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The future of the UK university research base

July 2010

What is the purpose of this report?

This literature and data review has been prepared to underpin a new Universities UK report on the future of the UK university research base, to be published in summer 2010. It provides additional data and expands on the arguments made in the Universities UK report. The additional background and contextual material presented here comes from a variety of sources, including academic research and government reports, and draws on reports and data compiled by *Evidence*, a Thomson Reuters business.

Facing the future

There is much evidence of the success of the UK Higher Education (HE) research base. The problem is that such success was founded in a different era and it is extremely dangerous to rely unduly on reference to the past record when the future looks very different and new adaptations must certainly be acquired.

- Investment in universities generally and their research in particular has grown on the back of expectations about the transforming power of higher education, the mobility of people and the contribution of research-driven innovation to the economy.

- Universities have grown enormously in number and size in recent years. Expansion has arguably placed the system, at least in part, in the role of a service provider and has an impact on the distribution of resources, activity and outcomes.

- Whilst universities remain autonomous institutions, increased public investment both through grants and fees income has made them more visible and more accountable. They must now strive harder to retain the respect once naturally granted.

- With the growth of the information society, universities are no longer the primary sources of information for many people so they must work to assert their role as arbiters of knowledge. The creation of accessible repositories is a signal of their potential contribution.

- Many research fields have grown, diversified and matured to an enormous extent. Many play an important role in public policy. Contemporary challenges cross disciplines and methodologies. Quality research demands huge resources, the allocation and use of which becomes a complex national and international challenge.

- Public expectations of research outcomes have changed from discovery to utility, reflected particularly in the overt objectives of policy instruments.

- Universities have become global brands, partly because of internet technologies, and compete for prestige, staff and students in an environment beyond national boundaries.

- The UK no longer sits at a unique hub between a global network in the Commonwealth, a link to European partners and a particular friend of the USA. The countries which will dominate the future global research base have altered the regional balance. Understanding their research culture and using their research language has a new priority.

In thinking through the possible changes required by the university research sector we must retain the many aspects of university research that remain effective and fit for purpose. The core values of universities protect a culture which distinguishes university environments from other research environments. These include an innate dynamic responsiveness not found elsewhere. At the same time, university research will need increasingly to demonstrate its connection with utility, and the response to this must include a discussion on the nature of research, drawing attention - for example - to the way in which economic or social impact can derive from mission-led research. This is not a stark choice between either academic/discovery research or economic/development research. It will be about balance.

The emphasis of our analysis and discussion points is therefore not on the success of the research base nor on its need for cataclysmic change but on 're-balancing'. This is to emphasise the record of achievement which must be preserved. The system will benefit from a series of modest shifts but it would be harmed by dramatic restructuring.

The success of the research base

There is much evidence of the success of the UK Higher Education research base on an internationally comparative scale and we provide an analysis of this evidence in later sections. This is primarily indexed in terms of academic impact, since these are the most ready data available on a like-for-like international basis. Here, we summarise some of that information.

Academic impact

The Government supports universities.

"I believe that the strength of our universities derives in large part from their autonomy. That autonomy is the envy of other nations […] governments must respect the autonomy of universities. We can strengthen this by giving them the widest possible range of diverse funding streams and institutional arrangements. We must place greater faith in the serendipitous paths that researchers take. Paradoxically, that is the best way of ensuring they make the fullest possible contribution to our economy and our national life."[1]

The UK university research base approaches the challenge of economic recession and resource constraint from a position of considerable strength. A high proportion of UK publications have a university author, or co-author. The UK has been excellent in its publication activity, usually second only to the USA in measures such as output volume and citation impact. Moreover, it has been efficient in achieving this with a higher output per researcher and per unit investment than other leading research nations. In international comparisons published by the Department for Business Innovation and Skills (BIS), the UK invests about 4% of Gross Expenditure on R&D (GERD) amongst its comparator group. With this it produces about 8% of world PhDs and of papers on the Web of Science® and is first in G8 on publication productivity. From this it generates 12% of world citations and 14.4% of the world's most highly-cited papers.[2]

The university sector has contributed substantively to the goals set out in the UK Science and Innovation Investment Framework 2004-14. For example:

- The target of remaining second to the USA on share of world citations was met.
- The UK remained the leading Organisation for Economic Co-operation and Development (OECD) country on citations per gross domestic product (GDP) and per researcher.
- Research contract income to HE from business more than doubled between 2001 and 2006.
- PhD awards per million population are increasing in the UK and second only to Germany.

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[1] David Willetts, Minister for Universities and Science – in a speech at University of Birmingham - 20 May 2010.
[2] Evidence (2009) *International comparative performance of the UK research base*. Report to the Department for Business Innovation and Skills.

Economic and social impact

Research Councils UK (RCUK) has published case studies illustrating complementary economic and social impact and how it relates to the research it funds.[3] These case studies illustrated that impact can be generated in many ways, including:

- Licensing revenue generated by software funded as part of this research
- Establishment of new companies
- Indirect improvements to industrial processes arising from the research
- The generation of knowledge and intellectual property.
- Impact on public policy with potential for significant economic impact
- Training of new researchers

People

The most important output from the research base and the one with most pervasive impact is the stream of highly skilled people, trained in a knowledge rich environment and with the competency to apply and use their abilities in a diverse range of careers across the economy. Given the state of the world and UK economies, we are currently at the point in the economic cycle when nationally we should be investing heavily in research training.[4]

This is an often underplayed aspect of the HE research base but it is critical. The UK produces about 16,000 PhD graduates per year which is about 8% of the OECD total and (as noted above) relatively high compared to population size. It is sufficient to replace the permanent UK academic research workforce every three years (around 50,000 people are submitted to each Research Assessment Exercise (RAE)), so most PhDs will go out into the wider economy which is entirely appropriate and a huge national benefit.

No other part of the research base systematically trains people and no other organisation trains to this level. This is therefore a unique selling point for the HE research base and it is the one most evidently critical to the economy.[5]

The demand side is less clear. The Office for National Statistics (ONS) data in the Annual Survey of Hours and Earnings suggests that about 500,000 people are employed as science or engineering professionals but a rather smaller group of around 90,000 are employed as research professionals, although the numbers in social science and business research are unknown.

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[3] RCUK (2007) *Study on the economic impact of the Research Councils – Part II: Case studies* http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/economicimpact/ei2.pdf

[4] A headline conclusion from the recent Royal Society report, endorsed by OECD policy papers.

[5] See also Clancy, P. and Dill, DD. *The research mission of the university: an introduction*, in Patrick Clancy and David D Dill (eds) *The research mission of the university: Policy reforms and institutional response.* Rotterdam: Sense. pp. 3-17.

Explicit research or science employment is evidently satisfied by the supply of people. Salaries in science professions have not risen faster than other sectors, although that of the engineering profession has done. However, researcher salaries have generally risen ahead of the rest of the economy.

Research users

It is notable that elsewhere in the UK progress has not been made against the government's key objective to increase Business Expenditure on R&D (BERD) from 1.25 percent to 1.7 percent of GDP by 2014. In fact this value had fallen to 1.15% in 2007 on OECD data. Industrial investment in universities has also fallen as a proportion of total research grant and contract income.

We will refer to this in more detail later, but it is important to record the extent to which the research base has continued to deliver against targets but industry has not apparently responded as the ultimate research user. Investment in R&D has not generally increased in response to better UK research quality. Although industry does complain of workforce shortages, salaries for scientists have not had to be raised at exceptional levels. University complaints about commercial unwillingness to cover the full costs of research contracts continue.[6]

In the translation of research outcomes into economic benefits, we will show evidence that there is a history of weakness on the user side, whereas government policy has consistently focussed on assumed weaknesses on the HE supply side.

Why is UK university research so successful?

There may be a need to recognise and distinguish internal characteristics, purposeful external characteristics and serendipity that have contributed to the modern outcome. Not all these past characteristics will be a guide to the future; the conditions that made some of them adaptive have passed.

Time

The UK has two of the oldest universities in the world. The 'idea' of the university is well established and the status of the institution and its inhabitants has been substantial. It has attracted exceptional individuals, rewarded by both opportunity and acclaim. Society's willingness to support the institution and individuals' willingness to contribute to its success must be seen as a significant component in the outcome.

By the late 19th century the UK had not just a few ancient universities but a growing network of civic institutions supported by local economies. This expressed the confidence of industry and the boroughs that a university would contribute to their economy, through expert knowledge, innovative research and trained people. Durham's college in Newcastle upon Tyne included ship-building while Leeds College had colour chemistry, dyeing and textiles.

Social and cultural factors

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[6] Results of the Public and Corporate Economic Consultants / Centre for Business Research (PACEC/CBR) survey of academics 2008 reported in PACEC/CBR (2010) *The Intellectual Property Regime and its Implications for Knowledge Exchange.* A report to HEFCE by PACEC and the Centre for Business Research, University of Cambridge - http://www.pacec.co.uk/documents/IPFullReport.pdf

The UK has had a strong base in secondary education. It has been described as enjoying an enquiring habit, derived from a dissenting culture and a rejection of authority. Compared with its major European neighbours, it appears to be characterised by greater competitiveness and individualism – attributes that can equally be seen to contribute to a less positive approach to social cohesion.

Early policy approaches

The Haldane Committee's (1918) separation of the advancement of knowledge ('research for general use') from the administrative priorities of the departments that would be interested in its findings established a theme that was revived at regular intervals of the 'independence of science' (standing for research generally). It firmly established the ability of Research Councils to fund university research that did not have to meet a government requirement. This distinction, that good research should be curiosity driven not policy driven, was sacrosanct until Rothschild introduced the customer-contractor principle, that every piece of research should have a commissioning agent.

Global presence

This model of a university and the university system that developed in the UK was exported around the world, not just within the Empire but more widely. The Empire itself provided a set of international links that reinforced the cultural primacy of the UK as a higher education pinnacle. Excellent scholars were attracted and many stayed, to the UK's benefit. Links with Europe were less important, and the UK system took a different direction to its neighbours while they also lacked the infusion of global talent.

