



**Concentration and diversity: understanding the relationship between excellence, concentration and critical mass in UK research**

**A report by University Alliance**

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## Concentration and diversity: understanding the relationship between excellence, volume and critical mass in UK research

### Executive Summary

#### 1. Selectivity not concentration has driven excellence

- A policy of selectivity – funding research based on quality – has driven up the quality of UK research since the introduction of the RAE, not concentration.
- Selectivity has resulted in concentration of research funding where quality exists. This is fully supported by University Alliance.
- The UK has one of the most highly selective research funding methods in the world – QR funding in 2009-10, based on RAE 2008, has not changed that:
  - In 2007-8, four institutions received 29 per cent of Quality-related (QR) funding (and 23 around 75 per cent).
  - In 2009-10, four institutions received 32 per cent of QR funding (and 25 around 75 per cent).
- Selectivity can, however, be taken too far. HEFCE's 'Fundamental Review of Research Policy and Funding' concluded that "a major increase in selectivity could reduce the number of research-led institutions to a level that would be inconsistent with the general health of the UK research base, in terms of both its economic and its social contribution...leading to complacency and ossification."

#### 2. Excellence is not determined by volume alone

- There is no direct correlation between volume and excellence outside some of the physical sciences.
- The relationship between volume and excellence varies by discipline. Three broad categories were identified by experts at the University of Leeds for the HEFCE Fundamental Review of Research Policy and Funding:
  - high impact at high volume (where volume is related to impact, for example the clinical sciences)
  - higher impact at high volume (where small units can be effective, for example in engineering and social sciences)
  - no clear pattern (where the 'lone researcher' can produce excellent research with high impact, for example in mathematics, arts and humanities)

- In the small number of science-based disciplines where there is a correlation between volume and quality:
  - there is no identifiable ‘threshold’ or ‘critical mass’
  - volume is ‘evidently not the only factor’ (HEFCE Fundamental Review)
  - the increasing capacity for both interdisciplinary and international collaboration can redefine what counts as critical mass

### **3. Peaks of excellence matter**

- It is the peaks of world-leading research excellence that determine the position of the UK as a world leader in research.
- These peaks of research excellence are more widely distributed across the sector than had previously been recognised before RAE 2008. Indeed, recent analysis by Evidence Ltd, published by HEPI, has shown that the sector as a whole has a higher percentage of ‘highly cited papers’ than the major research-intensive Russell Group universities (excluding ‘Golden Triangle’ institutions).
- Diversity across the sector is important for the health of both the UK research base and the UK higher education sector more broadly.
- The economic and social impact of research is related to quality – not necessarily volume. As demonstrated in Section 4 of this paper, Alliance institutions are business-like universities which are adept at using their research income strategically.
- A strong research culture is vital for research-informed learning, which is the essence of an enquiry-led, academic university learning environment that delivers the truly graduate-level skills needed for the economy.

### **Alliance Recommendations**

- The UK should continue its policy of selectively distributing research funding, based on quality, in order to continue to drive the quality and impact of UK research and secure the future health of the UK research base.
- The UK should continue to fund excellence in research wherever it exists in order to achieve appropriate levels of research concentration where needed.
- In a difficult fiscal environment it is essential that these existing principles are maintained because they have “enabled the Government and funding bodies to maximise the return from the limited public funds available for ...research”.

## Responding to the Higher Education Framework and Research Excellence Framework (REF) proposals

1. In November 2009, the Government published ‘Higher Ambitions: the future of universities in a knowledge economy.’<sup>1</sup> This framework for the future of higher education set out the following measure with regard to research funding:
 

”Sustaining our world class research base by continuing to focus on excellence, *concentrating research funding where needed to secure critical mass and impact*” (italics added).<sup>2</sup>
2. Within its ‘key proposals’, however, the framework recognised the fact that **“excellence must remain the defining basis for allocating research funding.”**
3. University Alliance agrees that “public investment in the UK must be prioritised on strengthening research centres with world-class capability.” We do not, however, agree that “this should mean more research concentration, not less.” An explicit policy of concentration – rather than selectivity, based on excellence – is not justifiable given the evidence presented in this paper.
4. We would urge the Government to consider the evidence and return to the aims outlined by HEFCE for the Research Excellence Framework (REF) to:
  - Drive up quality across the HE research base and in all forms of research.
  - Support and encourage innovative and curiosity-driven research, including new approaches, new fields and interdisciplinary work.
  - Reward and encourage the effective sharing, dissemination and application of research findings and the productive interchange of research staff and ideas between HEIs, business and other research users.
  - Reward and encourage HEIs that deliver benefits to business, the economy and society by building on excellent research.
  - Support better management and sustainability of the research base.<sup>3</sup>

<sup>1</sup> <http://www.bis.gov.uk/policies/higher-ambitions>

<sup>2</sup> DBIS formal press release 3<sup>rd</sup> November 2009

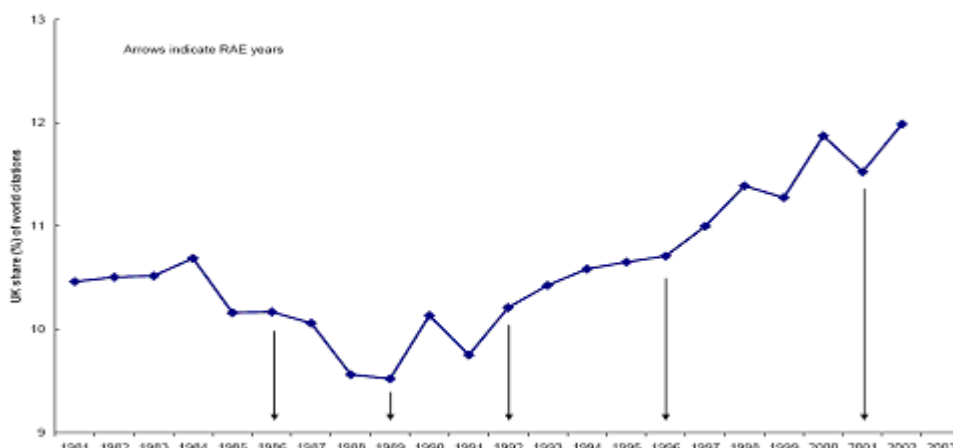
<sup>3</sup> HEFCE, Research Excellence Framework: Second consultation on the assessment and funding of research, September 2009/38 [http://www.hefce.ac.uk/Pubs/HEFCE/2009/09\\_38/](http://www.hefce.ac.uk/Pubs/HEFCE/2009/09_38/)

## Section 1: Selectivity not concentration has driven excellence

### Selectivity has driven excellence

5. The following chart<sup>4</sup> shows a clear upward trend in the UK share of world citations resulting from the introduction of the Research Assessment Exercise (RAE). Quality-related (QR) funding in the UK, based on RAE results, has never had an explicit policy of concentration. It is a policy of selectivity funding research, based on quality, which has driven up the quality of UK research through open competition since the introduction of the RAE in 1986<sup>5</sup>.

### Research assessment has led to an increase in the UK's share of world citations



6. It is widely recognised that it is the introduction of quality-related funding for research (based on the results of the RAE) that has driven excellence.

