.181	-0.134
Percentage of staff whose previous employment was overseas	-0.241	-0.193
Number of eligible staff	-0.209	-0.182
Number of research doctoral degrees awarded	-0.404	-0.396
Number of research doctoral degrees awarded per eligible researcher	-0.313	-0.337

We carried out both statistical testing and correlation analysis in order to gain greater confidence in our conclusions. Other characteristics should be viewed as worthy of further investigation.

Table 2 shows results of both of these analyses, with characteristics where there was both a significant test result and a significant correlation shown in italics. It is important to stress that these characteristics do not imply causality. For example there is a significant difference between our high-performing sample and the overall average in terms of percentage of staff on fixed term contracts (Figure 4c). This may be because high-performing staff attract external funding or are recruited with existing fixed term funding contracts, or simply that staff in high-performing units need to demonstrate success in attracting funding. Characteristics also tested, but where we did not find significant test results or correlations, are listed in Box B.

Table 2: Results of both testing methods[17]

Characteristic	Significant difference between our high performance sample and the overall average	Both correlations significant
Percentage of staff with PhDs	✔	✔
Percentage of professors	✔	✔
Percentage of early career researchers	✔	
Percentage of staff on fixed term contracts	✔	
Percentage of staff whose salary is not wholly institution funded	✔	✔
Percentage of staff with non-UK nationality	✔	✔
Percentage of staff whose previous employment was overseas	✔	✔
Number of eligible staff		✔
Number of research doctoral degrees awarded	✔	✔
Number of research doctoral degrees awarded per eligible researcher	✔	✔

Box B: Other characteristics tested for which no significant test results or correlations were found

- Gender
- Academic teaching qualifications
- Number of years at current HEI
- Age
- Mode of work (full-time or part-time)
- Ethnicity
- Senior management holder

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17 Italics denotes characteristics where there was both a significant test result and a significant correlation.

Professors and PhDs

Our analysis shows that high-performing research units have more staff with PhDs (Figure 4a) and a higher percentage of professors (Figure 4b). This is supported by the literature, including the finding that high-performing research departments have more full professors, and 'research stars' (Dunbar & Lewis, 1998), and that one of the drivers of higher individual research performance is having a PhD (Bland, 2005; De Witte & Rogge, 2010).

Salaries

Using the HESA data, we found a higher percentage of staff whose salary is not wholly institution funded in our high-performing sample than in the average (Figure 4d); however we have not found evidence in the literature on the source of the salary in relation to high performance. This characteristic correlates with two characteristics from the REF4b data: the total amount of research income (0.44), and the amount of research income per eligible researcher (0.40), suggesting that units with more research income have more staff whose salary is funded by external funding. In the HESA data we also found a higher number of research doctoral degrees were awarded in high-performing submissions (both net and per eligible researcher) (Figures 4h and 4i). These characteristics also correlate with the amount of research income (0.62 and 0.41 respectively), suggesting that units with more research income may also award more research doctoral degrees.

Department size

Our sample includes both small submissions with one focus area, and large submissions covering many fields. Interviewees from small focused submissions commented on how being small forces research to be focused and innovative, and that being in a small field can make it easier to know the sector and benchmark the department. An interviewee from a large submission commented that having a large single department can allow for more effective cross-fertilisation of ideas. Another interviewee thought that being relatively small was good for culture and morale, and allowed for sufficient researchers to cultivate a range of areas, but not too many that the department lacked cohesion.

A number of interviewees raised the importance of critical mass, both in terms of the size of research group, but also subareas within each discipline, a frequently researched topic (Quarshi, 1993; von Tunzelmann et al, 2003; Kenna & Berche, 2012). The size required for critical mass varied between disciplines. Many interviewees commented that the critical mass could be quite small, but that it was required to gain momentum, funding and to foster an expectation of high performance. One interviewee raised concerns about HEIs reorganising from the top down and not recognising the effectiveness of smaller groups, and the importance of identity to academics.

Diversity and other departmental mix

Interviewees tended not to discuss other aspects of departmental mix, such as age distribution and length of time staff stay at an HEI. In addition, we did not find a significant relationship between age and high performance (Box B), which agrees with previous studies that found that age does not have an influence on research output and impact on an individual level (Gonzales-Brambila & Veloso, 2007). In terms of the age of the group, Pelz & Andrews (1966) found that it helps for a group to have been together for long enough to develop group cohesion and that if the group climate stays similar then productivity does not drop off over time.

Some interviewees raised diversity as an issue that is being considered in recruitment decisions, although our quantitative data analysis of characteristics such as gender and ethnicity did not find any significant relationships. Interviewees who discussed diversity generally reported that paying attention to these issues affected the way people thought and created a better working – and hence academic – environment.

Observation B: High-performing research units are focused on recruiting the best and retaining them

Recruitment of the best staff was widely described in the interviews as a key element of high performance. This generally included being able to choose from an international pool of staff at all levels, allowing for recruitment of the best talent as well as increasing diversity, helping to spread ideas and cultures, fostering links and improving performance. This idea of recruiting from an international pool concurs with the finding from the HESA data that high-performing submissions have more staff with non-UK nationality, and more staff whose previous appointment was overseas (Figure 4e and g respectively). This aligns with a finding from a study providing an international comparison of performance of UK research which showed that the UK researcher population is internationally mobile (Elsevier, 2014). In addition, they commented on the link between high level of research mobility and collaboration as important drivers to high performance of the UK as a research nation.

Identifying 'the best'

The majority of interviewees described 'the best' as being world leading, with a number specifically mentioning that they take REF into account when hiring and look for 3* or 4* outputs in candidates. Interviewees tended not to discuss impact when talking about recruitment, although two who provided an institutional perspective (Pro Vice-Chancellor or equivalent) said that impact was beginning to become a factor in recruitment decisions.

Early vs senior researchers

As well as looking for the best researchers, interviewees discussed the ideal seniority level for hiring staff. From both the workshop and the interviews, the focus tended to be on hiring early career researchers – or 'catching rising stars'. One workshop attendee commented that when someone senior left, they would fill the position with an early career researcher (ECR), rather than hiring new senior staff. The hope behind this was that they would hire 'future stars', nurturing and promoting from within, and creating a culture where people feel supported and able to progress, rather than having people brought in from outside. Other workshop attendees agreed that this was the model they felt people should be aiming for. One interviewee also described hiring ECRs on fixed term contracts, but with the chance of an academic position at the end, as a mechanism for growing a department under financial constraints.

In the interviews we conducted, senior hires were often discussed as strategic decisions, based on whether the individuals align with the department strategy, or fill in gaps in the department. Interviewees expressed strategic decision-making in relation to the way recruitment is run, with a few mentioning that they have targeted rather than open recruitment calls, or that they specifically search for possible hires at conferences. Interviewees also discussed flexibility in hiring, in terms of not always having a specific topic in mind when recruiting the best researchers. Interviewees noted variation in the administrative level at which the recruitment is run. One commented that to avoid hiring 'familiar or safe staff' they appointed at a school rather than departmental level. Another noted that their unit had autonomy over hiring, giving the department identity and allowing them to foster their own culture.

Process of recruiting

Another key element of recruiting the very best people is the process itself and in particular the need for an investment of time and effort. A number of interviewees mentioned the emphasis that was put on recruitment, including thoroughly reading candidate's papers, and the length of discussions and thought that went into recruitment. Indeed the literature also suggests that this is important. Recruitment practices have been found to affect both the volume of research outputs (Snyder et al, 1991) and research excellence (Harvey, 2002). In particular, taking the time to recruit people with specific talents has been found to distinguish highly productive research and development units (Dill, 1985, 1986a, 1986b).

Incentives

To recruit the best staff the research unit needs to be attractive to researchers. Many interviewees commented that the reputation of the unit (at a department, group or faculty level), and sometimes also of the HEI, was important for attracting staff – 'People want to work with the best in their field and be the best'. Interviewees identified a number of incentives for attracting researchers (Box C), which they felt were needed to allow units to compete with comparatively generous packages from other world-leading HEIs, particularly those in the US.

Box C: Examples of incentives used to attract the best staff

- Salary
- Focus on research over teaching
- 'Honeymoon' period of low teaching
- Start-up packages for ECRs
- Longer term contracts
- Allowing senior researchers to bring their team along
- Flexi-time or part-time working arrangements
- Shared appointments
- Infrastructure and facilities
- Supportive culture

Student intake

Some interviewees discussed the relevance of student intake on high performance, a point also raised during the workshop. The ratio of staff to students was a mixed issue. Some interviewees commented that they felt pressure to increase the number of students, while others noted the importance of good graduate and undergraduate students in a position to help with research and encourage high-performing staff. One interviewee noted that from a departmental point of view, PhD students can bring in funding and that there might be a tendency to take those who bring in more funding over others.

3 | Institutional and departmental practices

Collaborations and networks

Strategy and funding

Culture and values

People

Leadership

Institutional and departmental practice

3 | Institutional and departmental practices

In the previous chapter we identified 'people' as a key *prerequisite* for high performance. In this chapter we focus on one of the *enablers* of research excellence closely related to people; which are the institutional and departmental practices that enable and support high performance. In particular, this study has identified the existence of robust and supportive operational structures and practices within HEIs at different levels as enablers of research excellence. These complement the processes and strategies in place for recruitment, described in the previous chapter. Some of these structures function at the departmental level but the majority are more centrally located (ie at the faculty/college/school or institutional level). They provide services and support to staff engaged in research and activities related to the wider impact and dissemination of the research.

The literature points to a variety of contributing factors that will lead to a productive research environment, including internal structures such as research facilities, libraries, time and funding, and the need for support services to have a strong commitment towards research. A recent report commissioned by the UK Department for Business, Innovation and Skills (BIS) to identify the drivers of excellence in the UK research base recognised the importance of formal training courses and workshops for winning research grants for ECRs, 'on-the-job training', and formal and informal arrangements for mentoring (Economic Insight, 2014).

These features are in line with our observations. One interviewee remarked that it was 'important that the research support quality matches the researchers themselves'. Others highlighted that support included the physical infrastructure such as laboratories and libraries. However, the most significant type of operational support identified by our analysis seems to be that given to the development of staff, be it through training, mentoring or other mechanisms. We include this as our final 'platform' characteristic that supports high research performance.

Observation C: High-performing research units provide training and mentorship programmes to develop staff, while offering rewards for strong performance

Training options

All the departments in our sample of high-performing research units reported that they offered training support to research staff, although the scope of this training varied across the sample. These training 'courses' (listed in Box D) were available centrally, predominantly through offices located at the institutional or faculty/college/school level, although in some instances, training was devolved down to the department level. In this latter case, the training covered areas that were more discipline-specific, such as publication strategy and advice, and field- or method-specific workshops (eg statistics, coding survey design, writing patents, intellectual property). A few of the interviewees also mentioned the importance of providing research staff with the option of external (paid for) training.

Box D: Areas covered by training courses that were mentioned by interviewees and workshop participants

- Publication strategies
- Field- or method-specific workshops
- Leadership
- Time management
- Grant applications
- Outreach and public engagement
- External collaboration and cultivating international networks
- Cross-disciplinary research
- Intellectual property
- Ethics
- People management and related policies

Mandatory vs optional training

In general, interviewees expressed that optional training and development courses were more effective in helping to motivate staff and sustain high performance than mandatory training. As one interviewee highlighted, 'we have to be careful with making things compulsory… it's about getting people to think about their personal career and getting them to do what they want to do.' Some interviewees mentioned that PhD students were required to attend a minimum number of training courses, while post-doctoral and early career researchers were 'strongly encouraged' to do so through the annual appraisal system. A divergent view, expressed by a minority of the interviewees, was that elements of the training courses offered were compulsory within their departments, in order to facilitate staff to do their best, particularly in the case of researchers who were on probation. Common examples of mandatory training courses cited by the interviewees were training to cover equality and diversity, research ethics and media training.