The old networks have been replaced by global electronic nets that make Berlin, Paris and Leiden as visible as Oxford and Cambridge. It is unclear whether the UK still obtains exceptional value from its history. Germany has a greater volume of collaborative publications with India. Even the UK's exceptional links with Australia are less important than they once were. It seems likely that Beijing, Fudan, the Indian Institutes of Technology and the National University of Singapore will become equally magnetic for Australian postgraduates and researchers.[7]

The growth of a European regional network may be required to balance emerging networks in Latin America and Asia-Pacific. Being an active and committed member of such a network may become obligatory to maintaining global presence.[8]

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[7] Adams J, King C and Singh V (2009). *Global Research report: India*. Thomson Reuters, London. ISBN 1 904431 21 6; Adams J, King C and Ma N (2009). *Global Research report: China*. Thomson Reuters, London. ISBN 1 904431 22 4; Adams J, King C and Webster B (2010). *Global Research report: Australia and New Zealand*. Thomson Reuters, London. ISBN 1 904431 24 0; unpublished reports to Research Councils UK offices in India and China.

[8] Unpublished analysis for BIS.

Do we need universities to do research?

Universities are in the knowledge business. They validate and hold knowledge, they create and transform knowledge, and they disseminate knowledge in publications and via skilled people. But they are not the only place that the public sector can buy research. They have been shown to be a fruitful source of sustained innovation,[9 10] however, and this makes a compelling argument for their primacy when combined with their people-development role.

Some national research systems are more dependent than the UK on institutes with stated missions, usually focussed on specific areas of economic or social impact. These therefore appear to be an attractive tool in the public sector armoury when such impact becomes a priority. If the expectations of both research funding bodies and of the public generally are that money should buy beneficial impacts for the wider economy and society, then an academic emphasis on discovery and curiosity-driven research looks vulnerable.

The Max Planck organisation in Germany and the Centre National de la Recherche Scientifique (CNRS) in France have long records of significant contributions to international research. However, both countries are changing the structure of their research bases and drawing such units alongside universities, so they are evidently no panacea.[11] The UK has also created and closed networks of institutes in the past. In the 1990s, the former Agricultural and Food Research Council (AFRC) found that research laboratories focussed on agricultural production were no longer serving an effective purpose. The network of industrial research and training organisations (the Association of Independent Research and Technology Organisations (AIRTOs)) has also changed to fit a new role away from traditional economic sectors.

It has been argued that there are more systematic and pervasive gains from university-based research systems. Lord May noted that those nations that had traditionally concentrated their research in universities generally produced a more competitive international performance.[12] A separate comparative study showed that HE-based UK, Australia and Canada achieved higher impact for their share of world publications across a diversity of research fields than did institute-based France, Germany and Japan.[13]

We first assessed the relative productivity of those countries which are the major contributors to global research volume, by major research sector (physical sciences, social sciences, etc) and specific research area (physics, physiology, politics, etc). We then analysed their research performance for the period 1988-1996, aggregating data across 47 subject areas corresponding to units of assessment (UoAs) used in the UK RAE and 13 research sectors corresponding to clusters of cognate UoAs.

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[9] Laursen K and Salter A (2005). *The fruits of intellectual production: economic and scientific specialisation among OECD countries.* Cambridge Journal of Economics, **29**: pp. 289-308.
[10] Salter A and Gann D (2003). *Sources of ideas for innovation in engineering design*. Research Policy **32**: pp. 1309-1324.
[11] Filliatreau G (2010, pers comm), OST Paris; news reports.
[12] May, R M (1997). *The scientific wealth of nations*. Science **275**: pp. 793-796.
[13] Adams, J (2000). Chapter in *Higher Education Re-formed*.

Two key impressions emerged. First, competitiveness in research tends to be a package: some nations perform well (USA, the UK) at both specific and general levels while others perform less well. The second impression is that some countries perform relatively evenly across areas, while others have more evident and characteristic core strengths. For example, while there is a widely recognised correlation between publications and citations, it is weaker for the UK than it is for other countries (correlation coefficient across 47 UoAs: England = 0.78, Germany = 0.93, USA = 0.94). In other words, the UK has a higher impact than expected in areas of low output relative to the rest of the world.

The outcomes of our study closely accorded with two studies carried out by May[14] [15] and there is a similar pattern of relative research effectiveness in relation to population and to total and civil research expenditure.[16] The bibliometric evidence does not therefore support the idea that the UK research system should be reconfigured. May[17] [18] argues that the significant differences in performance are a consequence of differences in institutional settings. Higher education, the normal host for basic research in the USA, England, Canada and Australia, appears to provide a better return on investment than does a dedicated research institute system. Managed research regimes can produce peaks of performance, but not the breadth of excellence.

University systems are self-managing, flexible and self-renewing. They determine their own priorities, tuned against the direction of public funds, and therefore escape the limitations of policy-set missions. As discoveries overtake objectives, so they continually reorientate. The constant turnover of research students and staff creates a vigour and continuous reanalysis. Because they compete through diverse and overlapping missions, institutions maintain a constant vigilance that would make external management an irrelevance.

Dainton [19] commented on von Humboldt's encouragement for dual appointments to the University of Berlin. These straddled industry and the university, forming an effective bridge for the two-way flow of ideas and the possibility of building mutual understanding. The difference in academic and industrial salaries and careers may make this untenable today, but project sharing in intermediate institutes is an alternative 'island' between knowledge producers and technology users.

The former Advisory Board for the Research Councils (ABRC) sent a group to Germany in 1991 to look at the function of the Fraunhofer Institutes with a view to developing policies for a comparable UK system (of Faraday Institutes). The ABRC's Fraunhofer study led to the establishment of Postgraduate Training Partnerships (PTPs) where academia and industry came together in the common ground of an industrial training organisation jointly to supervise a portfolio of postgraduate research projects.

More recently, the idea of a system of UK institutes akin to the Fraunhofer has again been revived. The core recommendation made by Hauser in his 2010 report is the establishment of analogous

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[14] May, R.M. (1997). *The scientific wealth of nations*. Science **275**: pp. 793-796.
[15] May, R.M. (1998). *The scientific investments of nations*, Science, **281**: pp. 49-51.
[16] Office of Science and Technology. 1997. *The quality of the UK science base*. A report of the Department of Trade and Industry, p27.
[17] May, R.M. (1997) op. cit.
[18] May, R.M. (1998) op. cit.
[19] Dainton, F. (1991). Are some science policy issues inevitable, irresolvable and permanent? pp. 47-68 in, *The Management of Science*, ed. D. C. Hague. London, Macmillan.

Technology and Innovation Centres (TICs). The purpose of these will be to "exploit the most promising new technologies, where there is genuine UK potential to gain competitive advantage".[20] The UK Government subsequently stated in the 2010 budget that this recommendation would be taken forward.[21] Hauser argues that although the UK is second only to the USA in scientific capability it is relatively poor at translating this into commercial propositions, and the TICs will bridge the gap between research findings and commercialisation by making technologies "investment ready".

The problem with intermediate institutes is two-fold; they are not performing cutting-edge research and, as an island, they require bridges both to the universities and to industry. They could, however, provide a location for facilities too expensive for any one university but of value also to industrial research partners. They would require significant investment, which could only be found at cost to the science budget.

However, history suggests that a major problem in the medium to longer term would be the lack of vitality and renewal that characterises the higher education research environment. Universities should therefore collaborate in owning any intermediate 'knowledge transfer' institutions established by government and should do so as partners with regional industrial consortia. This would provide the new institutions with direct access to the partner organisations and their knowledge and facilities, as well as enabling the universities to access the institutes. It would be a common ground with industry and a more attractive working environment because of its links. Mutual ownership would reduce threats and distance and joint management would foster collaboration, strategy and exchange. Strategies for enabling postgraduate researchers to work for extended periods in such institutes might also provide a source of the vitality required to enable them to refresh their mission.

[20] Hauser, H. (2010) *The Current and Future Role of Technology and Innovation Centres in the UK.* A report to Secretary of State Department for Business Innovation & Skills.
[21] HM Treasury (2010) Budget 2010: *Securing the recovery.*

Universities and their public and private sector partners

A policy agenda emphasising the economic and social objectives of research impact has become more overt.[22] The indicators relevant to these objectives remain unclear and are probably more variable across disciplines than academic impact indicators. Universities might want to take over and reconfigure this agenda, rather than having it forced on them with inappropriate expectations and targets. There would need to be commitment at institutional and disciplinary level for this to be effective. By seizing the initiative, the sector would demonstrate both commitment to economic innovation and competence in properly analysing and solving societal challenges.

Introduction

Over the last twenty years there has been a progressive shift in the performance regime applied to UK universities. Policy instruments have increasingly set the notion of the 'impact' of research in the context not only of academic impact judged by peers but of economic and social impact. The development of policy around the 1993 White Paper 'Realising Our Potential' was about wealth creation and the quality of life,[23] but this had limited direct effects on the 1992 or 1996 Research Assessment Exercises. In 2010, the reform of the RAE and its reshaping into the Research Excellence Framework (REF) has made these distinct aspects of research impact more clear.[24,25]

The justification is that research, as a publicly funded activity, should not only be good but also should be demonstrably useful. It should provide a return on investment through 'quality of life' in public policy, or health, or environmental quality. Or it should provide a return on investment through 'wealth creation' by underpinning new products and processes that make the economy more competitive.

Many researchers challenge this notion. That is probably unhelpful at a time when resources can quite legitimately, however erroneously, be withdrawn. It would be more constructive if universities sought to own this agenda rather than allow it to be imposed naively. In doing so they should also examine with extreme scepticism some of the philosophy behind government's assumptions about the relationship between the research base and the researcher user.

Does industry buy the knowledge product?