“The RAE is generally agreed to have had a significant positive impact. The exercise has driven a sustained improvement in the overall quality of the UK research base, and has made a major contribution to maintaining national economic growth and international competitiveness. It has highlighted the very best research and has encouraged HEIs to take a rigorous approach in developing and implementing their own research strategies.”<sup>6</sup>

<sup>4</sup> Source: Evidence, ‘The evaluation of UK research assessment’ March 2006

<http://www.tec.govt.nz/upload/downloads/pbrf-report-on-research-evaluation.pdf>

<sup>5</sup> The RAE is a UK-wide assessment of research quality. QR refers to the ‘quality-related’ funding method in England only. UK-wide data is used throughout this paper as a proxy to demonstrate the impact of an English policy because of lack of alternative data sources. Similar, but not identical, research funding mechanisms exist in Wales, Scotland and Northern Ireland.

<sup>6</sup> [www.rae.ac.uk/Pubs/2004/01/rae0401.doc](http://www.rae.ac.uk/Pubs/2004/01/rae0401.doc)

7. Previous research has identified that it is selectivity, rather than an explicit policy of concentration, that has driven research excellence.

“Concentration of activity has been supposed by some to be a mechanism for improving research excellence.... [In the UK] research activity has become concentrated without an explicit policy of concentration, but as a result of selectivity.”<sup>7</sup>

8. International comparisons have also shown that there is no necessary correlation between concentration and excellence.

“The relationship between the degree of concentration and impact compared to world average appears to hold for the USA, where the research base is also HEI focussed, but not for Germany, where it is focused in research institutes.”<sup>8</sup>

9. In Germany, where there is an intentional policy of concentrating research in a small number of research institutes, research quality is not higher than in other countries. It is also interesting to note that in the USA research concentration has been reduced and yet it continues to be the world leader for research (see below).

10. The distinction between selectivity and concentration is important to recognise because introducing an explicit policy of concentration of research funding would be detrimental to the UK research base. Selectivity drives improvement through open competition and selective funding is based on an independent assessment of quality. A policy of concentration, however, would protect historic levels of institutional funding based on past performance. The system has been intentionally selective about funding world-class research but it has not sought concentration for its own sake.

### **Selectivity has resulted in concentration**

11. A policy of selectivity has resulted in high levels of concentration of research funding. Some academics have argued that we have ‘hyper-concentration’ of research funding in the UK<sup>9</sup>. By international standards:

“the profile of selectivity in the UK is probably greater than that in other countries, selectivity has actually decreased in the USA”<sup>10</sup>

<sup>7</sup> HEFCE Fundamental Review of Research Policy and Funding: Sub-group to consider the role of selectivity and the characteristics of excellence, *Final report*, 2000 <http://www.hefce.ac.uk/Research/review/>

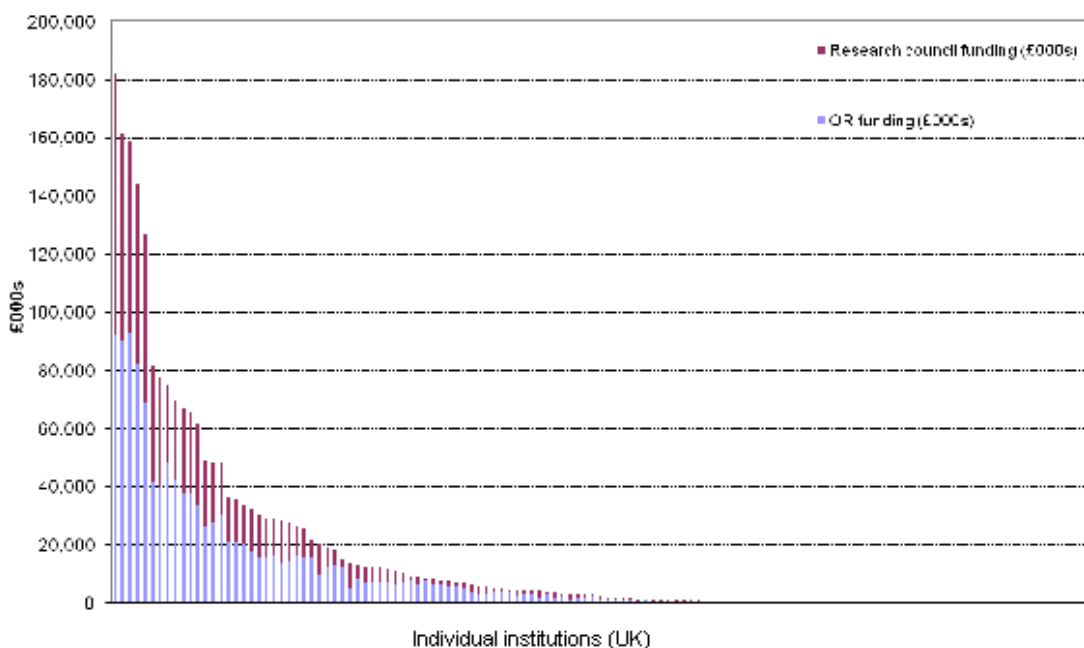
<sup>8</sup> *Ibid*

<sup>9</sup> Professor David Watson <http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=401289>

<sup>10</sup> HEFCE Fundamental Review of Research Policy and Funding: Sub-group to consider the role of selectivity and the characteristics of excellence, *Final report*, 2000 <http://www.hefce.ac.uk/Research/review/>

12. Selective funding of excellence will, quite rightly, result in concentration of research funding where there is a genuine concentration of excellence. If the excellence is more dispersed, however, the funding will follow this slightly broader pattern of distribution.
  
13. RAE 2008 and QR funding for 2009 re-directed a small amount of funding towards newly identified world-leading research but it did not reduce the overall concentration of research funding in the UK to any great extent:
  - In 2007-8, four institutions received 29 per cent of QR funding (and 23 around 75 per cent).
  
  - In 2009-10, four institutions received 32 per cent of QR funding (and 25 around 75 per cent).
  
14. The following chart demonstrates the high degree of concentration of research funding – both QR and Research Council funding – in the UK that has resulted from selectively funding quality in research.

**The UK’s research funding is highly concentrated**



### Selectivity has driven efficiency

15. A policy of selectively funding research, based on quality, has also:
- “enabled the Government and funding bodies to maximise the return from the limited public funds available for ...research.”<sup>11</sup>
16. In a more difficult fiscal environment with pressure on public funding, it will be even more important that we maintain the principle of funding excellence in research, wherever it exists.
17. Alliance universities deliver world-leading research in focussed areas of investment with comparatively modest QR funding. As demonstrated in section 4 of this paper, these are business-like universities which are adept at using their research income strategically.