It is worth noting that some of the interviewees highlighted that there was no value in providing generic training to researchers in how to conduct high-quality research and produce top publications, noting it was more about mentorship rather than 'attending courses'. Since they only 'recruited the best', this kind of 'training' should have been provided to researchers when they undertook their PhDs, and consequently, they should already be able to demonstrate the necessary skills.

Impact training

Training described in interviews often focused on capturing and articulating the impact of research and the wider dissemination of outputs. This is not surprising and is to be expected given the wider impact agenda in the UK higher education sector, and its explicit inclusion in REF 2014 assessment criteria. In general, most interviewees stressed the importance of training to support operationalisation of impact rather than the theory. To deliver this in several cases, dedicated members of staff were hired, predominantly located centrally or at the college/faculty/school level, who were responsible for assisting and advising researchers in the translation of their research into impact. Interviewees stressed the importance of academic engagement in this role. Examples given included 'impact champions' or 'impact directors' who provided both the enthusiasm and required expertise, while at the same time understanding the

challenges researchers encountered. One interviewee remarked, 'we have a 'professor in practice' who talks to staff and helps them [think through] who might be the right contacts to engage with'.

Mentoring

The majority of the interviewees and workshop participants linked high performance with the existence of healthy mentoring practices within departments. Mentoring was seen as being crucial to generate and develop new research ideas. In some cases, mentoring was more formal, involving members of staff – especially early career researchers – pairing up with senior colleagues within the department for a period of time. In the majority of cases, interviewees described a more informal and constant nature to the mentoring process. Mentors and mentees within – and sometimes across – departments had the freedom to develop their own relationships rather than adhere to a programme that would match people with each other and document outcomes. For example, a 'critical friend' would read a proposal or a book manuscript and provide feedback, or would offer advice on how to create impact. The need for a mix of seniority, which provides different experience, knowledge and new ideas to draw from, is in line with the over representation of professors and ECRs in high-performing research units, compared to the average.

Grant application training

Interviewees frequently mentioned research grant 'surgeries', internal peer review of applications, and training for funding panel interviews, as methods of improving success rates. In many cases, and particularly with regard to large grant applications, this took the form of a formal system in which senior academics with a range of specialities would read and approve (or reject) application drafts. Several interviewees also noted the existence of informal peer review mechanisms at a more 'local' level (eg at a departmental or research group level) for smaller grant applications or research ideas that were at an earlier stage of development.

Performance incentives

Interviewees noted performance and talent management as vital tools to 'operationalise' and facilitate research excellence, in terms of both impact and quality. A common model adopted by departments across our sample was to offer individualised incentives to motivate high performance and reward members of staff. The majority of interviewees stressed that this was a more effective approach to performance management than using targets or penalties. They felt that penalties had the tendency to have negative effects (eg 'terrible effect on morale'), although a few interviewees (from all Main Panels) and workshop participants acknowledged that penalties did exist in some form or the other as a means to manage 'low' performance.[18] A number of interviewees mentioned that research performance was 'officially' monitored through the annual appraisal/review system, using a selection of criteria like publication record (both number and 'quality'), success at winning research grants, scholarship (ie originality of research), and international prestige (eg awards and recognitions).

A majority of interviewees deemed it very important to recognise success in order to maintain research excellence within departments. Box E summarises some of the common incentives mentioned across the interviewee sample. This complements Box C (see Chapter 2) which gave examples of incentives used to attract the best staff. Specifically, promotion and financial rewards were strongly linked to outstanding performance. Financial reward could either be directly to the individual in terms of a

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18 Penalties were used by some as a means to manage 'low' performance. Researchers deemed to be underperforming would either be offered help to 'get back on track', have incentives withdrawn (such as removing research space), salaries adjusted, teaching load increased or movement to another role suggested (ie to pursue an alternative career pathway).

salary increase, or funding for the research group (eg PhD studentships, the purchase of equipment, or monetary support for travel to attend international conferences and visit collaborators). Notably, reducing the teaching workload and offering sabbaticals to high achievers were other common incentives mentioned during the interviews, though participants in the workshop expressed concern that teaching should not be seen as a punishment. Instead, they felt a more nuanced approach to match teaching, research and administrative workloads with individuals' specific skill sets resulted in better performance as well as a more highly motivated and balanced workforce.

Box E: Some of the common incentives to reward high performance mentioned by interviewees and workshop participants

- Promotions
- Reduced teaching load
- Financial reward (eg salary increases)
- Sabbaticals
- Funding
    - PhD students
    - Seed funding
    - Impact awards
    - Equipment
    - Attending conferences, visiting collaborators abroad, and/or inviting collaborators to the UK

4 | Research culture, underlying values and leadership

4 | Research culture, underlying values and leadership

Along with *People* (Chapter 2), in our analysis we identified research *culture, values and leadership* as another set of prerequisite characteristics associated with high-performing research units. The majority of interviewees discussed – often interchangeably – aspects of high performance relating to management and leadership. Some of this related to the level of autonomy given to staff, which can both influence or be a result of the underlying culture and values of the department. Below we examine some of these aspects in the literature before presenting our observations on this theme.

A report by Salmi (2009) for the World Bank proposes the following three inter-related attributes for defining 'world-class universities': (i) 'high concentration of talent' (both in terms of faculty and students); (ii) 'abundant resources to offer a rich learning environment and to conduct advanced research'; and (iii) 'favourable governance features' to facilitate autonomy, strategic vision and effective resource management. Although the unit of analysis in this study is the university, these success factors are nevertheless still relevant for examining research excellence at the departmental level, and map with our characteristics of: people (Chapter 2), institutional practice (Chapter 3), funding (Chapter 5) and leadership (described below). Tensions between central and devolved leadership are reported in a study by McCormack, Propper & Smith (2013).

Leadership also gives voice to a standard for high performance, establishes and sustains good management practices, and plays a part in setting cultural norms and strategic direction – creating 'vital and viable' organisations (Bennis & Nanus, 1985). In the study surveying 250 departments across UK universities, Bennis & Nanus (1985) found that while management practices varied widely, the practice of management was important to both teaching and research performance. Furthermore, they found it was the management practices within the departments, rather than centralised management practices, which mattered most to performance and similar views were expressed in the workshop in our study.

Finally, institutions employ a variety of formal and informal approaches to maintain a culture of high performance, outputs and impact. Indeed West et al (1998), suggest that departmental climate is as much an outcome of research excellence as it is a contributor to it.

Observation D: Staff within high-performing research units display a distinct ethos of social and ethical values

The majority of interviewees felt that the presence of a shared value system was an important part of a high-performing research unit – though there was considerable variability in how explicitly interviewees referred to this. Box F provides a flavour of some of the key values described by interviewees as important for maintaining a culture conducive of high performance. The list is divided into three overarching categories (public focus/high standards/supportive environment). This was in line with the observations and suggestions for action from the Nuffield Council for Bioethics study on the culture of scientific research in the UK that recommended that 'research institutions cultivate an environment in which ethics is seen as a positive and integral part of research' (Nuffield, 2014).

Academic freedom

Linking to the observation below on the need for leaders to have 'accountable autonomy', interviewees stressed the importance of creative and academic freedom of thought within the research culture. Many shared the view that departments should provide a nurturing environment and an ethos of mutual support and collegiality in order to contribute to a cooperative environment, versus researchers who sought to advance their own positions. On the other hand another interviewee flagged competition as a direct means to encourage researchers to prepare for independence and self-sufficiency. For example, their institution provided financial support for staff to put themselves forward for competitive funding on the assumption that staff would grow to become competitive themselves.

Evolving research culture

In terms of how such a culture could be achieved, participants in the workshop noted that it was not something that could be imposed from above; instead it must permeate from the 'bottom up'. Though none felt that there was a single 'best' culture, there was a broad consensus that a process of making values explicit – even informally – could help others to 'buy in' to an organisational culture. This aligns with findings from a

recent study by Kok and McDonald that highlighted the importance of open decision making in contributing to excellence in academic departments (Kok & McDonald 2015).

These findings around diversity of culture and its link to leadership are corroborated by evidence from the literature. Pelz (1956) studied the relationship between research performance and social environment in a large US government research organisation. He found that researchers 'performed more acceptably' when they had:

- the freedom to pursue original ideas
- a leader who gives neither complete autonomy nor excessive direction and allows for frequent interaction
- daily contact with several colleagues who have different employment backgrounds, have different values and/or tend to work in different scientific fields, but at the same time have frequent contact with one important colleague who shares the same values

More recently, Edgar & Geare (2010) studied the differences in management practices between high-performing and low-performing research university departments. They found that a 'notion of shared values' was evident in research. The high-performing research departments unanimously agreed on a need for a good research culture and that departmental values must communicate a value of the workforce, have an emphasis on quality, and work towards the development of an international reputation. While interviewees noted that strong leadership could help to articulate values and expectations, some felt that it was important to democratise the department away from a 'professorial elite' by bringing in younger talent.

> **Box G:** Examples of ways to share best practice and raise awareness of what high performance looks like
>
> - Lunchtime seminars eg 'Brown bag' lunches
> - University-wide 'impact of the year' award
> - 'Lifetime achievement' awards
> - Prizes for best paper and research presentations (particularly amongst graduate students)
> - Organising research and its presentation into challenge themes

Seeking out and sharing examples of best practice formed part of the culture of a number of high-performing institutions. Several interviewees described initiatives designed to raise awareness of what high performance looks like (Box G).

Observation E: The leaders of high-performing research units have earned 'accountable autonomy' within their Higher Education Institutions

A prominent but subtle theme arising from the interviews and reinforced in the workshop was the nature of leadership. For high-performing research units, leaders had 'earned' the trust of senior management and had a degree of 'accountable autonomy' in the way they lead and run their research unit. They were 'accountable' in that they had to 'check in' with central institutional staff to maintain the earned trust, but 'autonomous' in the sense they could shape the strategic direction of the unit and, more importantly, develop shared strategy and a communal culture. One interviewee noted the interplay between autonomy and accountability for the actions of teams in such a devolved leadership system:

> 'It is key that the heads of department get the support they like for [their] teams. You can have as many targets, etc, as you like, but unless there is buy in and support from heads, it's not going to work. This is crucial to our high-performing subjects.'

Leaders supporting cultures

Contributors to the workshop spent much time debating what 'good leadership' looked like at a departmental level. They noted that good leaders are often not aware of their own abilities, but that leadership 'can support or wreck a culture'. Nonetheless, from the discussions a broad consensus emerged regarding the qualities embodied by 'a good research leader', including being 'unselfish' and not merely a 'star performer', being supportive, fair, credible in ability to deliver work, harmonious and 'visionary'. These specific leadership qualities broadly align with those identified by a 2007 University of Leicester study, that found that the facets of leadership at both institutional and departmentallevels which proved to be important for research effectiveness included providing direction, creating a structure to support direction, having personal integrity, facilitating participation and consultation, and fostering a supportive and collaborative environment (Bryman, 2007).

Leadership by example

Some interviewees noted the role of senior team members in setting an expectation of quality. One referred to the importance of research excellence as a driving force to motivate staff, acting as a 'binding force', as expressed by interviewees:

> '[Success derives from] a culture of excellence set by the leaders, which everybody buys into, and is therefore motivated by. In each of the individuals we hire, we expect a high degree of self-motivation. They are naturally competitive and our environment helps them thrive in that context.'

> 'The high impact work of our research leaders is emulated by others and has become embedded in the organisational culture.'

This is commensurate with findings by Goodall et al (2014), who reported that a highly cited incoming departmental chair was associated with high subsequent research productivity. This suggests that successful researchers may 'behave differently' in their management practices, possibly providing more autonomy, accepting early failure while rewarding long term success. It also suggests that the reputation of a successful researcher will factor into recruitment and retention of other key scholars. Overall, as voiced by one interviewee: 'Excellence is the driving force behind the work we do'.