In the 1990s universities responded to pressure from government to increase their efforts to transfer knowledge into the economy through the development of commercial offices and the creation of spin-off companies. This had overt 'impact'[26] but it is difficult to translate the notion suggested by the Royal Society[27] about 'fledgling economic powerhouses' into something with management meaning in many universities. Regional Development Agencies (RDAs) certainly

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[22] Government policy statements regarding the structure of the Research Excellence Framework.
[23] The Chancellor of the Duchy of Lancaster, *Realising our Potential*. 1993.
[24] HEFCE (2009) Research Excellence Framework: Second consultation on the assessment and funding of research.
[25] HEFCE (2010) Research Excellence Framework consultation outcomes, Circular letter number 04/2010.
[26] Patents granted to UK universities increased by 136% between 2000 and 2008, while university spin-outs employed 14,000 people in 2007/08 and had a turnover of £1.1 Bn.
[27] Royal Society (2010) *The Scientific Century* - http://royalsociety.org/The-scientific-century.

support universities within their regions because they see them as a route to economic and social regeneration.[28]

Industrial engagement has, however, been a mixed domain.[29] A route for knowledge transfer opens when industry chooses to out-source research contracts and consultancies to academia. While this is worth about £300 million per year in the UK (see Figure below), it is not evenly spread across subject areas. This problem was obvious in the 1990s engineering sector.[30] The construction industry (with a £58bn output in 1998 and employing 1.4 million people) was reviewed by Sir John Egan's Construction Task Force, which noted that sector investment in R&D had fallen by 80% since 1980 and training halved over 25 years. Industry lacked the capacity for innovation in processes and academic civil engineering had become one of the weaker areas in the UK research base.[31]

The pharmaceutical sector provides a contrast, with a vibrant industrial research culture mirrored by a high performing part of the UK research base.[32] There is investment of industrial R&D in higher education based research and training through contracts and studentships which supports extensive dialogue. The sector is also marked by industrial research publication[33] which is often more highly cited than UK academic publications in the same disciplinary area.[34] Also, HEFCE's 2010 Higher Education-Business Community Interaction (HE-BCI) survey shows that UK universities received £2.96 billion from business and community interaction in 2008-09 – a 5.5 per cent rise on the previous year.[35]

OECD data show that expenditure on R&D in the business sector has been around 1% of UK GDP, while in Germany it has been closer to 1.5% and has been similarly higher than the UK index in other comparator countries. BERD in the UK has actually fallen since 1981, as a share of GDP, while the quality of the research has improved: better products, fewer customers is a strange response![36]

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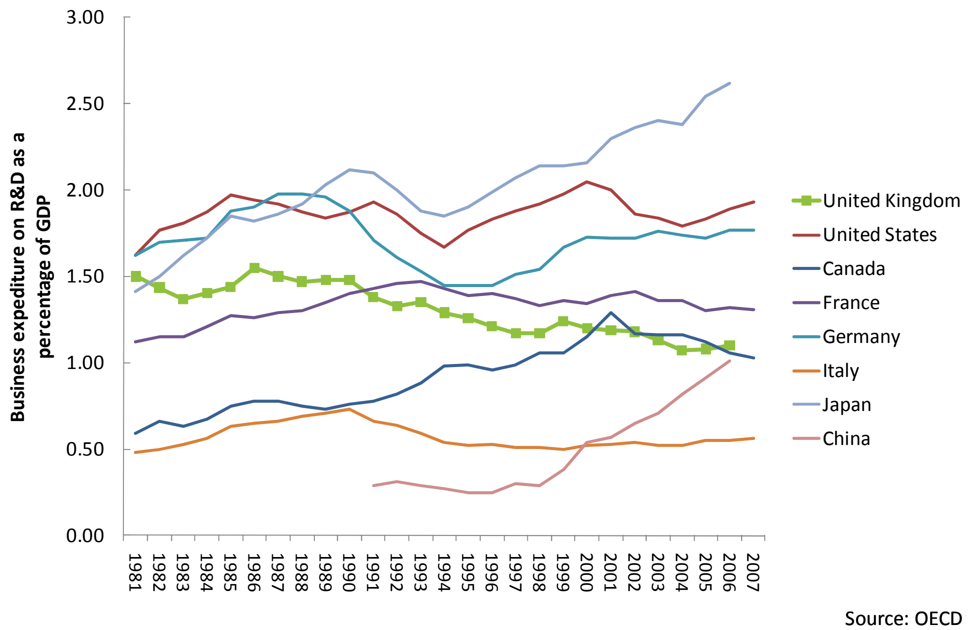
[28] See extensive work by Prof J Goddard and the CURDS group at Newcastle University.
[29] Adams J and Smith D (2004). *Research and regions: an overview of the distribution of research in UK regions, regional research capacity and links.* Report to the Higher Education Policy Institute, Oxford, p12.
[30] DETR. (1998). *Rethinking Construction*: report of the construction Task Force on the scope for improving the quality and efficiency of UK construction (The Egan Report).
[31] Adams, J., Bailey, T., Jackson, L., Scott, P., Pendlebury, D. and Small, H. (1998). *Benchmarking of the International Standing of Research in England: a consultancy study on bibliometric analysis*. University of Leeds, Centre for Policy Studies in Education.
[32] Adams, J. (1998). International benchmarking of research. *Nature*, **396**: pp. 615-618.
[33] Hicks, D. and Katz, J.S. (1997). *The changing shape of British industrial research*, STEEP Special Report No 6. University of Sussex, SPRU.
[34] Adams, J., Bailey, T., Jackson, L., Scott, P., Pendlebury, D. and Small, H. (1998). *Benchmarking of the International Standing of Research in England: a consultancy study on bibliometric analysis*. University of Leeds, Centre for Policy Studies in Education.
[35] HEFCE (2010) Higher Education – Business and Community Interaction Survey 2008/09 http://www.hefce.ac.uk/pubs/hefce/2010/10_14/10_14.pdf
[36] Adams J and Smith D (2004) op. cit.

Figure 1. Business Expenditure on R&D (BERD) as a percentage of Gross Domestic Product (GDP) for G7 countries plus China between 1981 and 2007.

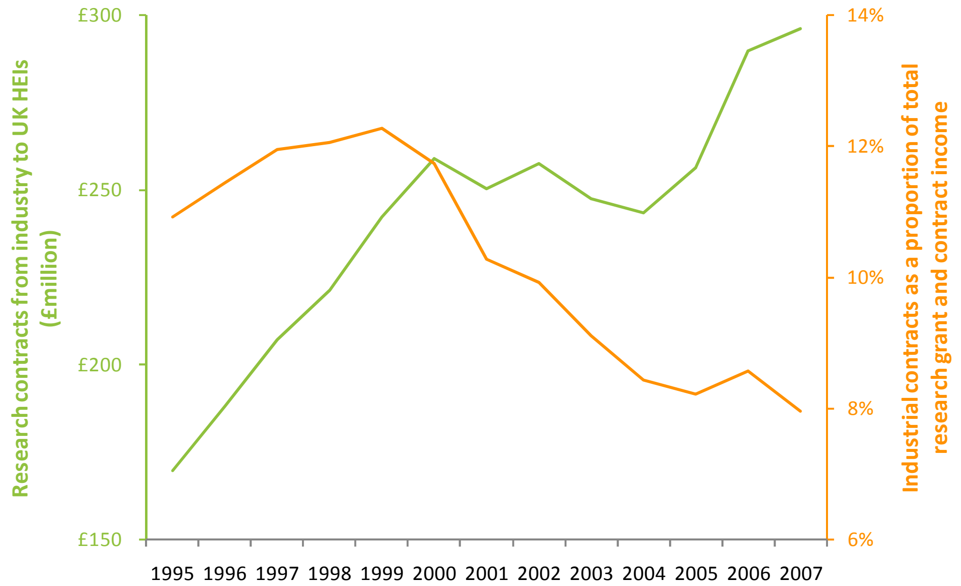


Exceptions to the general trend in the UK have been largely in the pharmaceutical and bioscience sector, as noted above, and it is just these areas where the UK university research base is now stronger than the USA.[37] That is not a coincidence. The commercial sector understands the need for cutting edge knowledge and for feedback to the researchers. It also offers worthwhile career opportunities to researchers and to a wide range of people with research competency. A further exception, that proves the rule, is Rolls Royce which stands out in advanced engineering for its research capacity, liaison with universities and career development pathways.

Not only gross statistics on BERD but our own data show the extent to which private sector R&D has fallen relative to the activity of the research base. Overall, though there has been a cash rise in industrial research contracts for UK universities, this has not risen as markedly as overall research grant and contract income. It has fallen as a percentage of national BERD, and BERD itself has fallen – not risen – during a period when government investment in the research base rose.

[37] *Evidence* (2009). Annual report to BIS: International comparative performance of the UK research base.

Figure 2. Contract research from UK industry to the UK higher education research base, as cash and as share of total research grants and contracts. BE-HERD (R&D in HE funded by business) fell from just over 2% of BERD to around 1.8% over the period shown.



Source: HESA

It is possible that university researchers fail to present research in a way which highlights its relevance to potential research users and the (reasonable) focus by academics on peer reviewed journals compounds the problem. The other side of this is that too often those in industry, in the NHS, or in other public sector agencies fail to articulate what they really need from university research. In many cases they may not even have a conception of what that need might be.[38]

To meet the legitimate expectations of wider society the university research community will need (to an extent) to compromise its preferred agenda and critically review its underlying culture and prejudices. Public and private sector partners need a stake in setting research agendas, but not a controlling influence. The goal should be 'mutual confidence' about what both sides bring to the table. The challenge is to identify innovative ways in which academic, commercial and social interests can be brought together.

It is essential that the higher education sector properly explains to government that knowledge transfer is a dialogue and that policy which addresses only the research base misses the research user. Summarising the views of observers on Victorian industry, Varcoe (1974) notes that '… there were few applied scientists working in British industry, many were poorly paid and were not used in ways which drew upon their scientific knowledge'. These policy issues remain problematic 125 years later. The effective transfer of knowledge, the utilisation of research, depends on the user as much as the producer.

[38] Lambert, R. (2003) Lambert Review of Business-University Collaboration. HM Treasury.

What does government want?

Funding may be diversifying but most money for most universities comes from public sources (see Figure 11). The future of research must therefore depend on what the government, as the proxy customer for both the public social and the public economic good, is prepared to pay for.

Historically, investing in university research has been an act of faith.

Up until 1970 "successive [British] governments believed that there was a necessary connection between science and growing national wealth".[39] Allan Bromley, the former US Presidential Science Adviser, commented that "since the war years, both Congress and the different administrations have shared the conviction that support of research in the nation's universities … represented an investment in the national future".[40]

The 1993 White Paper "Realising our potential" had the premise that the "understanding and application of science are fundamental to the fortunes of modern nations".[41] It saw the benefits of research as economic, coming from commercial exploitation, and social, through the tools provided for solving and dealing with the problems that face humankind (e.g. poverty and disease).