### Selectivity can be taken too far

18. Research undertaken for HEFCE as part of their ‘Fundamental Review of Research Policy and Funding’ concluded that the policy of selectivity could be taken too far – and doing so would have damaging effect for the UK research base:
- “We recognise the danger that **a major increase in selectivity could reduce the number of research-led institutions to a level that would be inconsistent with the general health of the UK research base**, in terms of both its economic and its social contribution. In supporting excellence, we believe that a significant increase in selectivity would undermine the dynamism of the system as a whole, leading to complacency and ossification.
- “It could also undermine research of national, regional and local relevance that is highly valued by users, and the removal from many institutions of the beneficial effects of research on teaching and other activities that have been identified by the sub-group investigating teaching, research and other activities.”<sup>12</sup>

<sup>11</sup> [www.rae.ac.uk/Pubs/2004/01/rae0401.doc](http://www.rae.ac.uk/Pubs/2004/01/rae0401.doc)

<sup>12</sup> HEFCE Fundamental Review of Research Policy and Funding: Sub-group to consider the role of selectivity and the characteristics of excellence, *Final report*, 2000 <http://www.hefce.ac.uk/Research/review/>



## Section 2: Excellence is not determined by volume alone

### No relationship between volume and excellence outside some of the physical sciences

19. We know that there is a relationship between volume and excellence in some of the physical sciences because of “scale and costly kit” where there are “genuine affordability constraints.”<sup>13</sup> Outside the physical sciences, however, the spread of peaks of world-leading research excellence across the sector demonstrates that critical mass is not relevant.
20. Research undertaken for HEFCE as part of their ‘Fundamental Review of Research Policy and Funding’ proved, nearly a decade ago, that there is no relationship between volume and excellence outside some of the physical sciences – in the UK or internationally. The 2008 RAE results showed an even greater dispersal of excellence across the sector in some disciplines. The Final Report to HEFCE of the Higher Education Policy Unit, University of Leeds, in considering the ‘role of selectivity and the characteristics of excellence’ found that:
- “The effect of size is significant in most science-based subjects (as summarised in the table below), but for performance of international quality it is evidently not the only factor. For Mathematics, however, there is **no proven relationship between the size of the research unit and the quality of its output**: concepts of critical mass do not apply in this area.”
- “The **scaling pattern does not hold in Mathematics, in the arts and humanities or for some areas in the social sciences**. It is also clear that there are a number of small units performing at the very highest levels. Output is generally more concentrated in science than engineering, which may be due to historical growth patterns. **This emphasises the need to understand both the research system, its components (peak and platform), and the discipline-specific context.**”<sup>14</sup>

<sup>13</sup> Professor David Eastwood, “Quietly flows the Don? Higher Education, turbulence, and timeless verities”, AUA Annual Guest Lecture, 24 October 2007. <http://www.aua.ac.uk/events/annuallecture/tenth/narrative.pdf>

<sup>14</sup> HEFCE Fundamental Review of Research Policy and Funding: “The Role of Selectivity and the Characteristics of Excellence” A Study by the Higher Education Policy Unit, University of Leeds, *Final report to HEFCE*, 2000 <http://www.hefce.ac.uk/Research/review/>

21. The research also found that this is not just a UK-specific phenomenon. It found similar patterns of correlation in the USA and Canada and even fewer subjects that demonstrate correlation in Germany:

“The pattern for the USA is very similar to that for the UK, as is that for Canada. For Germany, however, only in biological sciences and physical sciences is a clear positive relationship evident.”

### Three broad categories

22. The research identified three general patterns or categories of relationship between volume and excellence (described as impact). These are summarised in the following table.

#### Size (output volume) and impact within SUOAs<sup>15</sup> across institutions

|   |      |  |
|---|------|--|
| High impact at high volume -<br>Low impact at low volume        | e.g. | Clinical sciences<br>Biological sciences |
| Higher impact at high volume –<br>Variable impact at low volume | e.g. | Engineering<br>Social sciences           |
| No clear pattern  | e.g. | Mathematics<br>Arts and humanities       |

23. The research found that:

“In the first model the size relationship is strongest, perhaps suggesting the most evident management effect. In the second model, large size clearly benefits quality but **smaller units can still be effective**. In the third model, **research quality is not affected by size**; this is the classic 'lone researcher' model cited for the arts but it is interesting that it is also found in mathematics.”

24. These patterns are illustrated in the following Figure<sup>16</sup>. The research found that:

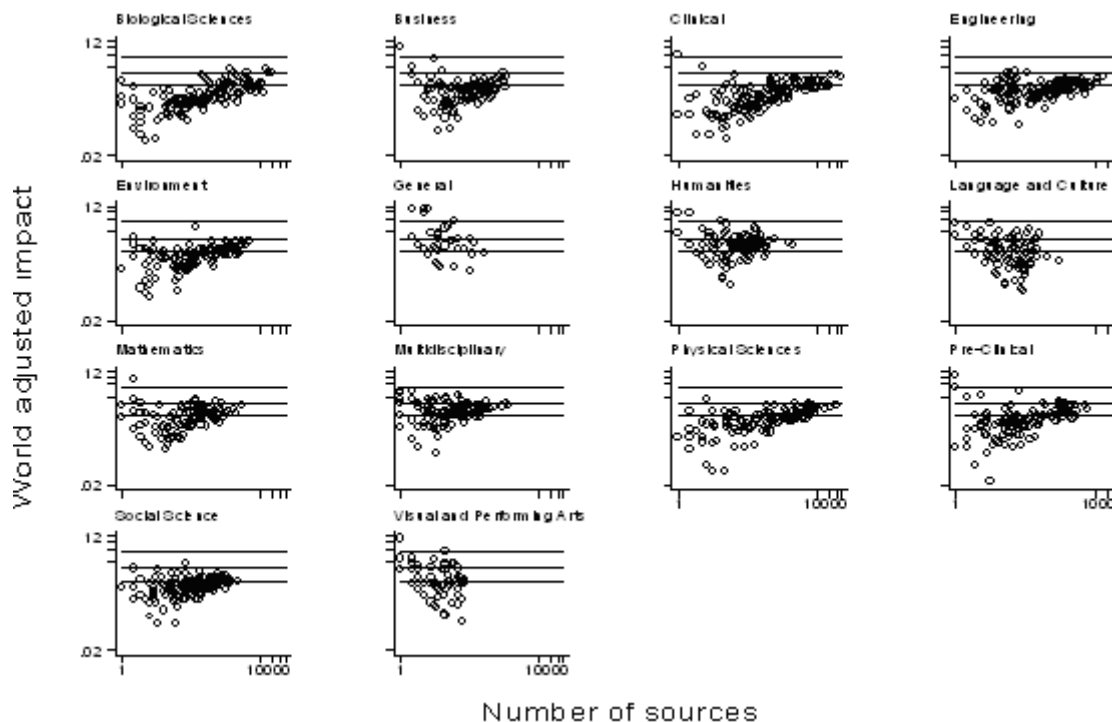
“The correlations for these sets of data are statistically significant ( $P < 0.05$ ) for science and technology subjects, but the correlation explains only 7% of the variance for the Mathematics data. The correlations for business and the arts-based subjects are not significant.”

“For Mathematics ... the discipline does not respond to a critical mass effect and behaviour is therefore distinct from other science subjects.”