5 | Living strategies, including diversity of funding

5 | Living strategies, including diversity of funding

A review of drivers of research excellence (Economic Insight, 2014) for BIS reported that research strategies play a role in the production of excellent research and that having an identifiable strategy can positively influence performance. This was a key theme that arose from our analysis but - along with *Collaboration and Networks, and Institutional and Operational Practice* – was not seen to be of the same importance as the two 'prerequisite' characteristics of *People and Leadership, culture and values*. For this reason we term these 'enabling' characteristics. Given research organisations' reliance on funding, and the specific mention of funding strategies highlighted in the interviews, we have also included funding (specifically diversity of funding) within this theme.

Observation F: High-performing research units have strategies that are real, living and owned, and more than merely a written document

High-performing research units varied greatly in their acknowledgement – and delivery – of implicit or explicit strategies to support and sustain high-quality research.[19]

Given the breadth of disciplines represented within any one HEI, it is perhaps not surprising that a number of interviewees highlighted the ways in which strategies differed between a particular institution and different departments within it. This is not to say that such differences prevented alignment in working practices. One interviewee noted the provision of a written research strategy as enabling buy-in amongst staff and providing a sense of team direction, as well as contributing to the working ethos of the unit or department. In contrast to this, many interviewees noted that good research took place in the absence of any top-down explicit strategy, in which case the strategy itself was to have an implicit strategy or ways of working together.

> 'In reality everything is bottom up. Many universities have a management plan of 'we must have a strategy and that will equate to results'. That is not effective, if you think about academic research, it's about passion for research and you cannot fabricate it. Management strategies can get you mid-way, but you can never reach world leading through a top down approach'.

Workshop participants noted the many ways in which strategic initiatives can be deployed within a research institution, at different organisational levels and for a variety of purposes. That said, the majority of discussions focused on processes and the relevance of explicit (ie written) strategy documents.

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19   Many interviewees noted strategies around institutional approaches to the REF process itself. While it may be that a focus on impact in REF 2014 has affected institutions' future strategies around the delivery and reporting of impact, this is not a topic forming the focus of this study and therefore has been excluded from our analysis.

Strategies as a process to create alignment

Workshop participants noted that to be relevant to activities, any strategy needed coherence – which could be defined in a number of ways (ie not necessarily 'focused' or 'broad'). In devising strategies, participants felt there needed to be a degree of autonomy granted to individuals feeding into the process, although they also acknowledged the need for some accountability. They noted the concept of a strategy as a 'living document', whose value lay as much in the processes of discussion and internal communication as it did in the generation of a printed product. As one interviewee said: 'our strategy is real, but the process is as important as the product'. Another reported that having a clear strategy for where the department was going and a relatively small number of core work streams enabled the team to show progress. Examples of specific strategies discussed by workshop participants included the setting out of research priorities and achievements transparently as a means to define high-quality outputs amongst staff.

Strategic thinking did not come without an opportunity cost to those engaged in such work. Interviewees spoke of activities ranging from monthly staff meetings and annual faculty retreats, to ad-hoc research events – all to encourage dialogue and a discussion of ideas around research plans and strategies. Support for these activities was in some cases 'implicit', but in one instance an interviewee noted time set aside by the department to discuss research strategy, with resources provided to enable this. This would seem to mirror sentiments expressed by other interviewees who noted the importance of providing research staff with protected research time and reiterated the importance of departmental support for strategic planning activities.

Themed groups

A number of interviewees described ways in which the research ambitions of their department and, in some cases, their institution, had been grouped into themes. They felt these helped to unify diverse strands of work under the banner of addressing 'grand challenges'. This could act both to improve public awareness of an institution's values and to encourage interdisciplinary working amongst staff, supporting internal and external collaborations. These could be interdisciplinary, topic-specific, or both. Key to their being relevant was the process institutions went through to derive the themes, as described by one interviewee:

> 'Theme leads are assigned for teaching and research purposes, and form a research committee – functional leads as opposed to senior staff within the department – which produces a strategic medium-term document on research plans. This feeds up into a senior academic group made up of a wider group of departmental staff, who debate and agree the direction of research. The document also feeds into postgraduate teaching and training plans, and to the School research committee'.

Observation G: High-performing research units receive more income per researcher than the average research unit

A handful of interviewees noted that they had a strategy towards their funding sources aiming to maintain some financial stability, for example, taking into account the reputation of funding source, or the value of the grant when deciding what to apply for. They highlighted the importance of a strong funding mix from: QR, grants, partnerships with industry and income from undergraduate fees, in particular those from international students. When asked about the role of quality related (QR) funding, interviewees were divided on whether they perceived it benefited the unit directly or subsidised others that did not perform as strongly in assessment.

> 'QR comes into a faculty budget, rather than departmental. Yes its important overall, as it's what allows us to maintain a research-led policy. But levels of funding differ and in some cases [one department's] QR may be subsidising others'.

Income per head

Johnes et al (1993) statistically analysed the results of the 1989 Research Selectivity Exercise in the UK and identified that research expenditure per member of staff was positively correlated to research performance. In our analysis of research income[20] (REF4b), we have summed sources of income and all years reported (2008–2014) and used the headcount of eligible staff for each submission.[21] We observed that high-performing research units have more research income per head than the average submission ($p < 0.05$) shown by the number of points in Figure 5 above the line. Additionally we found a significant correlation between the amount of research income per head and the overall research unit ranking.[22] The importance of reputation was highlighted when discussing industrial funding and collaboration, with interviewees stressing that potential collaborators approached the unit as a result of good performance in previous RAEs, rather than the need to seek partners and funders.

Figure 5: High-performing research units have more research income per head than average

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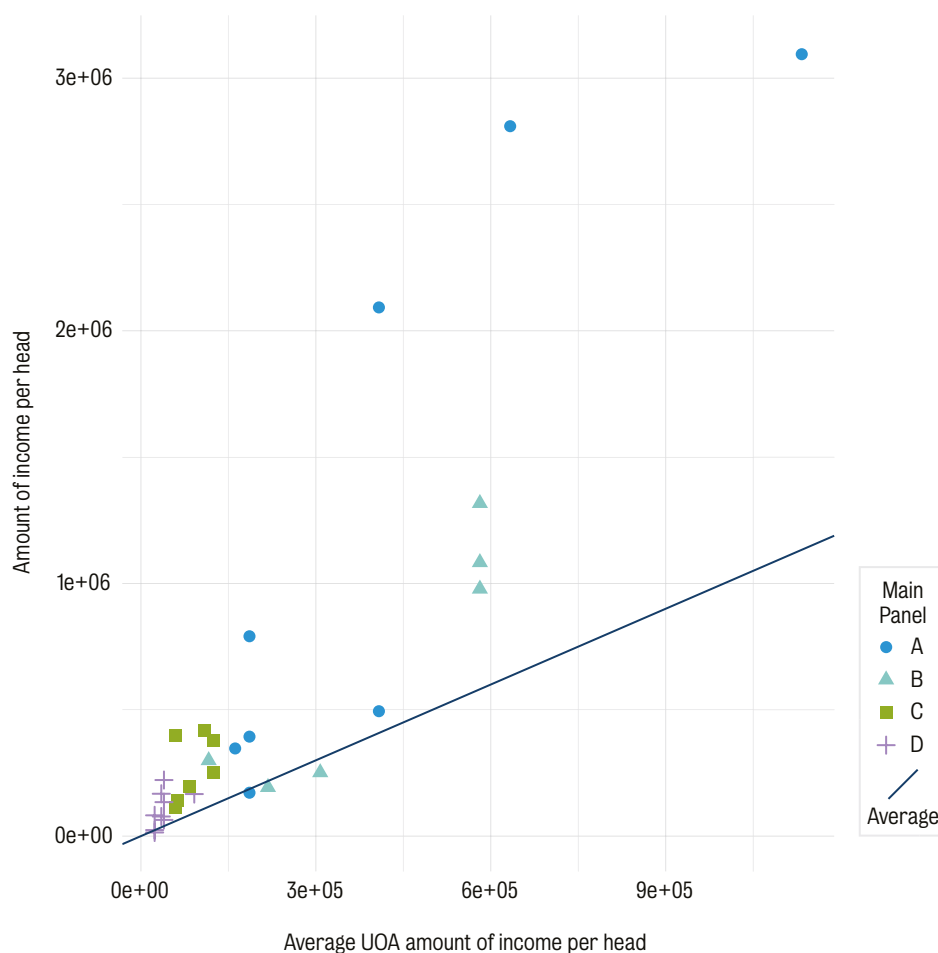
20 Sources of income are defined in REF4b as UK charities, UK industry, UK government, UK Research Councils, EU charities, EU industry, EU government, non-EU charities, non-EU industry, and other. It is important to note this excludes QR, or equivalent outside England. This is aligned with HESA definitions of research income in the Finance Statistics Return (FSR) Table 6b.

21 These analyses consider each characteristic and its relationship to performance separately; to start to understand how these characteristics as a whole relate to high-performance we have also built a preliminary predictive linear model (see Chapter 7).

22 Correlations between the proportion of papers with international collaborators and our ranking (Pearson =-0.27, Kendall tau-b = -0.39).

Diversity of income

Having a diversity of research income was important to over half the staff interviewed across all four panels; they describe a wide range of sources available to them and most commented on how their department encouraged them to find various sources of income.

> 'All of these systems and processes, and even just making sure that you're employing the very best staff, etc can only happen if you are assured of funding through research routes, through QR, Higher Education Innovation Funding (HEIF), impact acceleration etc. The continuity of these funding routes are absolutely crucial to supporting impact, enterprise, bid writing and support for new grants etc'.

Looking at research income, when we define income sources by geography and type, we see that high-performing research units have a greater diversity of income sources than the UOA averages (data not shown).[23] However, when we take into account the number of eligible staff in units, while we still see a significant difference between our high-performing sample and the rest of the units ($p < 0.05$), there is no correlation between the diversity of income sources per head and our ranking. As these two tests do not agree, this warrants further investigation to form conclusions.

In terms of using funding for research, the majority of interviewees acknowledged the considerable internal administrative support of the central or school/college/faculty research offices and research managers in helping to source funding (eg horizon scanning) and prepare grant applications, and some of this administrative support is available from QR funding.[24] Additionally, interviewees mentioned that administrative support structures were also in place to assist researchers in the 'post-award' period. These included managing and maintaining grant budgets, as well as intellectual property and spin-outs arising from the research.

Interviewees emphasised the importance of specific funding streams for impact. In particular, they highlighted Knowledge Transfer Partnerships (KTPs) as facilitating the transfer of academic knowledge to 'real-life' businesses, HEIF support for wider outreach and impact, and the Research Council UK's Impact Acceleration Accounts as providing flexible funding for knowledge exchange activities. Several interviewees noted the use of cross-institutional services such as the press office and the communications office to disseminate research.

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23 The types of funding in this database are defined by geography and type, where the possible geographies are UK, EU (without UK), International, and types are government, research council, charity, and industry.