The Science & Innovation Investment Framework 2004-2014[42] sets out explicit ambitions for *inter alia* greater responsiveness of the publicly-funded research base to the needs of the economy and public services, increased business investment in R&D and engagement in the science base, confidence across society in research and its innovative applications.

In 2006, the Warry Report[43] made recommendations to the Research Councils on increasing economic impact through leadership of the knowledge transfer agenda and engagement with users, which led the Research Councils to make economic impact a key driver.[44] [45]

In its 2009 White Paper "Higher Ambitions",[46] the Department for Business Innovation and Skills established incentives for the economic and social impact of research and positioned the Research Excellence Framework to "explicitly assess the impact of past research on the economy and society".

These drivers all link to the notions of economic growth and quality of life and are interdependent. The ultimate goal of research is set as economic and social impact, ultimately via people who create impact.

The House of Commons Innovation, Universities, Science and Skills Select Committee concluded in a report of 23 July 2009[47] that while Government should set the over-arching strategic direction, the Haldane Principle (the idea that research funding decisions should be separate from departmental policy) should still be the guiding principle. This highlights a broader dichotomy in the nature of

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[39] Wilkie, T. (1991). *British science and politics since 1945*. Oxford, Blackwell.
[40] Clinton, W. J. and Gore, A. (1994). *Science in the National Interest*. Executive Office of the President, Office of Science and Technology Policy.
[41] The Chancellor of the Duchy of Lancaster, *Realising our Potential*. 1993.
[42] HM Government, *Science & innovation investment framework 2004-2014*. 2004.
[43] Warry, P., *Increasing the economic impact of Research Councils*. 2006.
[44] Research Councils UK, *Increasing the Economic Impact of the Research Councils*. 2007.
[45] Research Councils UK, *Excellence with Impact.* 2007.
[46] The Department for Business Innovation and Skills, *Higher Ambitions*. 2009: London.
[47] House of Commons Innovation, Universities, Science and Skills Select Committee, *Putting Science and Engineering at the Heart of Government Policy*. 2009.

research funding: government wants to influence the university research agenda because of its effect on the economy, while needing research to be less reliant on government for funding.

Research as an economic solution

Current policy dilemmas have a deeper history. This is not a historical review but it is worth establishing the extent to which there has been a repeated cycle of expectation and disappointment because of underlying misconceptions about the environment for research impact.

First, in further support of the evidence given earlier about recent success, it is worth noting the historical record on university contributions to the economy and the long engagement between universities and local industries stretching back into the nineteenth century:

'The contributions of the civic universities to industry … were … remarkable and of considerable importance. They were now becoming a leading source of innovation for industry as Oxford and Cambridge never hitherto had been. The thrust bearing lubrication, colliery pumps, vanadium steels, chrome leather, gas fires, spark plugs, and radio tuning all owed much to the work of their professors while products like cheese, soap, beer, and quadruple expansion engine were considerably improved by their work'.[48]

The majority of universities in the UK were in fact established to fulfil economic functions.[49] Not only were the universities historically the great training grounds for the professions, but already by the 1950s industry was increasingly turning to arts graduates to solve a growing shortage of technologists.[50]

Second, government repeatedly returns to an argument about the need to make university research more business-like, rather than making business more research orientated. The 2003 Lambert report on business-university collaboration[51] was a relatively recent piece of policy thinking which exemplifies this. Lambert recognised the need to continue funding world-class research but argued the need to channel funds through RDAs to those able to demonstrate 'strong demand from business for their research activities'.[52] He claimed the importance of proximity in developing business–university collaboration and recommended regional funding to retain research capacity where business needed it, ignoring evidence elsewhere in the system. Pharmaceutical companies collaborate with HEIs irrespective of location.[53] More generally, and contrary to the rather pessimistic tone of the reports mentioned, a previous study had emphasised the 'spectacular growth in recent years across the United Kingdom in the scale, number and variety of linkages between higher education and industry' and 'industry's growing involvement as an interactive user of all types of teaching and training'.[54]

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[48] Sanderson, M. *The Universities and British Industry* 1850-1970. (1972).
[49] Bond, R. and Paterson, L. Coming down from the ivory tower? Academics' civic and economic engagement with the community. *Oxford Review of Education*, 31, 3, September 2005: pp. 331-351.
[50] Sanderson, op.cit.
[51] http://www.hm-treasury.gov.uk/lambert_review_business_university_collab.htm
[52] Lambert Review, op. cit., Executive Summary 6.
[53] Adams J and Smith, D N (2003). *Research and regions*: an overview of the distribution of research in UK regions, regional research capacity and links. HEPI report no 9. Higher Education Policy Institute, Oxford.
[54] Howells, J., Nedeva, M. and Georghiou, L. *Industry-Academic Links in the UK*. December 1998 HEFCE ref 98/70 (With assistance from Janet Evans and Susan Hinder) PREST: University of Manchester.

This is partly a problem of long-term and historical misunderstanding in the UK of the often hidden nature of the relationship between universities and their stakeholders. In summary:

- Government is unsure what it really wants and therefore links uncertain objectives to uncertain indicators.

- Research links uncertainly from discovery to application, via a route that is often entangled and usually very long.

- Although it is difficult to trace public funds through to economic growth, government makes vague investment for quick results. They don't know what they want but they want it now.

The Trend Committee, reporting to the Treasury in 1963, criticised the failure [in the 1950s] of the Advisory Committee for the Department of Scientific and Industrial Research (DSIR) to 'guide the path of development of research in sectors of the British industry of importance to the economy as a whole'. Lord Dainton has recounted further government misconceptions.[55] In the 1960s, the Wilson government saw universities as the powerhouse of the white-heat of the technological revolution needed to recreate stagnant industry that had long lost its competitive edge. It backed research with massive public investment. In the 1970s, the economy remained resolutely on a downward spiral. Blame was laid at the door of the researchers who had taken the bait and over-committed their institutions. Government concluded that, if the economy was still in trouble, then it was because the researchers had not delivered the solution.

In the late 1980s, after some retrenchment, the sector grew on the back of the new research assessment process. By the mid-1990s, the emphasis of the Department of Trade and Industry (DTI) was on the failure of universities to communicate their discoveries to industry and the need for new commercial offices, spin-out and venture companies. In the late 1990s, the Blair government invested heavily in the research base as a knowledge-based solution to social and economic change. In 2010, a new economic crisis forces a further review, constraint and likely new retrenchment with the delivery of impact as a key priority alongside curiosity-driven research.

From a distance it is obvious that the common problem was that the private sector of late 20th century Britain was largely incapable of picking up anything that research might have offered. But there was a problem also in the assumption that research would readily produce rapid and specific innovative outcomes – and that those outcomes would be relevant to the existing industries.

Knowledge transfer: how do we mobilise the return on investment?

The industrial history suggests that a successful outcome to effective knowledge transfer is not solely about reconfiguring the higher education research system. If government is to realise the benefits of investment in research, then attention has to be paid not only to supply-side output and delivery but to the demand-side and the relatively weak levels of R&D investment, knowledge capacity and research-based career opportunities outside specific sectors and companies.

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[55] Dainton, F. (1991). Are some science policy issues inevitable, irresolvable and permanent? pp. 47-68 in, *The Management of Science*, ed. D. C. Hague. London, Macmillan.

The impact and utility of publications is measured by their influence on subsequent work, reflected in citation counts.[56] Such bibliometric indices are only a proxy for 'real' information and reflect only one aspect of the utility of research. Citation counts are less informative for applied research and meaningless in the arts, and the shift in the production of knowledge means that this measure has even less utility as more publications circulate in forms that are not amenable to primary impact measures. One of the reasons why there is a shift to this different, or 'Mode 2'[57], knowledge production is that traditional academic publication is an inefficient way of transferring information.

People make a more efficient channel for knowledge and technology transfer than pieces of paper. For much of UK industry, the individuals trained under the Research Councils' Masters and Doctoral schemes are at least as valuable as any combination of publications because people carry with them not only know-ledge but know-how. The utility of this output is its employability: on average about one half of Research Council funded MSc graduates and about one third of PhDs go into industry. A similar number of PhDs go into academic appointments.[58] [59]

We discuss the issue of people and the workforce elsewhere. Here, we should note that ONS data indicate that, despite industrial complaints about a lack of qualified people, salaries for scientific and research professionals have not been raised at a rate much higher than the workforce as a whole. [60]

Deconstructing impact

The evidence above suggests that industry, with notable exceptions, has a long-term problem in its capacity to make use of innovative knowledge, has not sought to attract more research-skilled staff with better salaries and has not met government objectives to raise the level of R&D. Evidence presented later in this document suggests that the research base has responded to public investment through improved research quality and the production of greater numbers of skilled and competent people who have grown up in that research-rich environment.[61]

Combining these sources of evidence might lead to the conclusion that there is a weak public understanding of how research does impact beyond academia and that both connectivity and speed are over-constructed. Government has nonetheless positioned economic and social impact as a key performance indicator for higher education research. A suitable response for the university research base would be to take over the argument and reconfigure the specific objectives in a way that makes sense for the research base while responding to the broader objectives which public policy has set.

First, the relationship between the research process and its application needs to be spelt out in a more effective way. This will be a frustrating experience for the many academic and policy

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[56] Adams, J., Bailey, T., Jackson, L., Scott, P., Pendlebury, D. and Small, H. (1998). *Benchmarking of the International Standing of Research in England: a consultancy study on bibliometric analysis*. University of Leeds, Centre for Policy Studies in Education.

[57] Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994). *The new production of knowledge*. London, Sage Publications.

[58] Office of Science and Technology. 1998. *Science, Engineering and Technology statistics, 1998*. A report of the Department of Trade and Industry, Cmnd 4006.

[59] Royal Society, 2010. *The Scientific Century – securing our future prosperity* - http://royalsociety.org/the-scientific-century/

[60] Office of National Statistics, *Annual Survey of Hours and Earnings* - http://www.statistics.gov.uk/statbase/product.asp?vlnk=13101

[61] Evidence: various reports and presentations to BIS and Universities UK.

researchers who have explored this and can provide much detailed analysis. But it is apparent that a sufficiently clear and structured picture has not yet been accepted at the highest levels. Until government policy has secure foundations based on the reality of what is achievable, there will be further deviation between intention and outcome. It should be said at the same time that university leaders should be equally well briefed and avoid being drawn into compacts which their institutions cannot sensibly fulfil.