<sup>15</sup> ‘super’ units of assessment (SUOA) – combined UOAs

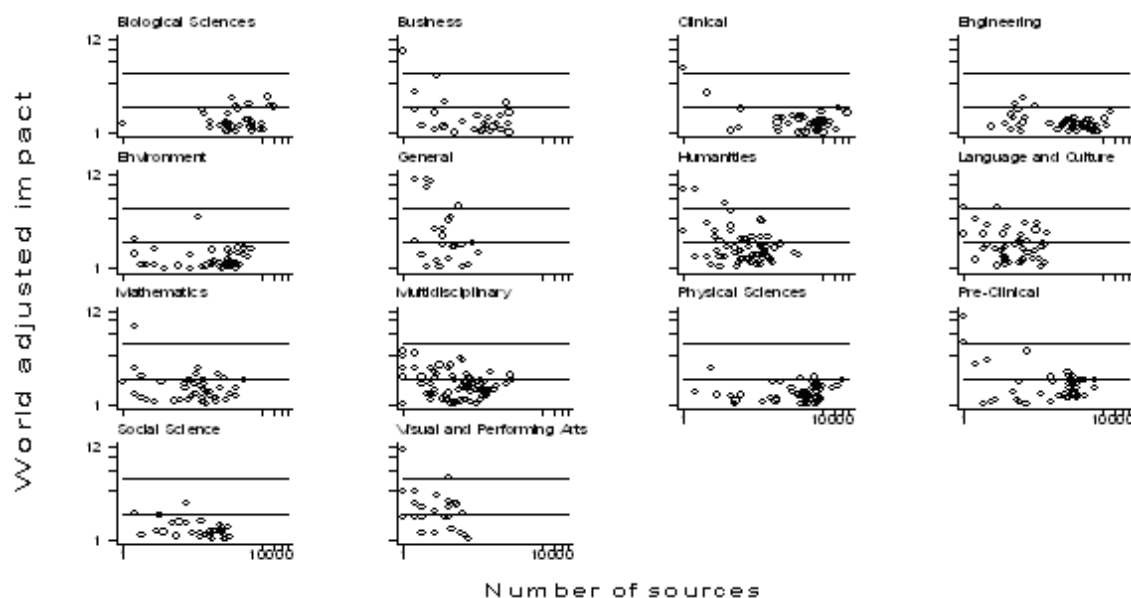
<sup>16</sup> Note that the X-axis is a log plot uniformly scaled for all UOAs, thus causing some compression in lower output subjects. The Y-axis is bibliometric impact scaled against world average = 1.0.

**Impact in relation to output by SUOA for all institutions - world average impact = 1.0 (horizontal lines at x1, x2 and x5 world average)**



25. The research then went one step further to investigate the distribution of excellence in more detail by looking only at average publication impact in UOAs that are above world average. As the Figure below shows, the correlation between volume and excellence becomes even less clear in this analysis.

**Impact in relation to output by SUOA for institutions where average impact exceeds world average impact (horizontal lines at x2 and x5 world average)**



### **No identifiable threshold of critical mass in ‘high impact at high volume’ subjects**

26. The research found that even in the ‘high impact at high volume’ disciplines, there was no specific ‘threshold’ for volume or ‘critical mass’ that could be identified because there was a continuous scale.

“There is indeed a positive size effect on the quality of outputs in many of the ... sciences. However, it is difficult to identify any specific threshold above which performance suddenly changes, rather the data suggests that the relationship between size and performance is continuous.”

### **Even in ‘high impact at high volume subjects, volume is not the only factor**

27. The research was careful to point out that even in ‘high impact at high volume’ subjects volume was ‘evidently’ not the only factor.

“We conclude that the effect of size is significant in most science-based subjects, but for performance of international quality it is evidently not the only factor.

“It is also clear that there are a number of small units performing at the very highest levels.”

### **Selectivity deals with volume**

28. Where there is a correlation between volume and excellence, this is borne out in the data and, therefore, reflected in the distribution of a selective funding model. In ‘high impact at high volume’ subjects, the RAE predominantly finds excellence where there is large volume and for these disciplines there is a higher level of concentration of research funding.
29. There is no need to introduce clumsy mechanisms such as a minimum threshold for funding (even if a threshold could be identified) because a policy of selectively funding research, based on quality, will achieve concentration where it is justified.

## Collaboration

30. Another reason not to attempt to establish any false ‘thresholds’ of volume in the system is that national boundaries for collaboration are becoming increasingly less relevant. UK internationally co-authored papers have risen from 32 per cent in 1998 of total world publications to 45 per cent in 2007.<sup>17</sup> We also know that papers resulting from international collaborations are more frequently cited and published in higher impact journals than those with UK-only authors.<sup>18</sup>
31. A ‘lone researcher’ could be part of a highly successful international research team that provides access to shared resource and peer support. If he or she is achieving world-leading research, even in a ‘high impact at high volume’ subject, through international collaboration, there seems no valid reason to exclude this person from the assessment process.
32. As the HEFCE Review found:
- “it is also unclear from a policy point of view whether critical mass is affected by distance; for example, can collaboration overcome local deficiencies in scale?”<sup>19</sup>
33. Again, a quality-related funding model for research is able to identify and support research that is overcoming local deficiencies in scale through collaboration without the need for further intervention.
34. As Professor David Watson has recently emphasised, it is increasingly important to adapt:
- “to a world of wider and deeper collaboration, in which at many of its scholarly frontiers the isolated institution is no longer the most sensible unit of analysis.”<sup>20</sup>

<sup>17</sup> Evidence Ltd / Department for Innovation, Universities and Skills, International comparative performance of the UK research base, July 2008

<sup>18</sup> Professor Sir Gareth Roberts, *International Partnerships of Research Excellence: UK-USA Academic Collaboration*, April 2006

<sup>19</sup> HEFCE Fundamental Review of Research Policy and Funding: “The Role of Selectivity and the Characteristics of Excellence” A Study by the Higher Education Policy Unit, University of Leeds, *Final report to HEFCE*, 2000  
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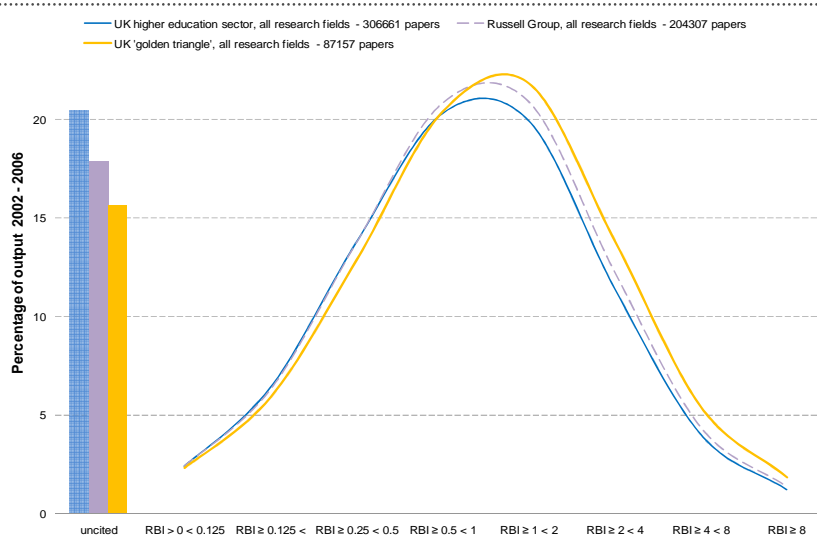
<sup>20</sup> Professor David Watson <http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=401289>

### Section 3: Peaks of excellence matter

#### Peaks of world-leading research are distributed across the sector

- 35. It is the peaks of world-leading research excellence that determine the position of the UK as a world leader in research.
- 36. Analysis of research and innovation in Europe has noted the importance of fostering peaks of research excellence because “Europe needs these peaks.”<sup>21</sup> These peaks of research excellence are more widely distributed across the sector than had previously been recognised before RAE 2008.
- 37. It is only when both quality and volume are taken into account that major research-intensives stand out. On quality alone, they do not. The following Figure<sup>22</sup> shows the percentage of research outputs by quality (as measured by their performance against the world-average citation level). It shows, very clearly, that the pattern of excellence in research across the sector as a whole is only slightly below that of the ‘golden triangle’ institutions and almost identical to the high performance of Russell Group institutions.