24 http://www.hefce.ac.uk/pubs/rereports/Year/2014/qrreview/Title,101530,en.html

6 | Enabling collaboration and building networks
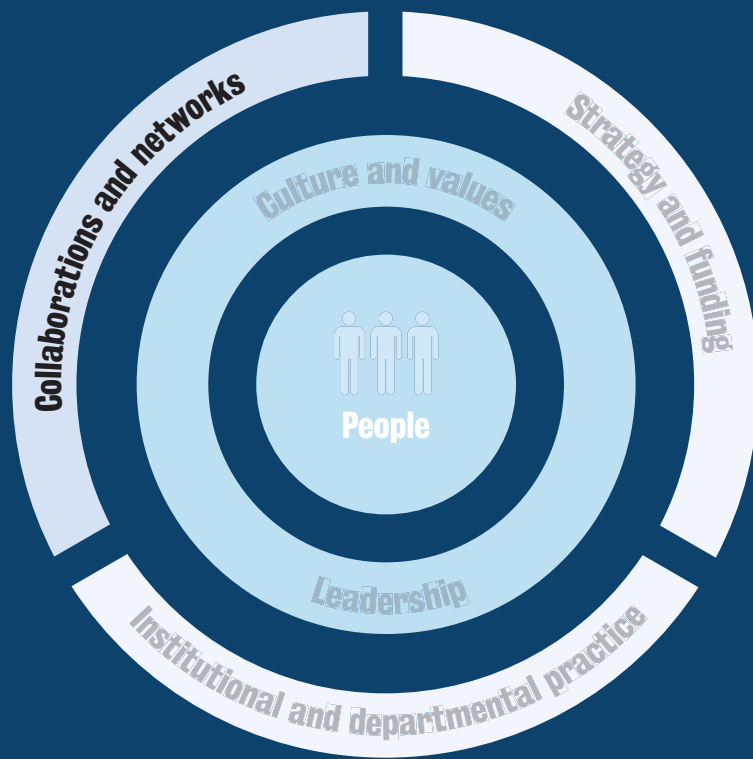
6 | Enabling collaboration and building networks

The progression of interdisciplinary research and increasing ways of communication between HEIs has opened up opportunities for researchers to engage in more collaborative work, both locally and internationally. It was suggested in interviews that the best performing research units are those that make the best use of their existing networks, seize opportunities to collaborate with the best researchers globally, and make the most of the communication and networking channels available. The literature also supports the notion that good collaborations and networks encourage high performance (Economic Insight, 2014). Collaborations for academics can take many forms: internal (within the institution or department, including cross-disciplinary work), external (with other academics at other institutions) and wider external collaborations outside of academia. The way researchers interact with these various types of collaborators varies according to the nature of their work and the requirements of the research. In analysing our own data, we concluded that collaborations and networks form a further 'enabling' characteristic that empowers high research performance (but that collaboration was not a prerequisite in its own right).

There was a view among interviewees, also raised at the workshop, that collaboration may not be equally important for every research discipline, or subsets that are more theoretical (eg philosophy, theoretical sciences). A number of interviewees noted that it took time to develop networks and relationships in highly applied research fields whose research design is both informed and influenced by an external partner. In a study examining the connection between industry funding and publication performance, Gulbrandsen & Smeby (2005) determined through a questionnaire that 'professors with industrial funding describe their research as applied to a greater extent, they collaborate more with other researchers both in academia and in industry, and they report more scientific publications as well as more frequent entrepreneurial results.'

Observation H: High-performing research units enable and encourage researchers to initiate collaborations organically as opposed to using a top down approach

In 2011, the Royal Society published a report stating that international collaborations on scientific research are increasingly becoming the norm, with significant benefits to the quality and impact of the research. They note that collaboration has a positive impact on the science as well as broader objectives – such as increased citation impact, access to new markets and broadening research horizons (Royal Society, 2011).

In both the interviews and workshop, participants commented on the importance of letting collaborations flow organically, initiated by the networks of staff themselves. About half of the interviewees specifically noted that they were not aware of a top-down strategy for collaboration (or dissemination of their work), but that they encouraged staff to establish networks and collaborations themselves. A handful of interviewees specifically mentioned the importance of letting collaborations develop where the researchers and the department already have existing strengths in the field. Discussions at our workshop also suggested and validated the notion that such organic collaborations are the most successful, as has been shown in previous studies.

Specific funding can also be a strategic enabler for collaborations to develop where they had not before; although at the workshop it was pointed out that this could create perverse incentives to focus on an area and 'force' interdisciplinarity, when there may be other social or research priorities to address. A handful of interviewees specifically noted that while funding can create new sources of collaborations, it does not always need to come first, given the organic nature of the strongest collaborations.

From our interviews, while collaborations per se were encouraged, the focus was predominantly on finding partners that were high-performing and suitable to the research activities of the department, whether local or international.

> 'Why would we want to collaborate with the best person in [our discipline] down the road, when we are collaborating with the best person in the world?'

These existing networks and collaborations were seen to be strong enablers of creating impact – and hence also helped when impact came onto the REF agenda. Our interviewees suggested that creating impact means creating networks and establishing links with those outside of academia, which inevitably takes time.

> '[A] key element is significant involvement with stakeholders throughout the research process and active dissemination with government, professionals and so on. There is also broader long term publication with the public, media, social media. We do our best to stay in touch once we have got it. Engagement and high quality go hand in hand'.

About a third of the interviewees, from across all four panels, noted that interacting with an external partner, such as industry, public organisation, health services, museums, or schools, was a natural part of what they did, re-emphasising the importance of long standing relationships.

Despite the emphasis on not promoting a top down strategy for collaborations, it is worth noting that some collaborations and opportunities to engage and network also occur within departments. While some of this occurred organically, a few interviewees noted that their senior leadership put in place activities to encourage a more collaborative environment.

> '[We] put on meetings where they get staff together to discuss what they are doing and get the opportunity to talk about research ideas. [Our department lead] thinks the more informal... meetings that you can arrange, the better. The first thing he did was to reshape the kitchen from a tiny cupboard that no one went into, into somewhere where people could stand and talk to each other. This dramatically increased the number of interactions between staff. These opportunities are really important for forming ideas and comparing notes with people.... you can't plan the interactions, but [you] can plan for opportunities for interactions to occur'.

The literature also indicates that such opportunities for collaboration and informal conversations can be as important as high-level strategic research collaborations.

Some of the earlier literature on collaborative networks suggests that higher-performing researchers tend to cite and network with other highly regarded researchers. Newman (2001), for example, identified that in all the networks studied there 'exists a giant component of scientists any two of whom can be connected by a short pattern of immediate collaborators', which means they continue to reference each other. He also found that researchers in experimental disciplines are more likely to have large numbers of collaborators on average than those in theoretical disciplines, although in biomedicine the degree of network clustering is also low.

In our statistical analyses we examined the proportion of outputs (papers that can be matched to Web of Science/Elsevier database) submitted to the REF,[25] which have at least one author with an international address. We found no significant difference between our high-performing sample and the rest of the submissions (Figure 6), and no significant difference if we look at each Main Panel separately. This analysis is in line with the findings from the Independent review of the Role of Metrics in Research Assessment and Management which found that number of author countries only weakly correlated with scores in the REF assessment and further that a higher number of author counties was associated with both high and low REF outcomes (HEFCE, 2015). It is important to note that these are only a subset of the output of an HEI. As institutions chose their best papers themselves, it is possible that they selected international ones over national, if these are the best papers, or there is a perception that these will be more highly valued in assessment. With this dataset we therefore cannot rule out that high performance may be linked with high numbers of international papers, though we did not find any observable distinction.

Figure 6: High-performing research units have similar proportions of outputs submitted to the REF which have at least one author with an international address to the average
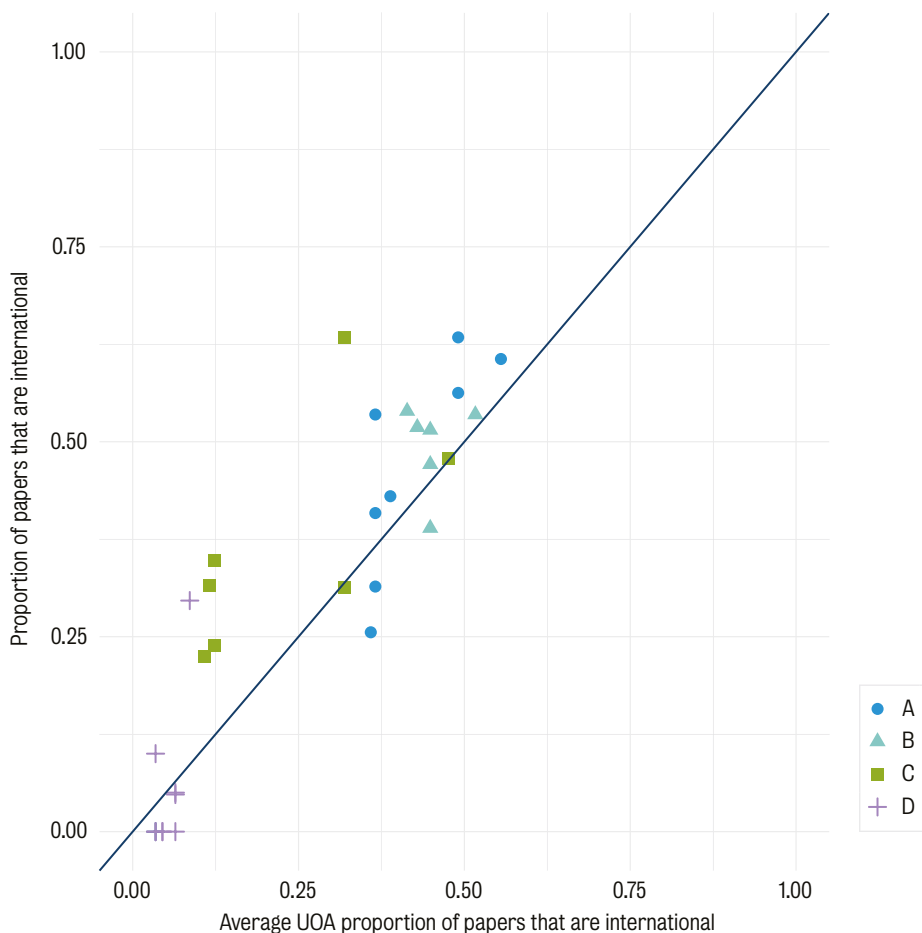
7 | Concluding thoughts

7 | Concluding thoughts

In this report we have synthesised a series of primary and secondary data sources to improve our understanding of the characteristics of high research performance. To do this we have focused on the most successful submissions to REF 2014. Inevitably, and as noted in our introduction, there are a number of methodological limitations to this approach and therefore we have presented our findings as 'observations' (as summarised in Box H) that warrant further investigation and understanding. As such these observations could be seen as a research agenda for HEFCE and HEIs to develop further. To support this, we undertook two further analyses – one conceptual and one empirical. Firstly, we tried to conceptualise the various characteristics into an explanation of high research performance, and secondly we built a simple predictive model of a subset of the characteristics discussed in the report.

> **Box H:** Observations about characteristics of units with high research performance
>
> A. In high-performing research units more of the staff have PhDs, professorial positions, international experience and externally funded salaries
>
> B. High-performing research units prioritise recruiting the best and retaining them
>
> C. High-performing research units provide training and mentorship programmes to develop staff, while offering rewards for strong performance
>
> D. Staff within high-performing research units display a distinct ethos of social and ethical values
>
> E. The leaders of high-performing research units have earned 'accountable autonomy' within their higher education institution
>
> F. High-performing research units have strategies that are real, living and owned, and more than merely a written document
>
> G. High-performing research units receive more income per researcher than the average research unit
>
> H. High-performing research units enable and encourage researchers to initiate collaborations organically as opposed to using a top down approach

Further research

We developed a conceptual model that helps explain how these observations may interact (Figure 7). Central to a high-performing research units are two 'prerequisite' characteristics. The first is *People*: this means recruiting and retaining the best. Additionally our analyses suggest that a certain staff mix is associated with high performance: staff who are research trained (PhDs), who are senior (professors), who have international experience and who can cover their salaries from external sources. The 'glue' that creates the high-performing research unit is its *research culture*,

underlying values and leadership. All the high-performance research units we spoke to had a degree of earned or accountable autonomy – that is, they were given a degree of freedom to manage and pursue research, mostly thanks to the recognition that they were successful due to their strong leadership, the presence of strong performing staff and thriving research culture.