Second, the range of possible indicators of economic and social impact needs to be much more imaginatively explored. That cannot be done within government agencies but needs to be done where the research is taking place so that there is a coherent linkage between evolving indicators and the activity to be indexed. The outcome of the current pilot exercise[62] being managed by HEFCE may be revealing but it is quite possible that it will not be sufficiently comprehensive and will lack widespread acceptance. The variation and diversity of indicators across discipline areas needs to be appreciated and scoped. What works in science, social science and arts is obviously going to differ because of the nature of the research, the range of typical outputs and outcomes and the contrasting target sectors. There may be very little read-across between some areas.

It should also be recognised that the spread and diversity of economic and social impact across the university research base will remain unclear until a valid and accepted set of indicators is in place. Is the map likely to be completely coincident with that of academic impact or is it different in distribution? If it differs, why?

Third, the assessment and evaluation of impact needs to relate not only to the effort and engagement of the research base but also the research user. It is fairly pointless ending up with indicators of a dead-cat bounce because the target is unresponsive. It is a legitimate part of the university response that it should draw attention to the need to have a competent and willing partner to which knowledge can be usefully transferred. Government effort should therefore be directed towards addressing deficits on the user side to balance effort on the supply side.

Fourth, once new and better indicators developed by the academic research community are available, individual universities should provide regular information to a common standard which reflects their work and indicates their engagement with the government's agenda and demonstrates to the public their commitment to this part of their mission.

Universities in the UK and partners overseas

The UK has a long history as a global leader, particularly in higher education and in research. That has made it an attractive destination for early-career researchers from many countries, some of whom have stayed in the UK. The UK system has been emulated in many places, reinforcing the positive image. However, the emergence of new economic centres has changed the balance of knowledge-based activity at the same time as access to, and flows of, knowledge have altered. The future seems likely to offer an environment in which there will be multiple regional research networks with less particular engagement with the UK. The UK needs to prepare for this now and that means changes in attitudes and culture as well as more practical approaches to partnership.

[62] HEFCE Research Excellence Framework impact pilot exercise to develop the methodology for assessing the impact of research (launched autumn 2009) - http://www.hefce.ac.uk/research/ref/impact/

Introduction

UK universities have evolved in an environment where their major concerns about comparison and competition were national. That is no longer the case, because globalisation has made huge differences to higher education, the way it is managed and the way it is perceived by stakeholders. Leading universities compare themselves with peer institutions in other countries, not their national neighbours. Students and staff are recruited globally, and can find out about alternative providers very quickly through the Internet. A key element for many of them will be the research achievements and profile of the target institution. Research performance has become part of the institutional brand, and the brand is global.

Industrial customers for research also buy globally. GlaxoSmithKline (GSK) has major research facilities in the area around London and collaborations with universities all over the UK. It also has a network of substantial collaboration from Stevenage and other UK sites with Europe, Australia, Japan and North America. The institutions it works with can be seen on other indicators to be world-leading in their specialisations.

Knowledge flows very quickly. The rate of exchange of ideas now would have been inconceivable even twenty years ago, well within most researchers' career span. There is no longer any need to attend a conference to find out what colleagues are doing. And with that speed of exchange there is a down-side which creates a loss of independent cultural advance because ideas and results move so quickly there is less 'space' for alternative possibilities to blossom in isolation. That leads in the policy arena to the problem of consensus over contention. Within the UK we have noted the gross similarities between regional R&D policies, but this is replicated globally. Every country is investing in biotechnology, innovative materials, ICT and climate change. That works well for the support of grand challenges but may be less conducive to a flourishing market in fundamental science.

Investment in a time of constraint

The OECD has pointed out that the countries that will emerge strongest from a period of financial constraint and recession are those that are best prepared to exploit new knowledge opportunities. Sustained investment in education and research should be a central part of national packages to boost the economy and provide the human resources that will enable future development to happen. The table below places the UK's current plans in the context of investment announced by other countries.

Table 1. Recently announced changes to R&D budgets as part of economic stimulus measures

Country	Changes in spending
Australia	$580 million fast-tracked into universities
Austria	€120m allocated for university infrastructure, €100m for R&D
Canada	$6 billion dollars for R&D – including funding to expand graduate student programmes
China	$860m R&D investment for Chinese companies
France	€730m boost for HE and research, more generous R&D tax credits
Germany	€500m for transport research, €900m for collaborative R&D in SMEs
Spain	2009 budget for R&D increasing 6.7% plus €500m for specific initiatives
UK	£25 million capital fund to commercialize research, £270 million university modernization fund – including funding for 20,000 additional student places
USA	$21bn increase in R&D on top of a doubling in basic science spend between 2006 and 2016

On these figures, the UK is not in a leading position. The risk must be that it will emerge from recession in what it considers to be a good position only to find that others have already moved ahead.

Compare with what?

Comparisons are useful if they identify where the UK is relatively weak, because this suggests a deficiency or inefficiency that may be remedied by appropriate management change. Where the UK is relatively strong there may be self-congratulation without consideration of how this is achieved or whether more could be delivered. Furthermore, analysis across multiple indicators frequently reveals a complex picture where gains and losses are traded in a net outcome where balance may be the over-riding consideration.

Traditionally, international analysis compares the UK with G7/G8 but this is no longer always a particularly informative grouping, and the emergence of new groups such as the G8+5 (which also includes Brazil, China, India, Mexico, and South Africa) has emphasised the fluidity of international alliances for different policy purposes. Italy has had serious problems for some time, Russia is also in a different place with a large but incoherent economy that has undermined its research legacy, and Japan has huge economic challenges. Canada is much smaller than UK and its G8 role is historical, although it bears comparison on a similar university system. The USA is much larger and is an interesting reference point rather than a competitor.

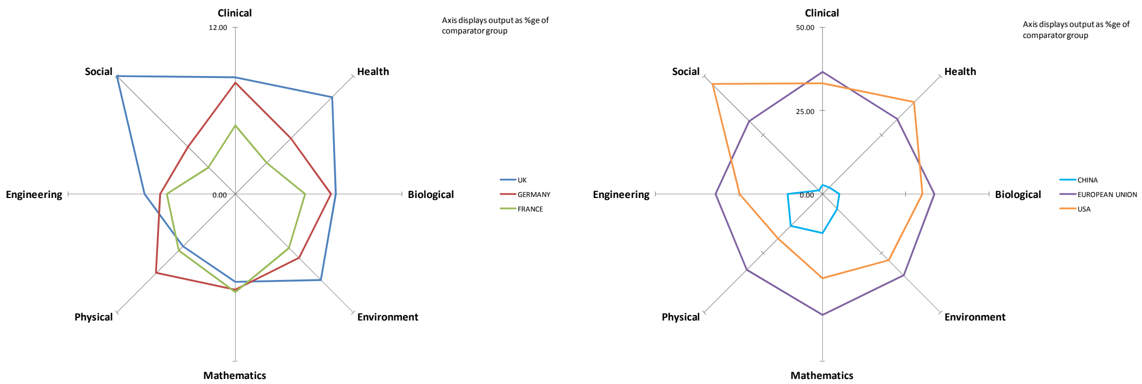
What the G8 does not comprise, because it is a historical reference, includes the most dynamic part of the global research base such as China, India and Brazil. Other countries, such as Iran and Egypt, are also emerging as potentially major research contributors with a pivotal role in their region but they are barely on the UK research radar.

In contemporary analysis, the more useful grouping places the UK within its region and the UK within the global economy. The definition of region is important. UK within EU makes some sense because of EU policy but, for functional purposes, the UK might better be thought of in Western or West/Central Europe. This would exclude the former Soviet Union (FSU) nations but include

Switzerland and Norway. That grouping makes more sense in terms of appropriate comparators and frequent collaborators.

The UK has a skewed research portfolio compared to France and Germany, its major collaborators in Europe. However, the combined EU portfolio is noticeably balanced when compared to the USA and suggests an emergent property that may contribute greater net competitiveness than any one European country.

Figure 3. The Research Footprint® of leading European research nations reveals complementary shares of world output for the UK, France and Germany. This results in a more balanced Research Footprint® for the EU compared to the USA.



In these diagrams the share of world output is shown for each entity, with the major EU countries on the left scaled to their national size and the global comparators on the right scaled to their larger size. Note how similar the balance of UK activity is to the USA, and how the net EU outcome provides a strong share of outputs across all research areas.

Compete or collaborate?

Policy analysis tends to position the UK in a competitive relationship with other nations, but this is not necessarily helpful. The concept may refer back to trading and markets, but in research the competition works to spur individual achievement rather than to capture knowledge domains. Indicators of 'who is winning' are of limited value unless they lead to other knowledge or insights about research process and management.

Previous analyses have made clear the infeasibility of surviving parasitically on knowledge developed by others.[63 64] To be aware of, and sometimes anticipate, critical innovation it is necessary to have a sufficient domestic technical competency. To be able to exploit such innovation that technical competency must be advanced. It is therefore necessary 'to be a player, to be in the game'. The classic example is of the SE Asian 'tiger' economies which, more rapidly than Europe appreciated, developed their own R&D base to match and then surpass technology originally lifted from European and American manufacturers.

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[63] Tilton, J.H (1971). International diffusion of Technology: The case of Semiconductors. Washington D.C.: Brookings Institution.
[64] Cohen, W.M. and Levinthal, D.A. (1989). Innovation and Learning: Two faces of R&D. Economics Journal **99**: pp. 569-596.

The UK is in a network of knowledge generation, acquisition and exchange. The cost of progress in research is enormous and the UK cannot conceivably achieve its ambitions on its own, so it must necessarily engage with researchers in other countries. It is in practice dependent on the research investments of other countries, directly through collaboration or indirectly through access to new knowledge, to progress. It needs to be successful not to 'beat' other nations but to be seen as a serious player and a worthwhile partner.