#### Excellence extends to other institutions



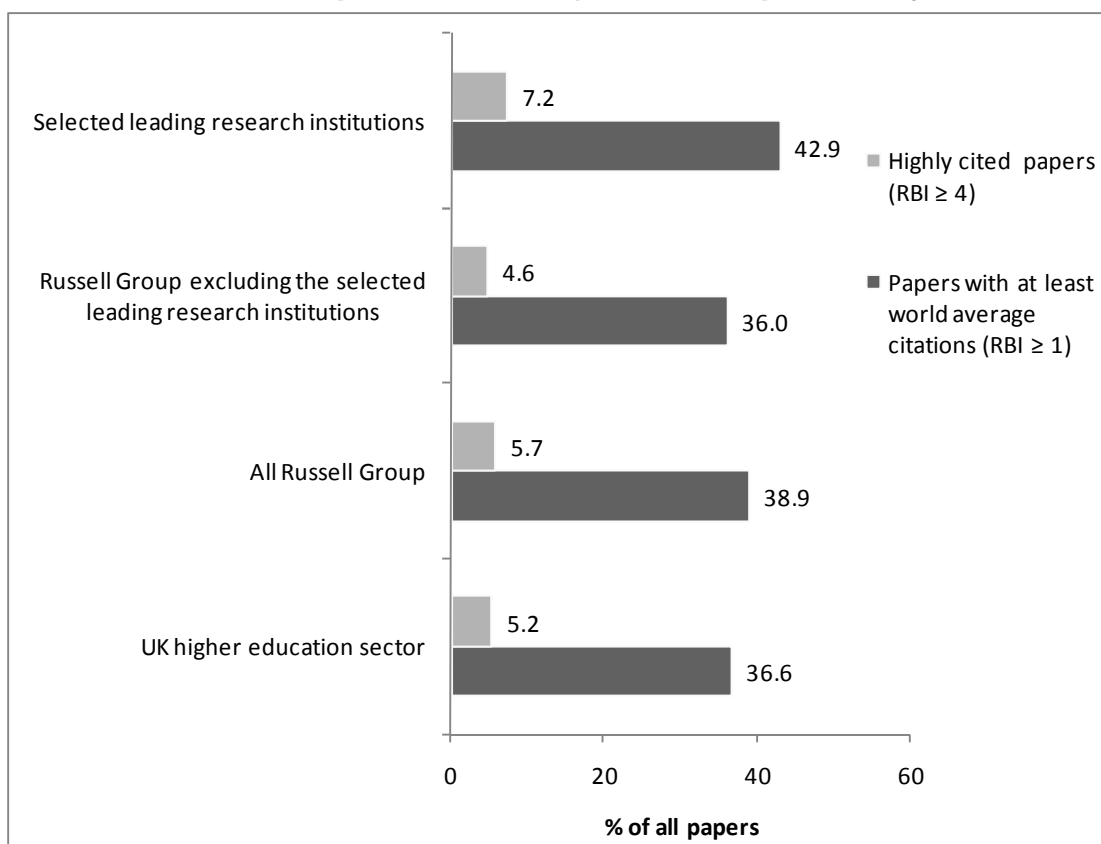
<sup>21</sup> Aghion, P., Dewatripont, M., Hoxby, C., Mas-Coleil, A., and Sapir, A., Higher Aspirations: an agenda for reforming European universities (Bruegel Blueprint Series, Volume V, 2008), p.24

<sup>22</sup> Jonathan Adams, Evidence. Presentation at HEPI conference, October 2009. <http://www.hepi.ac.uk/485-1734/Research-Funding-and-Assessment--The-Future.html>

- 38. Research recently published by the Higher Education Policy Institute (HEPI) further demonstrates the distribution of excellence across the sector as a whole.
- 39. The figure and table below compares the proportion of all papers produced by the ‘Golden Triangle’ institutions, other Russell Group major research-intensive universities and the whole HE sector between 2002-06 that are ‘highly cited’ and the proportion that were cited at least as often as the relevant world average.
- 40. HEPI found that on these measures of quality of research, the sector as a whole performed better than the Russell Group (excluding ‘Golden Triangle’ institutions).
 

“The proportions of papers published by the remaining Russell Group institutions that are cited at least as frequently as the relevant world average, and the proportion which are highly cited, are in fact lower than for the sector as a whole.”<sup>23</sup>

**Extract of citation data for papers published 2002-2006 - comparison of selected ‘golden triangle’ institutions (Cambridge, Oxford, Imperial College, LSE, UCL) with other Russell Group and UK sector (citation data provided by Evidence Ltd)**



<sup>23</sup> Oxford and Cambridge – How different are they? Juliet Chester and Bahram Bekhradnia (HEPI, 2009) p29 – 31 <http://www.hepi.ac.uk/466-1748/Oxford-and-Cambridge---how-different-are-they.html>

**Extract of citation data for papers published 2002-2006 - comparison of selected 'golden triangle' institutions (Cambridge, Oxford, Imperial College, LSE, UCL) with other Russell Group and UK sector (citation data provided by Evidence Ltd)**

| <i>Articles and reviews published by</i>                           | <b>At least world average (RBI ≥ 1)</b> |                  | <b>Highly cited papers (RBI ≥ 4)</b> |                  | <b>Total papers</b> |
|--|---|------------------|--------------------------------------|------------------|---------------------|
|  | % of total papers                       | Number of papers | % of total papers                    | Number of papers |                     |
| UK higher education sector   | 36.6%                                   | 112,238          | 5.2%                                 | 15,946           | 306,661             |
| All Russell Group  | 38.9%                                   | 79,475           | 5.7%                                 | 11,645           | 204,307             |
| Russell Group excluding the selected leading research institutions | 36.0%                                   | 42,174           | 4.6%                                 | 5,389            | 117,150             |
| Selected leading research institutions                             | 42.9%                                   | 37,390           | 7.2%                                 | 6,275            | 87,157              |

41. The fact that the sector as a whole has a higher percentage of 'highly cited papers' than the research-intensive Russell Group universities (excluding the 'Golden Triangle' institutions) is strong evidence of the distribution of peaks of excellence across the sector.
42. It is vital to the future health of the UK research base that these peaks of world-leading research continue to be supported through the selective funding of excellence in research, wherever it exists.

**Diversity across the sector is important for the health of both the UK research base and the UK higher education sector more broadly**

43. Diversity supports the health of UK research base:
- Supporting both the breadth and depth of UK research will ensure the health of the UK research base in the future.
  - Supporting peaks of world-leading excellence across the sector ensures that it is the highest quality research that is funded.
  - A diverse research base is important for encouraging a dynamic sector and progress in research. This includes interdisciplinary approaches where innovation often emerges.
  - Smaller centres of excellence for research can be important hubs for developing early career researchers and ensuring a high-quality supply chain for UK research.



- Concentration in selected institutions would lead to major geographical areas without research activity and a knowledge base. This could negatively affect SMEs and medium sized organisations with subsequent impact on local economies.

44. Diversity enables the high impact of peaks of world-leading research excellence:

- There is “good evidence of an association between research excellence and industrial innovation and application.”<sup>24</sup> The association is with excellence not necessarily volume.
- The peaks of world-leading research excellence within Alliance universities achieve high levels of impact (see case studies in next section).
- In terms of impact, the HEFCE Fundamental Review concluded that “research utility is as important as excellence in basic research.”<sup>25</sup> Alliance universities also have strong track records in engaging in near-market research and development work, which is underpinned by the excellence revealed in the 2008 RAE results.

45. Diversity supports a research-led learning environment:

- Supporting a more diverse research base enables research-active universities that have peaks of world-leading research to maintain their strong research cultures.
- A strong research culture is vital for research-informed learning, which is the essence of an enquiry-led, academic university learning environment that delivers the truly graduate-level skills needed for the economy.