Figure 7: Conceptual model for describing characteristics of high-performing research units
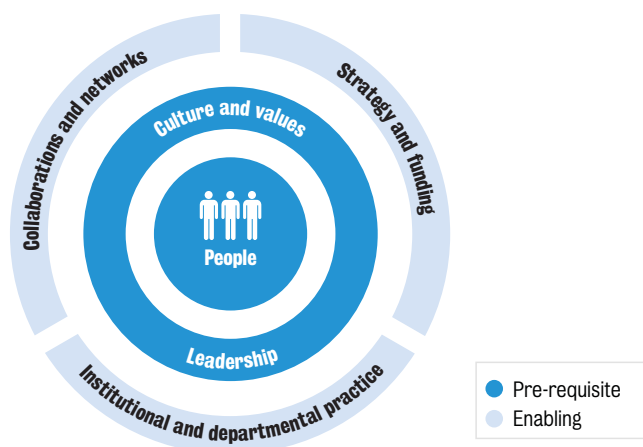
Three 'enabling' characteristics allow people, leadership, culture and values to thrive, and these are depicted in the outside circle in Figure 7. They are: enabling *collaboration and building networks*, having a *coherent strategy and diverse funding sources*, and supporting *institutional and departmental practices*. At this stage it is not clear from our analysis whether these three criteria are prerequisites for or facilitate high research performance. In addition it is worth considering that success and these characteristics may be mutually reinforcing to some extent. For example, being successful also makes it easier to attract good people and win funding and may also help maintain a collegial environment. The importance of reputation was highlighted when discussing funding and collaboration, with interviewees stressing that potential collaborators approached the unit as a result of good performance in previous Research Assessment Exercises.

In addition to the conceptual model in Figure 7, we have built a simple predictive linear model of our ranking using a subset of the variables discussed in this report and taking into account the UOA. A subset of the variables was used so that we did not include variables that correlate highly with each other. The variables that we found to have both a correlation with the ranking, and for which the tests between our sample and the average were significant, are all significant in the model (the variables are shown in Box I). We also find that the average time staff have spent at the HEI, the percentage of early career researchers, the number of eligible staff and the percentage of papers with international collaborations have a significant effect on the model. Taking into account the UOA is also significant, illustrating the importance of subject differences. The model has an adjusted R^2 of 0.45, indicating that our variables explain 45 per cent of the variation in quality, but highlights the fact that there is still a lot to be explained, by less quantifiable characteristics such as those described in this report.[26] Looking forward, statistical analysis could be used to try and look at the relationship between these characteristics and determine which are most important.

26 R^2, the coefficient of determination, indicates how well data fit a statistical model. It varies between 0 and 1, with 1 indicating that the regression line perfectly fits the data. As you add variables to a model R^2 never decreases, so the model with the most variables has the highest value, even if those variables only improve the model very slightly. Therefore we have used an adjusted R^2 which accounts for the number of variables in the model.

> **Box I:** Variables found to be significant in our model both in terms of their correlation with the overall ranking of research units, and when tested between our sample and the average research unit
>
> - Percentage of staff with PhDs
> - Percentage of professors
> - Percentage of staff whose salary is not wholly institution funded
> - Percentage of staff with non-UK nationality
> - Percentage of staff whose previous employment was overseas
> - Number of research doctoral degrees awarded

Using HESA and REF quantitative data, as well as qualitative data from interviewees and workshop respondents, we have assessed a number of departmental characteristics; however there are a large number of characteristics that we have not examined and which would be interesting to look into.

Workshop invitees raised the issue of student characteristics, which we have not studied here. Characteristics of interest included the size of undergraduate and graduate cohorts, the diversity of student nationality, and student opinions of teaching. We have not assessed these due to difficulties matching up teaching-only staff and student cohorts with the REF UOAs. However, it would be interesting to look at where there are correlations between these characteristics and high performance.

Interviewees and workshop participants discussed at length the importance of good early career researchers and strong professors. Exploring the characteristics of these specific groups could lead to further insights on high performance and demonstrate the extent of influence of each. It would also be interesting to explore the 'middle career researchers' who are neither at the early stages of their career, nor professors. The quantitative data we used did not provide the level of granularity required for such analyses. Diversity of subject within a department has also been shown as important for high performance. We have not had the capacity to explore this characteristic of the data within the scope of this project.

As mentioned in the Headline Findings, further work could include units that are not at the elite end of the performance scale (ie mid-ranking) or institutions that performed better on the impact element than the output assessment in REF. It may also be possible to develop and implement a survey that collects primary data that is focused on some of the observations. This would enable a more nuanced view as to how the observations interact, complement or substitute one another.

With a few exceptions, the literature on characteristics of high performance in HEIs is relatively old, with most studies from the early 2000s or before. Studies also tend to focus on productivity as defined by number of papers and citation impact (eg bibliometric studies), while our focus was to find more general characteristics of research quality and the creation of thriving research environments. Furthermore, most of the articles refer to high performance in HEIs more generally, rather than in individual research units, which is the focus of this study.

Concluding thoughts

In this study we have provided an overview of some of the characteristics of high-performing research units in HEIs, using the results of REF 2014 as a proxy for identifying 'high performance'. To determine key characteristics of high research performance, we used a combination of quantitative data analysis across all eligible staff, interviews and a workshop with individuals from high-performing research units, along with a review of existing literature.

From our analysis we identified two *prerequisites* (focusing on high-performing people as the main prerequisite, supported by culture, values and leadership), and three *enabling* characteristics (focusing on institutional and departmental practices, strategies and funding, and collaborations and networks). We conclude from our analysis that the characteristics within these categories can be associated with high research performance, but note that these warrant further investigation.

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Appendices

Appendix 1: List of Panels and Units of Assessment for REF 2014

Table 3: List of Panels and Units of Assessment for REF 2014

Panel	Unit of Assessment	
Panel A	UOA 1	Clinical Medicine
	UOA 2	Public Health, Health Services and Primary Care
	UOA 3	Allied Health Professions, Dentistry, Nursing, Pharmacy
	UOA 4	Psychology, Psychiatry, Neuroscience
	UOA 5	Biological Sciences
	UOA 6	Agriculture, Vetinary and Food Science
Panel B	UOA 7	Earth Systems and Environmental Science
	UOA 8	Chemistry
	UOA 9	Physics
	UOA 10	Mathematical Sciences
	UOA 11	Computer Science and Informatics
	UOA 12	Aeronautical, Mechanical, Chemical and Manufacturing Engineering
	UOA 13	Electrical and Electronic Engineering, Metallurgy and Materials
	UOA 14	Civil and Construction Engineering
	UOA 15	General Engineering
Panel C	UOA 16	Architecture, Built Environment and Planning
	UOA 17	Geography, Environmental Studies and Archaeology
	UOA 18	Economics and Econometrics
	UOA 19	Business and Management Studies
	UOA 20	Law
	UOA 21	Politics and International Studies
	UOA 22	Social Work and Social Policy
	UOA 23	Sociology
	UOA 24	Anthropology and Development Studies
	UOA 25	Education
	UOA 26	Sport and Exercise Sciences, Leisure and Tourism
Panel D	UOA 27	Area Studies
	UOA 28	Modern Languages and Linguistics
	UOA 29	English Language and Literature
	UOA 30	History
	UOA 31	Classics
	UOA 32	Philosophy
	UOA 33	Theology and Religious Studies
	UOA 34	Art and Design; History, Practice and Theory
	UOA 35	Music, Drama, Dance and Performing Arts
	UOA 36	Communication, Cultural and Media Studies, Library and Information Management

Appendix 2: Methodology

Sampling strategy

Submissions were ranked according to two scores:

- Grade point average (GPA) of submissions' combined outputs and impact scores (Figure 8a)[27]

- The percentage of overall submissions scoring 4* (calculated as an average of the percentages of submissions scoring 4* in each of the output and impact categories) (Figure 8b)

Figure 8: Scatterplots of all submissions a) output GPA against the impact GPA and (b) percentage of impacts scoring 4* against the percentage of outputs scoring 4*

Figure 8a

Figure 8b

▲ Top 25 submissions   ● Rest of the submissions
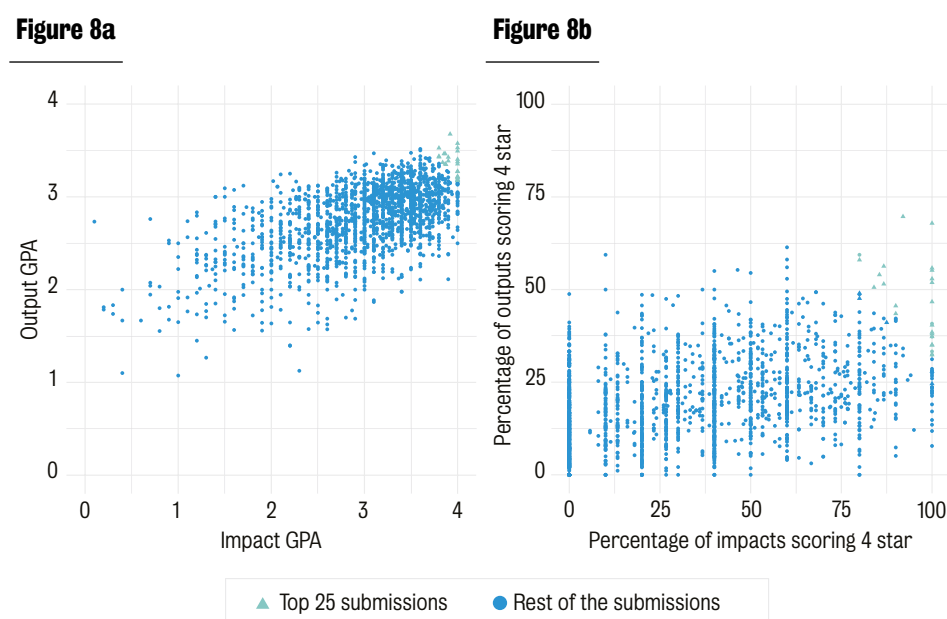
Some 20 of the same submissions ranked in the top 25 when comparing across each of these two scores, and were included in the sample along with the remaining five submissions from each ranking. Thus a total of 30 submissions were selected for inclusion in the sample, and those involved were invited to partake in the interviewees (Table 4). UCL, which had two UOAs in the sample (UOA11 and UOA18), declined to participate in this element of in the study, and therefore the next two submissions were added to our sample.

Selected submissions spanned 19 HEIs and were distributed as laid out in Tables 4 to 6 below, showing distribution by institution (Table 5), Main Panel (Table 6), and UOA (Table 7).

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27 The grade point average is the average star rating. To calculate this we multiply the percentage of 4* research by 4, the percentage of 3* research by 3, the percentage of 2* research by 2, the percentage of 1 * research by 1, sum these four numbers, and divide by 100. This gives a score between 4 and 0.