Collaboration materialises within a complex and sometimes uneasy relationship with competition. This relationship was recognised in the Government's 1998 White Paper *Our Competitive Future: Building the Knowledge Driven Economy* which acknowledged competition as the 'sharpest spur' to better productivity and rewards. At the same time it was observed that 'To compete more effectively we have to collaborate more intelligently', a comment that was also applied to partnership between academia and business.[65]

Evidence from subsequent studies of collaboration emphasises the sometimes delicate balance between different conceptions of the competitive-collaborative continuum. Being successful in research requires not just competitive edge but a capacity to work in partnership with other researchers. Hence the subject of collaboration has become a central consideration in any discussion of the changing dynamics of the HE research base including its policy, funding and institutional dimensions.

The assumption is that collaboration can foster closer connections between universities, business and industry, commerce, government and the public services. Specific drivers include the growth and complexity of the knowledge economy, the need to link the HE research base more closely with wealth creation and social development, a shift towards more applied knowledge creation in collaboration with research users, greater concentration of research activity and facilities and the growth of more directed models of research funding.[66]

In a previous review of research collaboration for the HEFCE Fundamental Review of Research in 1999-2000[67] it was noted that the benefits of collaboration had been widely signalled. Outputs of journal papers confirmed that collaboration had become 'the rule not the exception' in the research base. Of UK research papers published during 1994 no less than 88 per cent involved two or more authors and 55 per cent involved two or more institutions.[68]

Recent data, shown in the following figure, indicate that UK research is increasingly collaborative both domestically and internationally and that this trend shows little or no sign of abating. The number of domestically collaborative research papers (i.e. co-authored by at least two UK authors at different institutions) has increased by 21% between 1999 and 2009, while the number of UK research papers with at least one international collaborative author has increased by 61% over the same period. There have also been substantive increases in the number of papers with at least two authors and of papers with at least two authors at different institutions.

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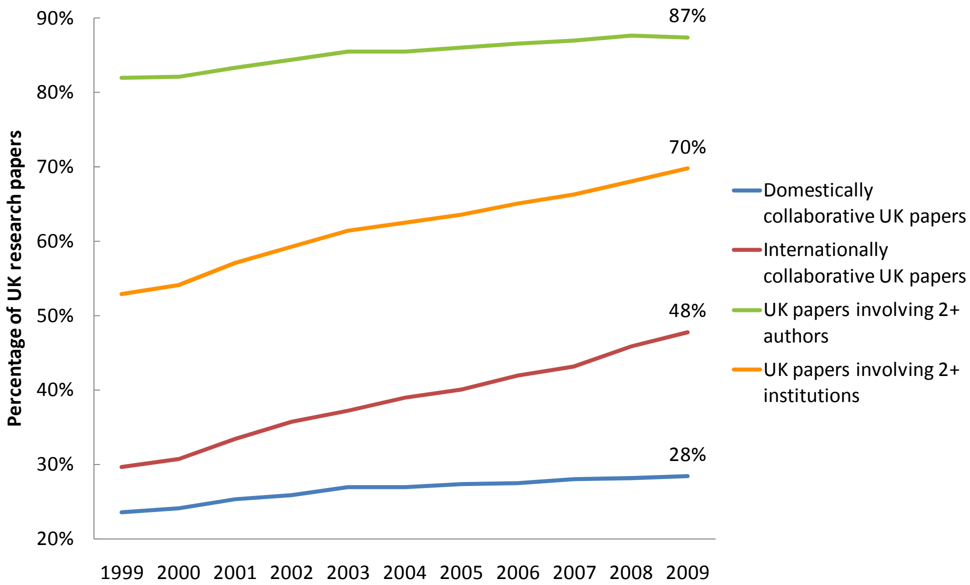
[65] HM Government (1998) *Our Competitive Future*: building the knowledge driven economy p7.
[66] Ibid. p11.
[67] Smith and Katz *Collaborative Approaches to Research*: Report to the HEFCE. A consultancy study within the Fundamental Review of Research Policy and Funding. HEFCE November 2000.
[68] Ibid.

Figure 4. Graph showing bibliometric indicators of collaboration – this indicates that the scale of collaboration both domestic and international has increased between 1999 and 2009.



Data & Analysis: *Evidence*, Thomson Reuters

Other analyses of publication indicators provided evidence that the largest HEIs collaborated most with industry,[69] but that others were increasing their industrial collaborations more rapidly. Collaborations across industrial sectors also revealed particular patterns and trends, but confirmed that 'in almost every sector collaborative publications outnumber non-collaborative, confirming that collaborative research is increasingly important in every type of industry.'[70] It was also asserted that HEI based researchers are 'by far the favoured partners of industrial researchers.'[71]

Concepts of collaboration and their applications

The production of collaborative papers provides a set of multiple indicators of the informal networks through which knowledge and information are passed. Although these indicators chart the rise of collaboration as a core feature of research and the informal networks through which knowledge and information flow, they do not in themselves indicate the conceptual and functional differences between alternative forms of collaboration.

Research collaboration is partly a matter of social convention among scientists.[72] The problem is that it is difficult to establish where less formal links between researchers end and more formal collaboration begins. Collaboration may be defined as 'working with someone else for a special purpose'[73]; it does not necessarily capture the range of formal to informal relationships and partnerships which characterise the research process. Collaboration occurs at several levels and for

[69] Higher Education Policy Unit, University of Leeds (2000) *The Role of Selectivity and the Characteristics of Excellence.*
[70] Hicks, D. And Katz, J. S. *The Changing Shape of British Industrial Research*. STEEP Special Report No 6, SPRU, March 1997: p81.
[71] Ibid.
[72] Ibid.
[73] Scottish Universities Research Policy Consortium (1997) *Interdisciplinary Research: process, structures and evaluation*, Scottish Higher Education Funding Council p7.

different purposes and can include individual researchers, groups, departments, institutions, sectors, regions and countries.

Policy analysis has tended to conflate several different concepts of collaboration. Four variants, at least, can be identified.

Funding efficiencies

For some time it has been assumed that collaborative approaches to research will help to offset the rising costs of research. Perhaps the most trenchant expression of this view was contained in the 1997 Dearing report which conjectured a link between selective funding of research and a tendency towards concentration of research effort.

It was suggested that this tendency might be magnified in cases involving the use of major and expensive pieces of equipment. Indeed, Dearing explicitly encouraged the development of a greater sense of co-operation and partnership among academic research groups in order to maximise the benefits of expenditure on research facilities.

It was a Dearing recommendation therefore that 'the Funding Bodies and Research Councils…review their mainstream teaching and research funding arrangements to ensure that these do not discourage collaboration between institutions; and that, where appropriate, they encourage collaboration.'[74] Dearing also recommended that the Funding Bodies explore possibilities for setting aside some of their total grant to fund collaborative projects.[75]

Facilities sharing and research infrastructure

Collaborative use of research facilities and plant may also be seen as a response to the need for funding efficiencies. Recognition by the late 1990s of a decade or more of erosion of the research base infrastructure of facilities and equipment highlighted collaboration as part of the re-investment argument.

A survey for the then Scottish Higher Education Funding Council (SHEFC) of collaborative use of research facilities concluded that 'the vast majority of research departments surveyed are using research facilities collaboratively.'[76] It was also noted that collaboration extended beyond Scottish HEIs to include those in the rest of the UK and world-wide.

However, the principal value of this report was its demonstration of the need to avoid collaboration as 'an end itself'. Successful collaboration around facilities requires considerable investment of time and money and that funding for travel for study and research time is critical if participation is to be productive. Lead times can be long and apart from the continuation and charging issues of funding the report further identified the need for specific forms of evaluation.

The report also underscored the need to differentiate between collaborative use of facilities, involving truly collaborative effort, and more simple forms of sharing those facilities. Each serves

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[74] Dearing Recommendation 68. The Garrick Committee report for Scotland echoed this view suggesting that 'mechanisms must be found to ensure that outstanding researchers, irrespective of location be eligible for involvement in collaborative programmes and have access to necessary facilities. Incentives to encourage this approach should be found.' Garrick Committee para. 4.107.

[75] Dearing Recommendation 75. Similar recommendations were included in the Garrick Committee report (11, 12).

[76] Scottish Universities Research Policy Consortium (1999) *Collaboration in the Use of Research Facilities*. Scottish Higher Education Funding Council.

different purposes. Researchers working together 'may add value to any particular piece of plant, equipment or expertise'. From this expertise may radiate since the collaboration fosters 'a critical mass, or range, of expertise to allow problems to be addressed which otherwise could not be tackled by researchers at the host site alone.' On the other hand, shared use may merely bring the benefit of enhanced cost-effectiveness.[77]

Subject collaboration or pooling

In addition to adding value or enhanced cost effectiveness through collaborative use of research infrastructures, collaboration has been used more progressively as a tool for achieving policy goals for particular subject areas. For example, since 2005 HEFCE has sought to secure the joint futures of a range of science activities which are high cost and vulnerable to recruitment pressures. The disciplines include physics, chemistry, chemical engineering, and mineral, metallurgy and materials engineering.

The pressure towards collaboration was primarily to avoid the deficits of operating in isolation. However, the rationale for closer collaboration included aspirations to increase levels of activity and securing additional funds. In addition to funding collaboration the aim has been to restructure inter-university governance arrangements to enable joint academic planning, together with better coordination and monitoring of activities.[78]

Similar impulses have driven collaboration in Scottish HE. In 2003 SHEFC determined that it would support pooling models 'to achieve critical mass in key areas and to respond to increasing international competition.'[79] As in England, physics was one of the initial pilot areas to test the pooling concept and was publicised as 'signifying a fundamental shift in the way university research was organised in Scotland.'[80]

In addition to Funding Council initiatives, Research Councils have sought to encourage closer collaboration in particular subject areas. Typically of course it is the business of Research Councils to support individual researchers and research groups through its project funding streams. In some cases they have teamed up with organisations responsible for research facilities to encourage closer collaboration in the areas concerned. For example, the Engineering and Physical Sciences Research Council (EPSRC) and the Science and Technology Facilities Council (STFC) have themselves

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[77] Ibid. pp.6-7.

[78] Collaborative projects include: the Birmingham Warwick Science City Interdisciplinary Research Alliance (Universities of Birmingham and Warwick, £9.6 million HEFCE funding); Great Western Research (Universities of Bath, Bristol and Exeter, £3.9 million HEFCE funding) and the Midland Physics Alliance (Universities of Birmingham, Nottingham and Warwick, £3.9 million HEFCE funding). See HEFCE website: News 7 April 2008 'HEFCE secures physics collaboration in South East England'.