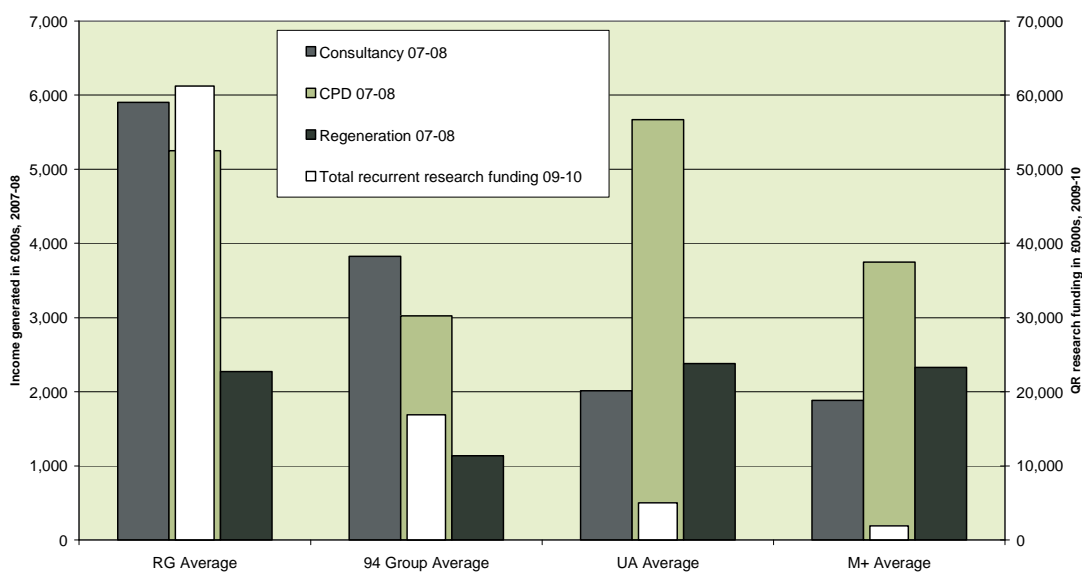
<sup>24</sup> HEFCE Fundamental Review of Research Policy and Funding: Sub-group to consider the role of selectivity and the characteristics of excellence, *Final report*, 2000 <http://www.hefce.ac.uk/Research/review/>

<sup>25</sup> Ibid

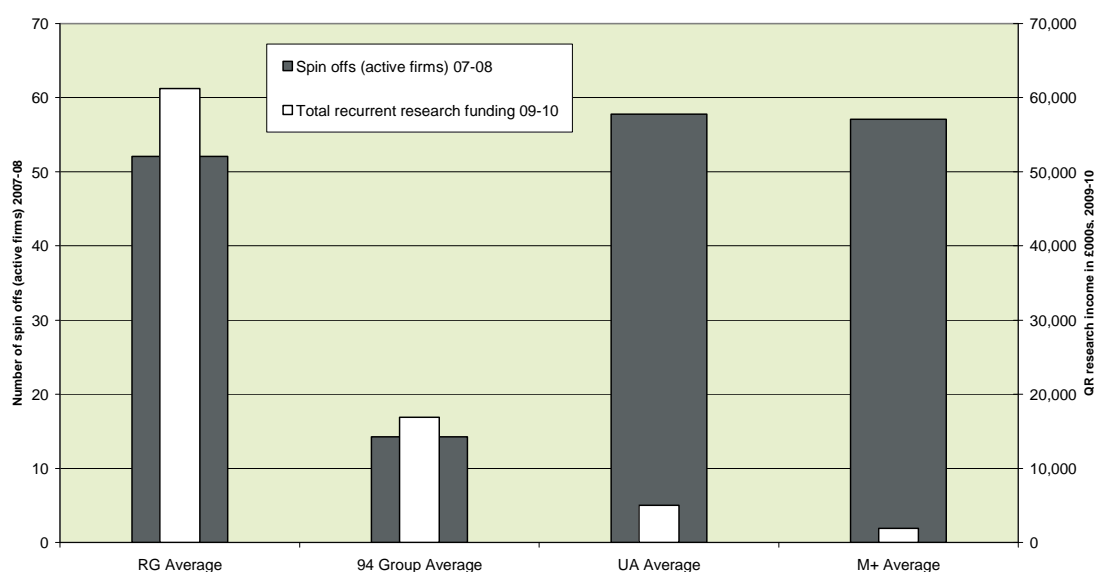
## Section 4: Peaks of research excellence with impact across the Alliance

46. As the following charts demonstrate, pound for pound Alliance universities are using their QR funding to achieve significant impact.

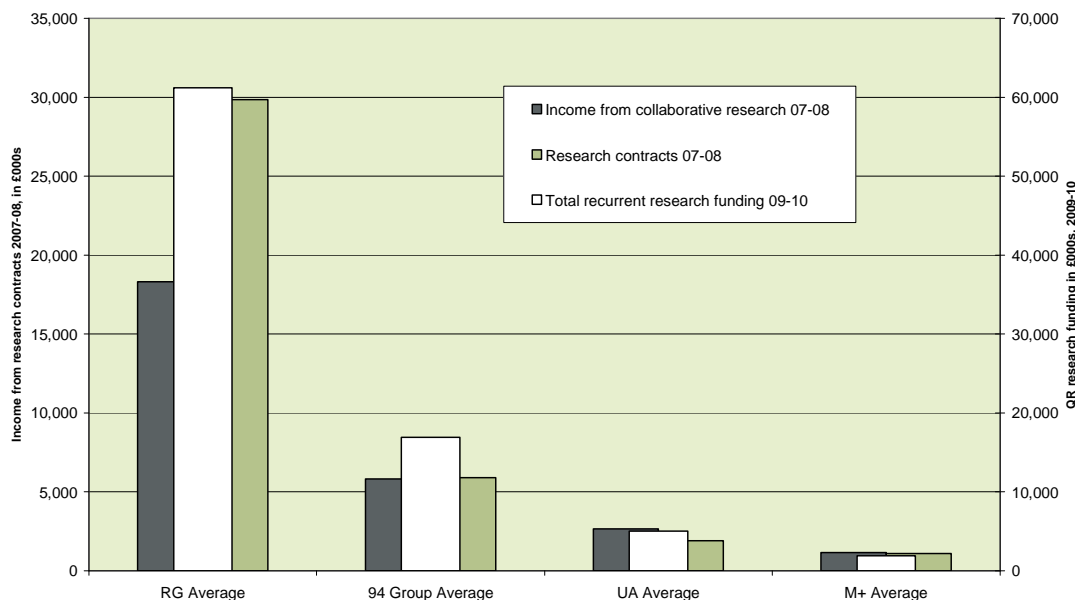
### Income generated from CPD and Regeneration greatest at Alliance universities



### Entrepreneurialism is driving spin-offs, not public research income



## Alliance universities generate more income from collaborative research as a % public research income than the research-intensive universities



## Case studies of peaks of world-leading research with high impact within Alliance universities

47. Alliance universities are using world-leading research to achieve significant impact; addressing social, economic, social, public policy and, cultural needs.

The **University of Portsmouth's** Institute of Cosmology and Gravitation has achieved an RAE result in which 75% of the work was judged as 4\* or 3\*, a proportion not exceeded by any other institution in this UOA.