Table 4: Sample of top 30 submissions

Institution Name	Main Panel	Units of Assesment	Multiple Submission Letter
Birkbeck College	A	4	
Cardiff University	D	36	
Cardiff University	B	14	
Imperial College London	B	13	A
Institute of Cancer Research	A	5	
Liverpool John Moores University	C	26	
London School of Economics and Political Science	C	22	
London School of Economics and Political Science	D	36	
London School of Economics and Political Science	C	18	
London School of Economics and Political Science	D	27	
Newcastle University	D	29	
Queen Mary University of London	D	35	
Swansea University	D	29	
University of Aberdeen	A	6	
University of Bedfordshire	D	29	
University of Bristol	C	26	
University of Cambridge	B	13	
University of Essex	C	21	
University of Leicester	D	36	B
University of Oxford	C	22	
University of Oxford	A	4	
University of Oxford	B	13	
University of Oxford	C	25	
University of Oxford	A	2	
University of Oxford	B	10	
University of Southampton	D	35	
University of Southampton	A	3	
University of Stirling	A	4	
University of Warwick	B	11	
University of Warwick	A	6	

Table 5: Institutions included in our sample

Institution Name	Number in our sample
Birkbeck College	1
Cardiff University	2
Imperial College London	1
Institute of Cancer Research	1
Liverpool John Moores University	1
London School of Economics and Political Science	4
Newcastle University	1
Queen Mary University of London	1
Swansea University	1
University of Aberdeen	1
University of Bedfordshire	1
University of Bristol	1
University of Cambridge	1
University of Essex	1
University of Leicester	1
University of Oxford	6
University of Southampton	2
University of Stirling	1
University of Warwick	2

Table 6: Panel coverage in our sample

Main Panel	Number in our sample
A	8
B	6
C	7
D	9

Table 7: UOAs covered in our sample

Main Panel	UOA	Number in our sample
A	2	1
	3	1
	4	3
	5	1
	6	2
B	10	1
	11	1
	13	3
	14	1
C	18	1
	21	1
	22	2
	25	1
	26	2
D	27	1
	29	3
	35	2
	36	3

For the workshop we invited the next 20 submissions in our sample, along with the two submissions that initially declined to partake: 18 accepted and attended the workshop (Table 8).

Table 8: Invitees and attendees at our workshop

Institution Name	Main Panel	UOA	Multiple Submission Letter	Attended?
Cardiff University	A	4		✔
King's College London	C	25		✔
Queen Mary University of London	D	28	A	✔
Roehampton University	D	35	A	✔
Swansea University	A	4		✔
University of Cambridge	C	19		✔
University of Cambridge	B	8		✔
University of East Anglia	C	22		✔
University of Exeter	D	27		✔
University of Hertfordshire	D	30		✔
University of Nottingham	C	25		
University of Nottingham	A	3	A	✔
University of Oxford	B	15		
University of Reading	D	35	B	✔
University of Sheffield	A	3	B	✔
University of Sheffield	C	25		✔
University of St Andrews	D	29		✔
University of Warwick	D	29		
University of Westminster	D	36		✔
University of York	C	22		✔
University College London	B	11		✔
University College London	C	18		

Comparison of rankings

Our ranking system is just one possible way of ranking submissions. A number of different rankings, with various benefits and drawbacks, have been suggested, including:

- A GPA using the REF weighting with a ratio of 65:20 for outputs and impact respectively
- Research intensity (GPA multiplied by the submission rate)
- Research power (GPA multiplied by the number of staff submitted)
- Weighting of scores based on REF funding weightings

Our ranking correlates well with the REF weighting (Pearson = 0.84), and with REF funding weightings (0.89). However, it does not correlate as well as would be expected with either research intensity (0.53) or research power (0.59).

Quantitative data sources

In this study we have used HESA data, data submitted to the REF and further analyses of these data. From the REF, we have used the output data from REF2, research funding data from REF4b and the number of graduate degrees awarded from REF4a. HEFCE also provided us with analysis they have carried out on the authors of the REF2 submitted outputs for each submission, identifying whether co-authors are international, national, or institutional. This analysis was originally carried out for *The Metric Tide* (2015).

HEFCE also provided us with HESA[28] data on the characteristics of REF eligible staff (detailed in Table 9).[29] HESA data includes departments which declared eligible staff, but then did not submit any staff, and so there was no submission. Where possible we have included the data from these potential submissions, as they are part of the research sector.[30]

Table 9: HESA variables that data were received on

HESA variable[30]	Characteristic(s) derived
Contract levels	Percentage of staff who are professors
Terms of employment	Percentage of eligible staff on fixed-term contracts
Source of basic salary	Percentage of eligible staff whose salary is wholly institution funded
Nationality	Percentage of eligible staff who are international
Early career researcher status	Percentage of eligible staff who are ECRs
Eligible for REF	Number of staff who were eligible
Date of birth	Average age
Date appointed at current HEI	Average time at HEI
Ethnicity	Percentage of staff who are a specific ethnicity
Legal sex	Percentage of staff who are female
Previous employment	Percentage of staff whose previous employment was overseas
Academic teaching qualification	Percentage of staff with an academic teaching qualification
Mode of employment	Percentage of staff who are full-time

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28 HESA data is self-reported by the universities. There are a number of known small inaccuracies, details on these can be found at https://www.hesa.ac.uk/ref2014
29 Conditions of eligibility for REF can be found in Part 3 Section 1 of the REF assessment framework and guidance on submissions at http://www.ref.ac.uk/media/ref/content/pub/assessmentframeworkandguidanceonsubmissions/GOS%20including%20addendum.pdf (as of 1 September 2015).
30 Further details on variables can be found at https://www.hesa.ac.uk/index.php?option=com_studrec&task=show_file&mnl=13025&href=a^_^index.html (as of 1 September 2015).

Statistical testing

For each characteristic of interest we performed:

- A Mann Whitney U test to compare the high-performing sample with the rest of the submissions

- An empirical non-parametric bootstrap, comparing each submission in our sample with the UOA average

- A Pearson correlation between the characteristic and our overall research unit ranking

- A Kendall Tau-b correlation between the characteristic and our overall research unit ranking

The first two allow us to look at the differences between our sample and the rest of the submissions. The first compares the sample as a whole. The second is a stratified test, which takes into account differences between the UOAs. When a characteristic defined from HESA data is tested, we include all departments which declared eligible staff, even if they did not submit any of these staff.

The third and fourth allow us to look at the characteristics over the entire ranking. Pearson correlations measure the extent of linearity between two characteristics. Kendall Tau-b correlation is a rank correlation, taking into account ties, which measures how monotonic a relationship between two characteristics is. As we are comparing characteristics with the ranking based on REF results, we include only the departments which submitted staff to the REF.

False discovery rate multiple testing correction was performed on the p-values of all tests to ensure that the expected false discovery rate was not higher than 0.05.

Linear model

To explore the relationship between the characteristics and the overall research unit ranking, we fitted a linear regression model to the quantitative data. Specifically we modeled the rank calculated using the GPA and percentage of overall submissions scoring 4*, as described previously. Initially we built a full linear regression model, using all of the available characteristics from the HESA, and REF data, along with the units of assessment (coded as categorical variables). A number of the estimates of this model were non-significant, as a number of the variables are correlated with each other. Therefore we reduced the number of variables down using a combination of the Pearson and Kendall Tau-b correlation coefficients (Tables 10 and 11), and step-wise model fitting of the characteristics. This reduced the model to 12 characteristics, along with the 36 UOAs coded as categorical variables. This reduction is subjective, and it is possible that the choices could affect downstream analyses run using the model; therefore care should be taken when using the model in the future.

The full model is not presented here as it is likely that the error estimates are inflated (due to a violation of the assumption that variables are independent). The characteristics included in the reduced model are shown in Table 12[31].

This simple linear regression was used to build a quick model explaining the ranking. In the future, more complex models could be used to explore the data further. It is also important to note that this model only includes variables for which data was available from HESA and from the REF submission.

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31 Due to their number, categorical variables are not shown, but are available on request from the authors

Table 10: Pearson correlation between the characteristics

Key:
- ■ Strong positive correlation
- ■ Strong negative correlation

	Percentage female	Percentage of staff with PhDs	Percentage of professors	Percentage of staff who are permanent	Percentage of staff who are wholly institution funded	Percentage of staff with UK nationality	Percentage of staff with EU nationality	Percentage of staff on fixed-term contracts	Percentage of staff with atypical contracts	Average time at HEI	Average age of staff
Percentage female	1.00	-0.34	-0.27	0.00	0.05	-0.28	-0.01	0.00	0.03	-0.04	0.10
Percentage of staff with PhDs	-0.34	1.00	0.45	-0.05	-0.10	0.40	0.11	0.06	-0.06	-0.11	-0.27
Percentage of professors	-0.27	0.45	1.00	-0.03	-0.19	0.25	0.01	0.03	-0.01	0.03	0.15
Percentage of staff who are permanant	0.00	-0.05	-0.03	1.00	0.30	-0.06	0.02	-1.00	-0.14	0.24	0.03
Percentage of staff who are wholly institution fudned	0.05	-0.10	-0.19	0.30	1.00	-0.09	-0.01	-0.30	0.01	-0.02	0.04
Percentage of staff with UK nationality	-0.28	0.40	0.25	-0.06	-0.09	1.00	0.10	0.06	0.02	-0.27	-0.31
Percentage of staff with EU nationality	-0.01	0.11	0.01	0.02	-0.01	0.10	1.00	-0.02	-0.02	0.03	-0.11
Percentage of staff on fixed-term contracts	0.00	0.06	0.03	-1.00	-0.30	0.06	-0.02	1.00	0.05	-0.24	-0.04
Percentage of staff with atypical contracts	0.03	-0.06	-0.01	-0.14	0.01	0.02	-0.02	0.05	1.00	-0.03	0.05
Average time at HEI	-0.04	-0.11	0.03	0.24	-0.02	-0.27	0.03	-0.24	-0.03	1.00	0.43
Average age of staff	0.10	-0.27	0.15	0.03	0.04	-0.31	-0.11	-0.04	0.05	0.43	1.00
Percentage of ECRs	-0.09	0.19	-0.01	-0.11	-0.07	0.18	-0.03	0.12	-0.07	-0.33	-0.41
Percentage of full-time staff	-0.30	0.48	0.18	0.23	-0.05	0.26	0.07	-0.22	-0.16	-0.01	-0.32
Percentage of staff that are white	0.26	-0.12	-0.13	0.05	0.08	-0.38	0.24	-0.05	-0.03	0.10	0.03
Number of eligible staff	0.06	-0.23	-0.04	-0.09	-0.30	-0.06	0.02	0.09	0.01	0.06	0.06
Total amount of funding	-0.14	0.13	0.21	-0.13	-0.41	0.04	0.06	0.14	-0.02	0.07	0.02
Number of funding streams	-0.22	0.25	0.27	-0.08	-0.36	0.12	0.08	0.09	-0.01	0.10	-0.01
Percentage of submitted papers with institutional authors	-0.31	0.12	0.05	0.01	-0.14	0.01	0.02	-0.01	-0.01	0.08	-0.04
Percentage of submitted papers with international authors	-0.44	0.31	0.22	-0.08	-0.31	0.22	0.12	0.08	-0.05	0.01	-0.14
Percentage of submitted papers with national authors	-0.01	0.03	0.01	-0.02	-0.17	-0.14	0.01	0.02	-0.01	-0.06	-0.05
Percentage of submitted papers with a single author	0.19	0.06	0.01	0.07	0.21	0.07	-0.01	-0.08	0.05	-0.11	0.00
Number of research doctoral degrees awarded	-0.21	0.25	0.30	-0.08	-0.37	0.12	0.06	0.08	-0.02	0.11	0.02
Number of funding streams per eligible staff member	-0.08	0.16	0.05	-0.17	-0.02	0.07	-0.07	0.17	0.02	-0.08	0.02
Number of research doctoral degrees awarded per eligible staff member	-0.25	0.37	0.37	0.04	-0.12	0.13	0.00	-0.04	0.02	0.16	0.07
Amount of funding per eligible staff member	-0.21	0.18	0.35	-0.13	-0.49	0.12	0.08	0.14	-0.02	0.13	0.02