[79] Subsequent investments have included £6.9 million for the Scottish Universities Physics Alliance (SUPA); £9 million for Chemistry pool ScotCHEM; £9.7 million for the Edinburgh Research Partnership in Engineering and Mathematics (ERPEM); £6.5 million for the Scottish Alliance for Geoscience, Environment and Society (SAGES); £9.4 million for the Scottish Institute for Research in Economics (SIRE); £26.5 million for the Scottish Research Partnership in Engineering (SRPE);£27 million for the Scottish Universities Life Sciences Alliance (SULSA); £5.6 million for the Scottish Imaging Network: A Platform for Scientific Excellence (SINAPSE) in Medical Imaging; £14.5 million for the Scottish Informatics and Computer Science Alliance (SICSA); and £17.4 million The Marine Alliance for Science and Technology for Scotland (MASTS). See SUPA Website: http://www.supa.ac.uk/news/supa-sfc-announcement

[80] Ibid.

collaborated to encourage researchers to develop joint proposals for collaborative access to existing facilities or for the development of new facilities where the need can be demonstrated.[81]

A final variant of subject focused collaborative funding has been the pursuit of broader institutional reconfiguration. Since 2005 HEFCE has sought to apply Strategic Development Funding (SDF) support to lever strategic research collaboration. In this scheme the aim has been to build and support strategic collaboration between two or more HEIs. The underpinning assumption is that the collaboration will be sourced from and carry forward the strategic plans of the HEIs concerned. Hence the focus has been on capacity building, research quality and the broader contribution to the sustainability of the research base.

Collaborative approaches to people and skill issues

We have suggested that the bedrock of collaborative activity is people focused. Researchers – whether as individuals or in groups or units – collaborate as part of the social conventions of their subject areas. Such collaboration is indicated in the patterns of inputs (funding) and outputs (publications). However, other forms of collaboration include corporate and team collaborations which may be differentiated from other forms of individually orientated collaboration by level, rationale, structure, ownership and benefits.

At the time of the 2000 Fundamental Review of Research it was observed that while collaboration is vital to the achievement of institutional mission, people and skill issues tended to be tackled in a somewhat ad hoc rather than strategic manner. However, it was noted from field based evidence that the traditional pattern of research training within individual departments and institutions was being extended by the development of two types of collaborative partnerships.

First, strategic partnerships designed to enhance at least part of the learning experience by developing some form of collaborative provision. Typical examples include agreements between the partners to enrich part of the training programme with residential or similar activities provided on a collaborative basis. Resources are retained by partner organisations, but the collaborative element at least provides some form of strategic locus for the development or enhancement of provision.

Second, the development of executive frameworks for the collaborative organisation and delivery of the whole of the research training programme. Such partnerships are typically subject based and regional, though they are distinguished by institutional agreements. Since resources and organisation of teaching is collaborative there is a need for something more than a strategic agreement at the level of departments or units.

In the decade since the Fundamental Review of Research the UK policy agenda on research training has been transformed by the interventions of Sir Gareth Roberts. For example, *SET for Success* outlined a radical agenda for supporting researchers in higher education based around the need to develop transferrable skills for employment. Underlying the report was recognition of a comparatively low level of research and training collaboration between universities and businesses. Whilst Roberts highlighted some excellent examples of innovative collaborative research, he also called for an increase in order to improve the flow of scientists and engineers into business R&D.

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[81] Joint position statement by the Engineering and Physical Sciences Research Council (EPSRC) and the Science and Technology Facilities Council. Support of Collaborative Research Groups at ESRF and ILL.

The reports of RCUK's Research Careers and Diversity Unit chart subsequent institutional progress in implementing the Roberts' recommendations. They highlight some fundamental shifts in the funding, organisation and management of research training, including the development of graduate schools which appear to be facilitating more collaborative thinking:

'A strategic decision was made to add value to what we have traditionally offered for research staff by collaborating with other institutions to: enable networking; increase critical mass and; expose researchers to industry and commerce.'[82]

It is also evident that the individual research councils are reassessing traditional approaches. The ESRC for example announced in May 2009 that it was moving away from 'recognised' training outlets and individual courses towards creation of a new national infrastructure through the establishment of institutional- and consortium-level Doctoral Training Centres (DTC) and Doctoral Training Units (DTU).

Whilst the Roberts agenda was not about collaboration *per se* it is clear that the recommendations for training have stimulated some important changes in the landscape. Despite the development of the funding pulses directed at specific forms of subject oriented collaborations there is little evidence of any substantive shift towards greater inter-institutional collaboration in approaches to post-graduate training. On the contrary, funding imperatives are probably more likely to impel institutions towards a view of training provision as a form of competitive advantage.

A question for the sector to address is whether collaboration now needs be embedded far more systematically into the training process. A legitimate subject for further debate and inquiry, therefore, is the extent to which the sort of collaborative arrangements highlighted have permeated the system. Part of this enquiry might include the opportunities for further reform to ensure that the expectations of Roberts can be embedded in the system through more sustained collaborative working not just within but between institutions.

Collaboration is emblematic of a new approach to successful research. In fact there is nothing new about collaboration in the research process. Collaborative papers are the norm not the exception and are indicators of the informal networks that are essential to both knowledge and information flows and the broader innovation process.[83] Despite successive policy pronouncements on the benefits of collaboration the pursuit of a more formalised collaborative agenda for the funding and organisation of UK research has proved somewhat more problematic than might be envisaged, for two reasons.

First, beyond its superficial appeal and the evidence of publication outputs that collaboration is a key part of research, the reality is that collaboration is difficult both to define and operationalise with any degree of consistency. As a concept, collaboration is not well understood. It has multiple meanings and occurs in complex contexts of research endeavour.[84]

Second, collaborative relationships within HEIs can occur at different levels, each level characterised by different sets of purposes and rationales. Whilst it is clear that the achievement of institutional mission is highly dependent on successful research collaboration, it is evident that funding

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[82] Research Careers and Diversity Unit Career Development and Transferable Skills Training Payments: Summary of 2008 Reporting.
[83] Hicks and Katz, op. cit. v.
[84] Smith and Katz 2000 op.cit.

collaboration as a goal in itself may not be a sensible way of facilitating productive or effective research collaboration. Whilst there has been some important progress towards achieving a more collaborative research climate over the last decade or so, it remains a challenge both for policy and institutions to devise sensitive and appropriate forms of support for collaboration.

Europe

Within Europe, there are two aspects to any analysis. One is scale related: how well are economies like the UK's performing and what implications does this have? The other is achievement related: which countries are delivering exceptional research, irrespective of size? And from these both, what lessons might we draw for UK policy?

The obvious direct comparators for the UK are France and Germany as shown above. Other, smaller countries are extremely successful in some research areas. Scale alone is, not surprisingly, not a sufficient measure of research success. Producing more papers, patents or people is valuable only so long as the product meets a quality standard. Analysis must therefore weigh up both dominance of market (share) with this quality component and consider what delivers real value, now and in the longer term.

The UK's place within the EU research policy environment is important. The role of the Framework Programmes needs consideration, as does the development of the European Research Area. What both of these signal is the UK's unavoidable location. UK researchers are more likely to interact generally with other European researchers because of physical proximity.

Examples of facilities and missions we cannot afford on our own include:

- EIROforum: a collaboration between seven major European intergovernmental research organisations responsible for laboratories and infrastructure.
- European Social Survey: A social sciences survey of over 30 countries with a UK-based secretariat.
- CERN: the facilities at CERN are clearly unaffordable at national level.
- EFDA-JET: the Joint European Torus (JET) is situated at Culham near Oxford, and is used by EURATOM which covers 20 European countries.
- EMBL: The European Molecular Biology Laboratory is funded by research money from 20 member states and an associate member state, Australia.
- ESA: the European Space Agency. On 24 March 2010, the UK announced that a new UK Space Agency will take over responsibility for UK government policy and the budgets for ESA.
- ESO: the European Southern Observatory is in Chile and naturally has no Latin American membership but does have headquarters in Garching, Germany.
- ESRF: The European Synchrotron Radiation Facility (ESRF), located in Grenoble, is a joint facility supported and shared by 18 EU countries plus Israel.
- ILL: The Institut Laue-Langevin operates one of the most intense neutron sources in the world, feeding beams of neutrons to a suite of 40 high-performance instruments.

- SHARE: The Survey of Health, Aging and Retirement in Europe is a survey of over 45,000 people over 50 years of age co-ordinated by Germany.
- JRC: the Joint Research Centre operates a network of Community laboratories and research facilities including the European Laboratory for Structural Assessment (at Ispra in Italy), the High Flux Reactor (at Petten, NL), the GELINA neutron time-of-flight facility and the 7MV Van de Graaff accelerator (in the Institute for Reference Materials and Measurements at Geel, Belgium) and VELA, Vehicle Emission Laboratory (part of the Institute for Environment and Sustainability, also at Ispra).

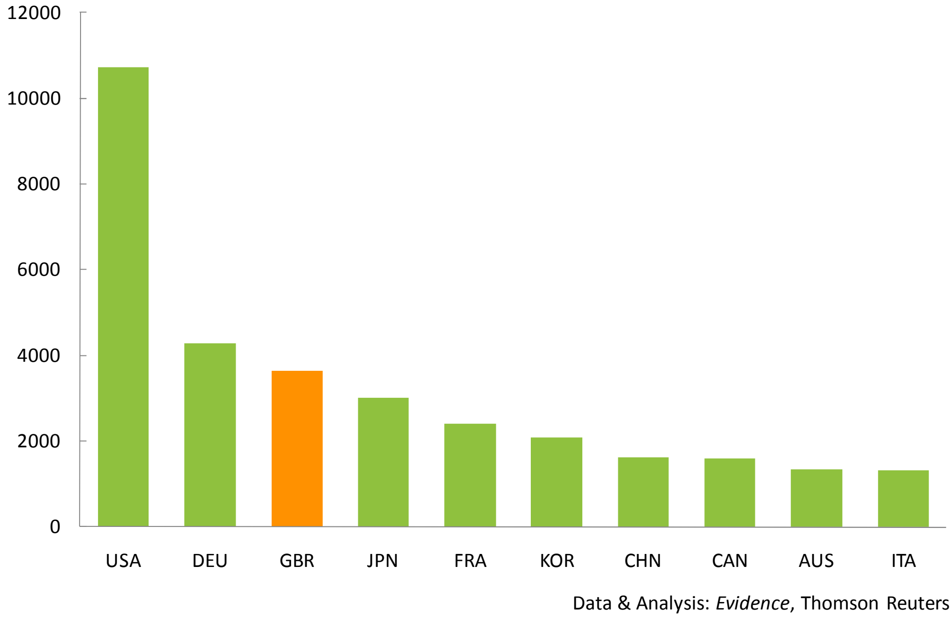
The list is included here to assert the view that the UK is already heavily dependent on regional collaboration for its research future. It is increasingly drawn into the common support of trans-national facilities and it cannot afford an alternative route. The UK's research future is indissolubly linked. It is not a matter of simple 'juste retour' but of the value to be gained by participation in programmes that will inevitably continue. Withdrawal from European research institutions would be a death knell for the UK research base since it would clearly be unable to maintain its profile without such collaboration. Active participation to guide the proper development of the European Research Area seems the only logical strategy.