The Institute works in fundamental areas of cosmology and astrophysics, supported by the Research Councils, the European Union and other international funding bodies.

Its areas of expertise include The Cosmic Microwave Background, Galaxy Surveys, Dark Energy, Brane-world Cosmology and String Cosmology, Relativistic Dynamics and Geometry, Relativistic Astrophysics and Gravitational Waves.

Cosmology | University of Portsmouth

The **University of Hertfordshire** has been placed in the Shanghai Jiao Tong League Table of the World's Top 500 Universities for Research. The University entered for the first time in 2008 and has just been reconfirmed for 2009.

Hertfordshire's Physics and Astrophysics Research has been strongly supported by the University for over 30 years and it attracts a large amount of research income from organisations including the Research Councils, Royal Society, Leverhulme Trust, Nuffield Foundation, Meteorological Office, Defence Science and Technology Laboratory and NASA. The RAE 2008 submission in Physics included 28 staff and with 90% of its research internationally recognised. The submission incorporated two Research Centres within the University's Science and Technology Research Institute, namely the Centre for Astrophysics Research and the Centre for Atmospheric and Instrumentation Research.

The two Research Centres have a balanced portfolio of research in fundamental physics, astrophysics and atmospheric physics including both observational and experimental work, together with knowledge transfer and exploitation. In addition, the two Centres embrace interdisciplinary work in the development of instrumentation to measure light-scattering in situations ranging from extra-solar planets to dust in the Earth's atmosphere.

Astrophysics | University of Hertfordshire

The **University of Glamorgan's** very successful engineering research focuses on multi-disciplinary approaches to key issues facing society, including sustainable energy generation and clean technologies for power systems and vehicles.

The University brings together staff with expertise across areas of engineering and links them with applied sciences to work with users to create holistic, innovative solutions

Relating to a key priority of the Welsh Assembly, 'Building a low carbon economy' has been a major research theme. This research focuses on the use of hydrogen as a pollution free energy vector and addresses sustainable generation of hydrogen, uses of hydrogen in waste streams of industrial processes, hydrogen fuel cell technology, advanced materials for hydrogen storage and hydrogen powered vehicles.

Engineering | University of Glamorgan

Research Fortnight's RAE 2008 Power Table showed that the **University of Plymouth** was ranked at number 50, with the highest increase in ranking (15 places) from 2001 to 2008. The University has attracted more than £5.6M research income across its schools and faculties. The University's largest Unit of Assessment for the 2008 RAE, with 36.5 staff submitted, was Earth Systems and Environmental Sciences (UOA17), which includes the marine physical sciences and chemistry. In this unit 95% of the research was judged to be at least internationally recognised, with 50% being internationally excellent or world leading.

The University was one of only two UK universities selected to take part in a landmark pan-European marine project worth €55M. The Universities of Plymouth and Reading have joined forces with 60 of the leading marine organisations across Europe to carry out the landmark MyOcean project. Funded by the European Commission, the ambitious project aims to create the first-ever European-wide resource for ocean monitoring and forecasting by integrating the research skills and expertise across 28 countries. The University of Plymouth's role in the project will be to contribute its expertise to the numerical modelling of ocean dynamics and calibration/validation of prognostic services in the Black Sea, an area of research where the university has already achieved an international reputation.

Climate Change | University of Plymouth

The research strengths of **Liverpool John Moores University** primarily lie in the STEM and STEM-related areas. Amongst the highlights from RAE 2008, the University would single out the outstanding performance achieved by two, small, specialist research groups, namely General Engineering and Electrical & Electronic Engineering. Both units were rated with 60% of their activity at 3\* and 4\* in the 2008 RAE.

Significant levels of external funding have been attracted by these researchers from a wide range of competitive sources, including EPSRC, industry (direct funding and KT schemes), TSB and from successive European Framework Programmes. Worldwide collaboration is a fundamental aspect of the research which engages with other Universities, world-leading hospitals and with industry (multinational and SME) – often through multidisciplinary projects. User take-up clearly demonstrates that their work has directly influenced; radiotherapy, medical imaging, advanced manufacturing, precision measurement, industrial inspection, material and chemical processing, communications, signal-processing and remote-sensing.

Engineering | Liverpool John Moores University

**The Open University** achieved the second largest climb in UK research rankings in the 2008 Research Assessment Exercise, with more than 50% of its research rated as ‘internationally excellent’ (3\*) and 14% as ‘world-leading’ (4\*).

The University supports a vibrant research portfolio and fosters research teams who compete with top ranked institutions in the UK and worldwide. Research highlights include Dr Robert Saunders’, work to develop a model system for studying the molecular and cellular nature of a genetic disorder known as Werner’s Syndrome (WS) caused by defects in a gene.

Ultimately, the research project is expected to shed new light on the nature of ageing” known as WRN. Werner’s Syndrome is a condition that leads to rapid ageing and early death, and is frequently used as a model for normal ageing. Because the condition is rare, human material is limited and it is often difficult to use experimentally. However, Dr Saunders and his team have identified a homologue in the fruit fly *Drosophila* of the gene involved in this syndrome, and have initiated a successful £271,462 research project funded by the Biotechnology and Biological Sciences Research Council (BBSRC).

75% of **Oxford Brookes University** research was internationally recognised in the 2008 RAE

The Movement Science Research Group at Oxford Brookes is based in Oxford Brookes’ Biomechanics and Human Performance Laboratories and has excellent clinical links with the Oxford Centre for Enablement, Nuffield Orthopaedic Centre, the Oxford Centre for Functional Imaging of the Brain, John Radcliffe Hospital and the Department of Clinical Neurology, University of Oxford.

The Group’s many projects include:

- Mapping central nervous system activity during movement and motor learning and recovery
- Monitoring and improving safe mobility, activity and fitness levels in patients with neurological or neuromuscular disease

The Group is in receipt of Wellcome Trust funding to facilitate technology transfer of a methodology for gait analysis (the measurement of walking parameters) from a laboratory tool into a measure that is in every day clinical use.

The **University of Bradford** has 700 researchers and an annual research income of more than £16m. The University actively promotes interdisciplinary research across the University and through external collaboration with organisations such as the Ministry of Defence, the National Health Trust, and Universities worldwide.

This research impacts positively on industry through regular collaborations. From small, local and regional companies such as Briton Engineering and Materia-Medica; to large multinationals like, GlaxoSmithKline, Smith & Nephew, Ford, and PZ Cussons (UK) Ltd.

The University's Centre for Polymer Micro and Nano Technology has a world leading research capability in micro- and nano-moulding technologies advancing knowledge in areas such as materials modelling and characterisation, process optimisation, product characterisation and testing, and simulation. In parallel with and building upon these research activities, the Centre has developed comprehensive industry links. Knowledge transferred to companies of all sizes includes design consultancy, process and product development, proof of concept manufacturing, specification of turnkey systems for device manufacture and packaging and full-scale manufacture of devices. The Centre offers significant expertise in nano-materials preparation, materials understanding, design for micromoulding, process/product characterisation and modelling.

Nanotechnology | University of Bradford

The **University of Salford** is a world-leading university in Architecture and the Built Environment.

The University's Research Institute for the Built & Human Environment specialises in research across the broad themes of the environment, management and ICT.

The University's return constituted by far the largest submission to this unit of assessment, and the results reflect the fact that the university produces the highest volume of world-leading and internationally significant research in this area.