Percentage of ECRs	Percentage of full-time staff	Percentage of staff that are white	Number of eligible staff	Total amount of funding	Number of funding streams	Percentage of submitted papers with institutional authors	Percentage of submitted papers with international authors	Percentage of submitted papers with national authors	Percentage of submitted papers with a single author	Number of research doctoral degrees awarded	Number of funding streams per eligible staff member	Number of research doctoral degrees awarded per eligible staff member	Amount of funding per eligible staff member
-0.09	-0.30	0.26	0.06	-0.14	-0.22	-0.31	-0.44	-0.01	0.19	-0.21	-0.08	-0.25	-0.21
0.19	0.48	-0.12	-0.23	0.13	0.25	0.12	0.31	0.03	0.06	0.25	0.16	0.37	0.18
-0.01	0.18	-0.13	-0.04	0.21	0.27	0.05	0.22	0.01	0.01	0.30	0.05	0.37	0.35
-0.11	0.23	0.05	-0.09	-0.13	-0.08	0.01	-0.08	-0.02	0.07	-0.08	-0.17	0.04	-0.13
-0.07	-0.05	0.08	-0.30	-0.41	-0.36	-0.14	-0.31	-0.17	0.21	-0.37	-0.02	-0.12	-0.49
0.18	0.26	-0.38	-0.06	0.04	0.12	0.01	0.22	-0.14	0.07	0.12	0.07	0.13	0.12
-0.03	0.07	0.24	0.02	0.06	0.08	0.02	0.12	0.01	-0.01	0.06	-0.07	0.00	0.08
0.12	-0.22	-0.05	0.09	0.14	0.09	-0.01	0.08	0.02	-0.08	0.08	0.17	-0.04	0.14
-0.07	-0.16	-0.03	0.01	-0.02	-0.01	-0.01	-0.05	-0.01	0.05	-0.02	0.02	0.02	-0.02
-0.33	-0.01	0.10	0.06	0.07	0.10	0.08	0.01	-0.06	-0.11	0.11	-0.08	0.16	0.13
-0.41	-0.32	0.03	0.06	0.02	-0.01	-0.04	-0.14	-0.05	0.00	0.02	0.02	0.07	0.02
1.00	0.17	-0.03	-0.09	0.02	0.00	0.07	0.07	0.03	-0.02	0.02	0.07	-0.01	0.05
0.17	1.00	-0.14	-0.11	0.07	0.17	0.20	0.22	0.06	0.07	0.15	0.02	0.21	0.14
-0.03	-0.14	1.00	-0.07	-0.07	-0.16	-0.23	-0.23	-0.08	0.08	-0.13	0.05	-0.07	-0.07
-0.09	-0.11	-0.07	1.00	0.59	0.41	0.18	0.24	0.25	-0.20	0.63	-0.32	-0.05	0.18
0.02	0.07	-0.07	0.59	1.00	0.37	0.18	0.34	0.14	-0.22	0.77	-0.10	0.15	0.53
0.00	0.17	-0.16	0.41	0.37	1.00	0.45	0.55	0.41	-0.28	0.52	0.04	0.26	0.40
0.07	0.20	-0.23	0.18	0.18	0.45	1.00	0.53	0.53	-0.43	0.31	-0.05	0.18	0.24
0.07	0.22	-0.23	0.24	0.34	0.55	0.53	1.00	0.50	-0.55	0.36	0.00	0.18	0.45
0.03	0.06	-0.08	0.25	0.14	0.41	0.53	0.50	1.00	-0.42	0.16	-0.02	0.01	0.17
-0.02	0.07	0.08	-0.20	-0.22	-0.28	-0.43	-0.55	-0.42	1.00	-0.21	0.03	-0.08	-0.28
0.02	0.15	-0.13	0.63	0.77	0.52	0.31	0.36	0.16	-0.21	1.00	-0.15	0.41	0.42
0.07	0.02	0.05	-0.32	-0.10	0.04	-0.05	0.00	-0.02	0.03	-0.15	1.00	0.22	0.26
-0.01	0.21	-0.07	-0.05	0.15	0.26	0.18	0.18	0.01	-0.08	0.41	0.22	1.00	0.29
0.05	0.14	-0.07	0.18	0.53	0.40	0.24	0.45	0.17	-0.28	0.42	0.26	0.29	1.00

Table 11: Kendall Tau-b correlation between the characteristics

Key:
- Strong positive correlation
- Strong negative correlation

	Percentage female	Percentage of staff with PhDs	Percentage of professors	Percentage of staff who are permanent	Percentage of staff who are wholly institution fudned	Percentage of staff with UK nationality	Percentage of staff with EU nationality	Percentage of staff on fixed-term contracts	Percentage of staff with atypical contracts	Average time at HEI	Average age of staff
Percentage female	1.00	-0.25	-0.20	0.00	0.11	-0.20	-0.01	-0.01	0.05	-0.03	0.08
Percentage of staff with PhDs	-0.25	1.00	0.31	0.00	-0.11	0.25	0.09	0.01	-0.07	-0.05	-0.19
Percentage of professors	-0.20	0.31	1.00	-0.05	-0.19	0.18	0.02	0.05	-0.02	0.01	0.07
Percentage of staff who are permanant	0.00	0.00	-0.05	1.00	0.18	-0.03	0.01	-0.99	-0.11	0.12	-0.01
Percentage of staff who are wholly institution funded	0.11	-0.11	-0.19	0.18	1.00	-0.09	-0.04	-0.19	0.01	-0.04	0.02
Percentage of staff with UK nationality	-0.20	0.25	0.18	-0.03	-0.09	1.00	0.05	0.03	-0.01	-0.18	-0.23
Percentage of staff with EU nationality	-0.01	0.09	0.02	0.01	-0.04	0.05	1.00	-0.01	-0.01	0.04	-0.07
Percentage of staff on fixed-term contracts	-0.01	0.01	0.05	-0.99	-0.19	0.03	-0.01	1.00	0.06	-0.12	0.00
Percentage of staff with atypical contracts	0.05	-0.07	-0.02	-0.11	0.01	-0.01	-0.01	0.06	1.00	-0.01	0.04
Average time at HEI	-0.03	-0.05	0.01	0.12	-0.04	-0.18	0.04	-0.12	-0.01	1.00	0.30
Average age of staff	0.08	-0.19	0.07	-0.01	0.02	-0.23	-0.07	0.00	0.04	0.30	1.00
Percentage of ECRs	-0.08	0.17	0.05	-0.03	-0.09	0.18	-0.01	0.04	-0.07	-0.27	-0.34
Percentage of full-time staff	-0.23	0.29	0.10	0.18	-0.05	0.20	0.04	-0.17	-0.11	-0.03	-0.23
Percentage of staff that are white	0.17	-0.04	-0.11	0.04	0.10	-0.27	0.18	-0.04	-0.01	0.07	0.03
Number of eligible staff	0.01	-0.17	0.00	-0.07	-0.24	-0.02	0.00	0.07	0.07	0.07	0.05
Total amount of funding	-0.21	0.18	0.29	-0.11	-0.44	0.14	0.06	0.11	0.00	0.10	0.00
Number of funding streams	-0.16	0.15	0.22	-0.09	-0.36	0.10	0.04	0.09	0.02	0.08	-0.01
Percentage of submitted papers with institutional authors	-0.21	0.05	0.05	-0.03	-0.18	0.02	0.02	0.03	-0.01	0.05	-0.03
Percentage of submitted papers with international authors	-0.29	0.19	0.16	-0.06	-0.26	0.15	0.07	0.06	-0.05	0.01	-0.09
Percentage of submitted papers with national authors	-0.06	0.00	0.03	-0.03	-0.14	-0.08	0.01	0.03	0.00	-0.03	-0.03
Percentage of submitted papers with a single author	0.17	0.00	-0.01	0.06	0.17	0.05	-0.02	-0.06	0.05	-0.08	0.01
Number of research doctoral degrees awarded	-0.18	0.22	0.32	-0.06	-0.34	0.18	0.03	0.06	0.01	0.10	0.00
Number of funding streams per eligible staff member	-0.11	0.27	0.13	0.04	0.06	0.08	0.03	-0.04	-0.06	-0.02	-0.05
Number of research doctoral degrees awarded per eligible staff member	-0.24	0.39	0.39	-0.02	-0.24	0.21	0.02	0.02	-0.03	0.10	0.00
Amount of funding per eligible staff member	-0.26	0.30	0.35	-0.10	-0.40	0.17	0.06	0.10	-0.03	0.09	-0.02

Percentage of ECRs	Percentage of full-time staff	Percentage of staff that are white	Number of eligible staff	Total amount of funding	Number of funding streams	Percentage of submitted papers with institutional authors	Percentage of submitted papers with international authors	Percentage of submitted papers with national authors	Percentage of submitted papers with a single author	Number of research doctoral degrees awarded	Number of funding streams per eligible staff member	Number of research doctoral degrees awarded per eligible staff member	Amount of funding per eligible staff member
-0.08	-0.23	0.17	0.01	-0.21	-0.16	-0.21	-0.29	-0.06	0.17	-0.18	-0.11	-0.24	-0.26
0.17	0.29	-0.04	-0.17	0.18	0.15	0.05	0.19	0.00	0.00	0.22	0.27	0.39	0.30
0.05	0.10	-0.11	0.00	0.29	0.22	0.05	0.16	0.03	-0.01	0.32	0.13	0.39	0.35
-0.03	0.18	0.04	-0.07	-0.11	-0.09	-0.03	-0.06	-0.03	0.06	-0.06	0.04	-0.02	-0.10
-0.09	-0.05	0.10	-0.24	-0.44	-0.36	-0.18	-0.26	-0.14	0.17	-0.34	0.06	-0.24	-0.40
0.18	0.20	-0.27	-0.02	0.14	0.10	0.02	0.15	-0.08	0.05	0.18	0.08	0.21	0.17
-0.01	0.04	0.18	0.00	0.06	0.04	0.02	0.07	0.01	-0.02	0.03	0.03	0.02	0.06
0.04	-0.17	-0.04	0.07	0.11	0.09	0.03	0.06	0.03	-0.06	0.06	-0.04	0.02	0.10
-0.07	-0.11	-0.01	0.07	0.00	0.02	-0.01	-0.05	0.00	0.05	0.01	-0.06	-0.03	-0.03
-0.27	-0.03	0.07	0.07	0.10	0.08	0.05	0.01	-0.03	-0.08	0.10	-0.02	0.10	0.09
-0.34	-0.23	0.03	0.05	0.00	-0.01	-0.03	-0.09	-0.03	0.01	0.00	-0.05	0.00	-0.02
1.00	0.14	-0.05	-0.04	0.06	0.06	0.06	0.08	0.03	-0.01	0.08	0.06	0.09	0.08
0.14	1.00	-0.09	-0.07	0.11	0.09	0.11	0.13	0.02	0.02	0.14	0.14	0.22	0.16
-0.05	-0.09	1.00	-0.12	-0.16	-0.14	-0.16	-0.17	-0.09	0.04	-0.18	0.04	-0.12	-0.14
-0.04	-0.07	-0.12	1.00	0.38	0.38	0.22	0.22	0.22	-0.12	0.41	-0.60	0.01	0.14
0.06	0.11	-0.16	0.38	1.00	0.65	0.37	0.47	0.31	-0.25	0.62	-0.05	0.41	0.76
0.06	0.09	-0.14	0.38	0.65	1.00	0.38	0.47	0.36	-0.25	0.53	0.06	0.34	0.55
0.06	0.11	-0.16	0.22	0.37	0.38	1.00	0.49	0.50	-0.32	0.26	-0.01	0.16	0.33
0.08	0.13	-0.17	0.22	0.47	0.47	0.49	1.00	0.46	-0.40	0.32	0.01	0.21	0.44
0.03	0.02	-0.09	0.22	0.31	0.36	0.50	0.46	1.00	-0.31	0.18	-0.02	0.06	0.26
-0.01	0.02	0.04	-0.12	-0.25	-0.25	-0.32	-0.40	-0.31	1.00	-0.13	0.03	-0.07	-0.24
0.08	0.14	-0.18	0.41	0.62	0.53	0.26	0.32	0.18	-0.13	1.00	-0.13	0.60	0.50
0.06	0.14	0.04	-0.60	-0.05	0.06	-0.01	0.01	-0.02	0.03	-0.13	1.00	0.21	0.17
0.09	0.22	-0.12	0.01	0.41	0.34	0.16	0.21	0.06	-0.07	0.60	0.21	1.00	0.51
0.08	0.16	-0.14	0.14	0.76	0.55	0.33	0.44	0.26	-0.24	0.50	0.17	0.51	1.00

Table 12: Variables included in the reduced model, and their coefficients. Variables found to be significant in the model are shown in italics

Characteristic	Coefficient
Intercept	0
Percentage of staff with PhDs	-5.9
Percentage of professors	-6.8
Percentage of staff who are wholly institution funded	-4.2
Percentage of staff with UK nationality	-0.23
Average time at HEI	-0.1
Percentage of ECRs	-2.1
Number of eligible staff	-6.7
Percentage of submitted papers with international authors	-0.04
Percentage of submitted papers with institutional authors	-0.02
Percentage of submitted papers with a single author	-0.02
Number of funding streams	-1
Number of research doctoral degrees awarded	-2.5

Submission strategy

REF 2014 did not require that all eligible staff were submitted; departments were given discretion over who they entered. The submission strategy of different universities, and the effect of different strategies on the rankings, has been a hotly discussed topic (in *THE* articles, blogs, etc)

Figure 9 shows the headcount of submitted staff versus eligible staff for our sample. The dotted line represents full submission of all CatA staff, the dashed line represents the average submission rate of units which submitted, and the long dashed line represents the average submission rate including potential submissions who had eligible staff but did not submit any of them. Our sample shows a range of submission rates, with some submissions submitting all of their staff, while others were more selective. All but two of our sample submitted more of their staff than the average submission rate of departments which submitted.