Built Environment | University of Salford

The 'Intermittent Predictive Control Systems' governing human movement and posture project interfaces between Engineering and Life Sciences and received glowing reports from all four reviewers in the 2008 RAE. Audited through **Manchester Metropolitan University** a three year EPSRC award will also support work at the University of Birmingham (Dr Martin Lakie) and in the University of Glasgow (Dr Henrik Gollee).

A future application of this important fundamental research may be the development of artificial control systems that are interfaced to humans via brain machine interfaces and spinal cord interfaces. The collaboration with Dr Henrik Gollee in Glasgow's Centre for Rehabilitation Engineering, working with the Queen Elizabeth National Spinal Injuries Unit, is of particular interest since they are concerned with the use of electrical stimulation to restore movement to para and tetra plegic patients, in which field there is a need to develop an engineering control system that mimics human neural control.

At Manchester Metropolitan University, the experimental work into physiological control will be conducted in the new IRM Posture Laboratory which is being built as part of the 'state of the-art' IRM Research Institute development on the John Dalton site of the Faculty of Science and Engineering. The research will utilise a unique multisensory balance apparatus being developed by Dr Ian Loram and constructed by Messrs Tom McKee and Des Richards.

Physiology | Manchester Metropolitan University

Nursing at **Northumbria University** exemplifies high quality, high impact research. Achieving 50% 3\* and 4\* in the RAE 2008, the research centre returned the highest level of research grant income per Category A FTE returned in the UOA (almost 4 times the UOA average) and one of the highest levels of PGR activity.

In policy and in practice, as well as internationally, the work of the centre has high impact and is highly esteemed. Just one example is in the field of risk management in dementia care: initiating and leading a highly successful International Collaborative Research Network on risk in ageing populations (funded in part by the British Academy, and with partners in USA, India, Australia, Germany, South Africa and well as across the UK), several national research awards and PGR studentships, and with numerous outputs including three special editions of international peer reviewed journals. This work has informed practice in dementia care and is currently informing implementation of the National Dementia Strategy.

Health | Northumbria University



A joint submission was made to the 2008 RAE by two University Alliance members; the **University of Wales, Newport** and the **University of Wales Institute Cardiff (UWIC)** under the aegis of the Wales Institute of Research in Art & Design (WIRAD: the Newport School of Art, Media & Design, the Cardiff School of Art & Design and the National Centre for Product Design & Development Research).

The research cultures in Art & Design at Newport and UWIC are long established and the 2008 RAE success was built on strong performances in the 2001 RAE of 5\* and 4\* for Newport and UWIC respectively. The structure of the research in WIRAD comes under four over-arching themes where a broad range of exciting and internationally leading research is carried out in the following areas:

- Design Enhanced Human Futures
- Fine Art & Ceramics, Design Policy & Practice
- Film
- Photography & Screen Media

Art & Design | University of Wales, Newport and UWIC

The excellent RAE 2008 result at **Nottingham Trent University** includes a major breakthrough in airport security systems which will help identify suspect packages more quickly and efficiently.

Nottingham Trent University is working on the world's first 'scatter-enhanced' 3D x-ray security scanner to identify contraband substances. The hi-tech equipment combines a novel x-ray diffraction technique with high-resolution 3D x-ray imaging capability to create an impression of an object's depth, partially rotate it, and even see around or behind it. The system will speed up security checks and reduce false alarms.

Experts in the University's School of Science and Technology have patented the scanner in conjunction with Cranfield University and are working closely with the Home Office Scientific Development Branch and the US Department of Homeland Security.

Security | Nottingham Trent University

The Centre for Applied Childhood Studies at the **University of Huddersfield** was submitted under UOA40 - Social Work and Social Policy Administration and achieved excellent 2008 RAE ratings (>75% of the outputs were found to be internationally excellent or internationally recognised with some activity world-leading).

Research within the Centre is primarily multidisciplinary and involves partners from health, education, criminal justice, social work and social care. International partners include universities from North America, Europe, Hong Kong, South Africa, Australia, the Caribbean and several international organisations.

Research in the Centre is clustered around four main groupings:

- Child Health (child and adolescent mental health, chronic illness, HIV-AIDS, sibling donors)
- Child Wellbeing (child neglect, child abuse, safeguarding, parenting, economic well-being, child-centred practice and research)
- Marginalised Childhoods (e.g. disabled children, looked after young people, children of migrant families and young asylum seekers)
- Critical Theory, Policy and Professional Practice (discourse and identity; policy formulation and analysis; practice and service evaluation)

The **University of Lincoln's** Centre for Vision and Robotics Research exemplifies the rapid research progress that can be made by small, ambitious and flexible University Departments.

Founded in 2004, the Centre has grown in just four years to nearly twenty members with around £750k external funding, more than seventy publications, and an international reputation in people tracking, medical vision, autonomous robotics and neural vision. The Centre's first three postgraduate students graduated in 2008.

The **University of the West of England's** Institute of Biosensing Technology (IBST) is the first of its type using Bio-sensing technology in non-invasive detection of disease, healthcare (being able to detect metal fatigue in hip replacements before they hurt), security and many other applications. This attracts inward investment from overseas.

IBST was formalised in 2008 and has already secured major research contracts such as a £1 million project in collaboration with DePuy (a Johnson+Johnson company) and Gwent Electronic Materials, funded by the Technology Strategy Board. The project aims to develop a new rapid, point-of-care diagnostic system for the measurement of metal ions after joint replacement. This will inform clinical decision making around the need for pre-emptive revision in case of high levels of metal wear.

IBST has also become an affiliate member of the Sensors & Instrumentation Knowledge Transfer Network (SIKTN), a government funded initiative to develop a joined-up approach to the bio-sensing and instrumentation community. The Institute is already working with the SIKTN on a project to develop a National Directory of UK companies working in bio-sensing.

Bio-sensing | University of the West of England

The Department of English and Creative Writing at **De Montfort University** achieved an exceptionally high rating in RAE2008, with 40% of its output being rated 4\* resulting in a rank of 9/87 in the THE. This was an exceptional performance for a relatively small research group of 20 individuals and can in the main be attributed to the work of its two research centres.

The Centre for Textual Studies, in existence since 1996, has developed innovative software to support digital scholarly editing, and has gained an international reputation for work in this area. Recent grant-winning successes include £520,280 for the Browning Correspondence project in 2006, and £52,780 for a genetic edition of 'Time Passes' by Virginia Woolf in 2007.

The Centre for Adaptations brings together the work of internationally acclaimed scholars in this exciting new sub-discipline, so that De Montfort University can truly claim to be the hub of adaptations studies in the UK. Host to the Association for Adaptation Studies, supported by Leverhulme Network funding, the Centre gathers together scholars from all over the globe.

English & Creative Writing | De Montfort University

**Bournemouth University's** National Centre for Computer Animation (NCCA) is working with the University of Bath to create the first Industrial Doctoral Centre for the Computer Animation industry. This pioneering project has been awarded nearly £6 million by the Engineering and Physical Sciences Research Council (EPSRC).

With an annual turnover of approx £7 billion the computer animation industry is of increasing importance to the UK economy. The Centre aims to improve knowledge transfer between academia and industry and provide training in the technical, artistic, research and management skills needed by the next generation of industry leaders.

For the past two years, 3D World magazine has rated the NCCA as the best place to study computer animation in the UK. The publication also rated the Centre as number eight in the world.

Other recent grant successes include £290,000 over three years from the EPSRC to improve the realism of animated virtual humans. These characters will be used by partners Lancaster, UCL and the Metropolitan Police to study psychological responses to street violence.