Figure 9: Submission rates to REF 2014 of high-performing research units
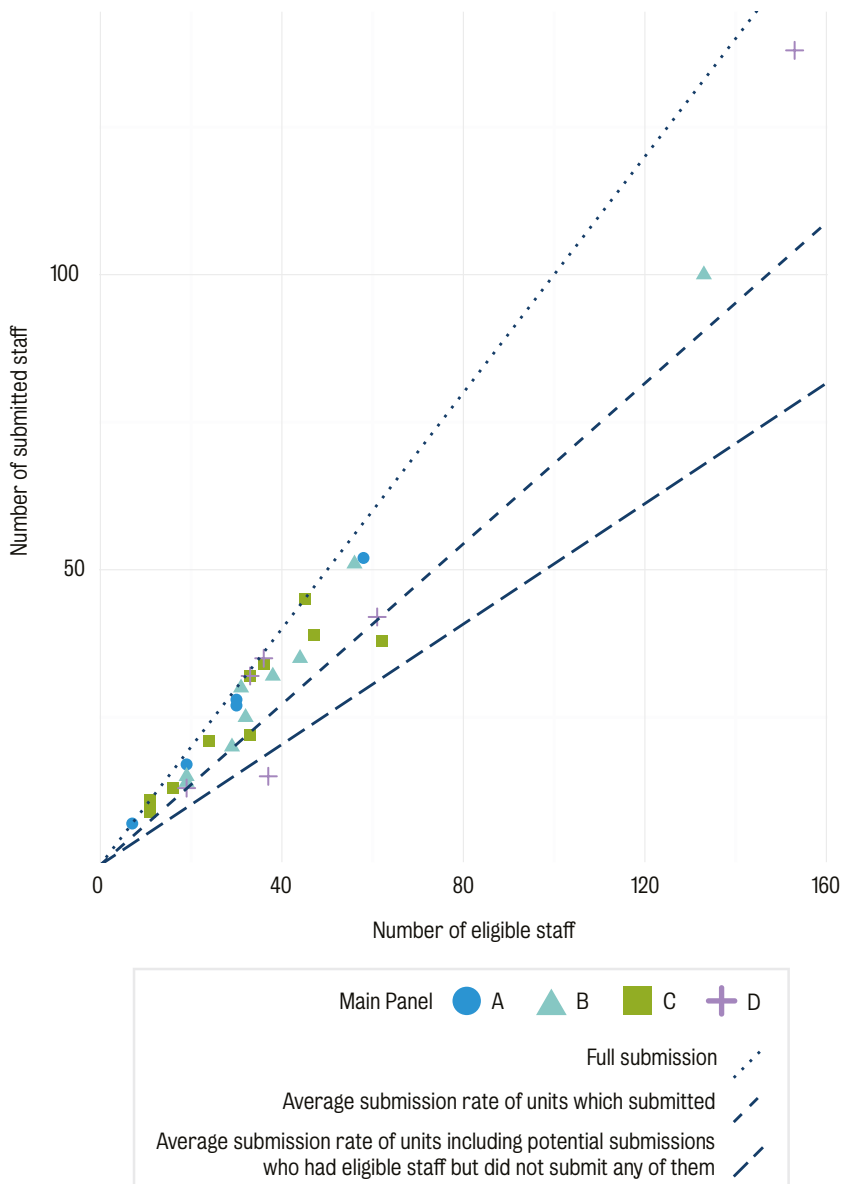
Appendix 3: Interview protocol

The interview will be semi-structured – with the interviewer using the following questions as a topic guide. Questions are broadly grouped around stages in the research lifecycle, but we would encourage you to explore any areas that may not be covered.

Introduction

RAND Europe and the Policy Institute at King's College London have been commissioned by HEFCE to assess the defining characteristics of high-performing submissions, using performance in REF 2014 as proxy for high-quality research and impact. Using a combination of ratings for output and impact, your submission was in the top 30 of all of those submitted. We'd therefore like to explore with you features such as your research environment and organisational culture, your department/ institution's research strategy, and other factors that might be relevant to high performance when looking at the delivery of high-quality research and its translation into broader societal impacts.

With your permission, we would like to record this interview for the purposes of writing up our own notes for data analysis. These recordings will be destroyed at the end of the study. In reporting the study, all information provided will be anonymised and not attributed to any individual without specific consent.

If not clear in advance of the interview, start with: *Did the research detailed in the UOA submission come from an actual (ie an administrative unit) or virtual (ie a series of thematically linked but administratively separate) team(s)? If a virtual submission which departments or research groups contributed?*

Overarching questions

1. What would you describe as the key features of your institution's and/or department's strategy and culture for supporting high quality research?

2. What targets, incentives and penalties do you have in place to support the delivery of high performance?

For the next questions we are interested in the department(s) in question, but if you only have wider institutional knowledge, please specify this.

I am now going to ask you a series of questions about the processes your department(s) has in place and what you think is important in supporting the production of high quality research and its translation into wider impacts. We have grouped the following questions around stages in the research lifecycle, so if I could first ask you to consider:

Stage 1: Research inputs and enablers

3. What does the funding 'mix' of the department look like?

4. What support is available in your department(s) to assist at the earliest stages of forming research ideas, and in preparing grant applications and proposals?

5. How does your department facilitate the following for research:

   a. collaboration within and beyond the institution?

   b. engagement with wider stakeholders (non-academics)?

Stage 2: Research processes

6. What kinds of procedural support does your department(s) provide to support studies through the research lifecycle?

7. What training does your department(s) offer researchers to obtain the skills to:

    a. conduct high-quality research?

    b. achieve impact?

Stage 3: Primary outputs and dissemination

8. What departmental processes are in place to support the dissemination of research to

    a. academic audiences?

    b. non-academic audiences?

Stage 4: Secondary outputs and impact

9. How does your department facilitate impact from the research undertaken?

Final questions

10. Could you describe your submission(s) selection process?

11. Which characteristics do you feel are the most important and effective for submissions? Why do you think this department is particularly successful?

Appendix 4: NVivo

NVivo QRS Version 10 was used to analyse the interview reports in this study. It is a qualitative data analysis software package that allows the coding of text-based information, such as interview notes.[32]

The code book was produced using the emerging topics and the interview protocol, and all 47 interview notes were coded. We assigned recorded statements to different descriptive and analytical categories. The code book is made up of themes, classified as nodes, which contained sub-themes within them. In total there were 90 nodes in the code book (Figure 10). Statements within the interview notes were qualitatively reviewed and coded to as many nodes as applicable. A total of 2,062 phrases were coded in NVivo. Analyses of the interview notes in NVivo included the generation of various cross tabulations by the attributes associated with the submission (eg HEI, UOA, type of interviewee, etc) and characteristics associated with the key themes.

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32 For further information on the software see: http://www.qsrinternational.com/products_nvivo.aspx (as of 1 September 2015).

Figure 10: Nodes in the code book

- 1. Characteristics
  - 1.1 People
    - 1.1.1 Recruitment
    - 1.1.2 Performance management
    - 1.1.3 Mentoring
    - 1.1.4 Other
  - 1.2 Funding
  - 1.3 Department make up
  - 1.4 Cross interdisciplinary research
  - 1.5 Other
- 2. Vision and strategy
  - 2.1 Focus
  - 2.2 Enabling culture and values
  - 2.3 Practices
  - 2.4 Operational support
    - 2.4.1 Infrastructure
    - 2.4.2 Training
    - 2.4.3 Other
  - 2.5 Leadership
  - 2.6 Strategy for REF subsmission 2014
  - 2.7 Other
- A. Type of high performance
  - A.1 Outputs
  - A.2 Impact
- B. Level of activity
  - B.1 Individual
  - B.2 Group
  - B.3 Department
  - B.4 HEI
  - B.5 Other
- C. Part of the process
  - C.1 Developing research questions and applying for funding
  - C.2 Conducting research
  - C.3 Dissertation
    - C.3.1 Academia
      - C.3.1.1 Within HEI
      - C.3.1.2 Beyond own HEI
    - C.3.2 Wider stakeholders
  - C.4 Network building
  - C.5 Downstream impact
  - C.6 Other
- 3. Particular to the UOA within the HEI
- Z. Institutions
  - Z.1 University of Aberdeen
  - Z.2 University of Bedfordshire
  - Z.3 University of Bristol
  - Z.4 Birkbeck University
  - Z.5 University of Cambridge
  - Z.6 University of Cardiff
  - Z.7 University of Essex
  - Z.8 Institute of Cancer Research
  - Z.9 Imperial College London

- Z.10 University of Leicester
- Z.11 Liverpool John Moores University
- Z.12 London School for Economics
- Z.13 Newcastle University
- Z.14 University of Oxford
- Z.15 Queen Mary's, University of London
- Z.16 University of Southampton
- Z.17 University of Stirling
- Z.18 University of Swansea
- Z.19 University of Warwick
- Y. Type of interviewee
  - Y.1 Central
  - Y.2 UOA level
- X. Type of REF submission
  - X.1 Administrative unit
  - X.2 Virtual unit
- W. Unit of assessment
  - W.1 Main panel A
    - W.1.1 UOA1
    - W.1.2 UOA2
    - W.1.3 UOA3
    - W.1.4 UOA4
    - W.1.5 UOA 5
    - W.1.6 UOA6
  - W.2 Main panel B
    - W.2.1 UOA7
    - W.2.2 UOA8
    - W.2.3 UOA9
    - W.2.4 UOA10
    - W.2.5 UOA11
    - W.2.6 UOA12
    - W.2.7 UOA13
    - W.2.8 UOA14
    - W.2.9 UOA15
  - W.3 Main panel C
    - W.3.1 UOA16
    - W.3.2 UOA17
    - W.3.3 UOA18
    - W.3.4 UOA19
    - W.3.5 UOA20
    - W.3.6 UOA21
    - W.3.7 UOA22
    - W.3.8 UOA23
    - W.3.9 UOA24
    - W.3.10 UOA25
    - W.3.11 UOA26
  - W.4 Main panel D
    - W.4.1 UOA27
    - W.4.2 UOA28
    - W.4.3 UOA29
    - W.4.4 UOA30
    - W.4.5 UOA31
    - W.4.6 UOA32
    - W.4.7 UOA33
    - W.4.8 UOA34
    - W.4.9 UOA35
    - W.4.10 UOA36

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