Collaborating with the world

Some requirements go beyond regional capacity. Many opportunities exist outside Europe. Much future research innovation will take place in other regions. As an example of what has now become inter-continental research collaboration, we have the International Thermonuclear Experimental Reactor (ITER). Seven participants formally joined and agreed to fund the ITER project in 2006: the European Union, India, Japan, the Republic of Korea, China, the Russian Federation and the USA. EU Member states have established agencies to mediate between their national governments and the ITER Organization. The European Agency "Fusion for Energy" represents the 27 Member States of the European Union, Euratom and Switzerland as a third-party country. The ITER programme is anticipated to last for 30 years — 10 years for construction, and 20 years of operation. It will be based in Cadarache, France.

The UK is thought of as having an exceptional global role through its history, and particularly through its Empire which created enduring cultural associations. The university systems and research bases of far-flung and economically significant countries have their origins in a British system. The Yearbook of the Association of Commonwealth Universities is a weighty, two-volume publication. It is unclear, however, whether the UK still obtains any exceptional value from this history. Germany has a greater volume of collaborative publications with India, both recently and in the past despite a difference in language and equal geographical challenges.

Figure 5. India's international research collaboration is greater with Germany, in terms of co-author publications, than it is with the UK. Collaboration with other countries in Asia is growing rapidly.

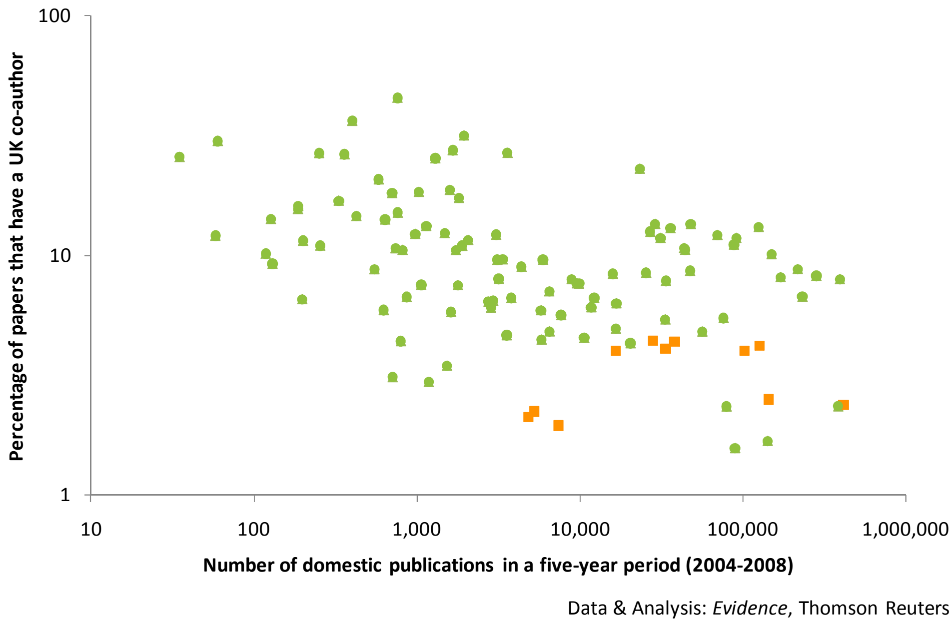


The data show that India is increasing most rapidly its regional links, with China, Japan and Korea and with Australia. The UK does have exceptional links with Australia but even these are less important than they once were. Australian universities are also collaborating increasingly with China and other S E Asian partners, as well as with Pacific coast US universities.

This raises questions about the UK's overall ability to maintain its profile in a world that becomes more complex, and collaborative rather than competitive. The dominant feature of the global research base over the last quarter-century has been the shift from a strong trans-Atlantic axis to a more diverse geography of science. In the 1980s the focus was on a group of south-east Asian economies that were exhibiting particular technological proficiency. More recently, the focus has been on larger economies with the resources to grow their research portfolio at an unprecedented rate. These changes have been seen as a 'threat' within the policy framework of competiveness rather than as an opportunity within that of collaboration. The emphasis has therefore – arguably – missed the significant path that the UK should logically follow.

The UK collaborates and publishes research articles with over 100 countries. Typically, about 10% of other countries national output is collaborative with the UK but that share varies by the size of the national research base and is greater for smaller nations.

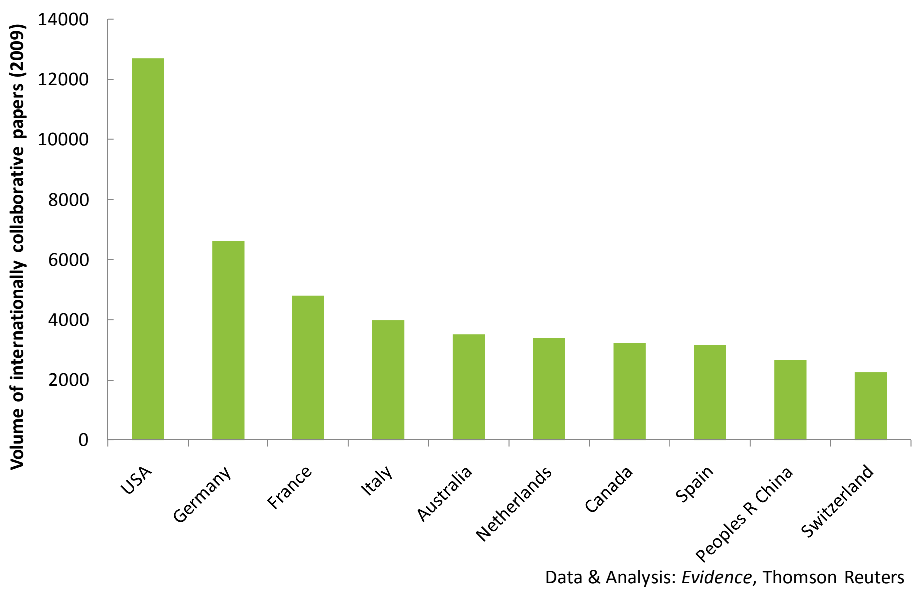
Figure 6. National output of countries collaborating with the UK compared with the percentage of their research output which has a UK co-author. UK share generally falls as output grows and there are some very low outliers among major emerging economies (coloured orange).



Malawi produces fewer than 100 papers per year, although of average impact above world average, 45% of those papers have a UK-based co-author. The UK continues to share a relatively high percentage of output from other Commonwealth countries.

The greatest volume of UK collaboration is with traditional G7 partners led by the USA with approaching 13,000 papers per year and followed by Germany, France, Italy, Australia and the Netherlands.

Figure 7. The volumes of research papers published by UK authors with at least one international partner showing in 2009 illustrate that the USA is the UK's largest partner.



What is of more concern are the countries with which the UK has relatively little research collaboration. We recently reported on research activity in Africa. In contrast to the good links with East Africa, the UK has a relatively low density of collaboration with the network linking Egypt, Tunisia, Algeria and Morocco although this is emerging a significant regional grouping and has strong links to other EU countries and especially to France.

Equally worrying is the level of collaboration with the BRIC countries. In terms of domestic share, Russia is 97th, Iran is 98th, Brazil is 100th, India is 104th and China is 105th in descending order of output shared with the UK in the list headed by Malawi. There are 10,000 collaborative papers with China over five years but this is now only 2.5% of China's output. If the UK stopped collaborating it would have no impact on China but the UK would lose access to an invaluable source of information about innovation.

Motivation for international collaboration

The UK should be concerned about these partnerships. It is not about doing better than other key competitors but doing enough to be seen as a valuable continuing partner by the target country. We need to establish these partnerships now, while those target nations are still growing and while they still have to establish their quality credentials. As they become established, the cost of collaborating at a distance will start to outweigh the benefit of sharing the UK's experience.

As we suggested earlier, the principle motivational factors for collaboration are two-fold. One is that you cannot afford to do everything and you cannot afford to do some things at all without partners, which underpins the European collaboration on facilities. The other is that collaboration is active and participatory and you learn more things than you can from reading papers.

We need to share the laboratory bench with researchers in emerging research nations because they will bring new approaches and ideas to the problem. They will complement and then extend the methods and technologies that we use. They can potentially reveal new approaches that might not occur to conventional European thinking conditioned by a strongly established research culture. We need to work with China and India not only to learn what they find out but why they chose those problems and how they tried to solve them.

What is the motivation for these partners to work with the UK? Our research competence is certainly part of that but we must not rely on such an approach and assume that people will always want to work with us because we will always be a lead nation. Apart from anything else, only some institutions have such an exceptional global profile that excellence alone is enough.

Feedback suggest that Germany has been more successful than the UK in developing collaborations in India, and is gaining a strong position in China outside Hong Kong, because the German approach is more functional and pragmatic than the UK approach. Rather than offering signed agreements to work towards excellence, the Germans offer equipment and technology. Recent reports also show evidence of a similar German approach in South Korea where the Max Planck Society is negotiating with Pohang University of Science and Technology to establish two joint research centres.[85] The firm benefits today of high-quality new hardware are much greater for research that is still climbing the

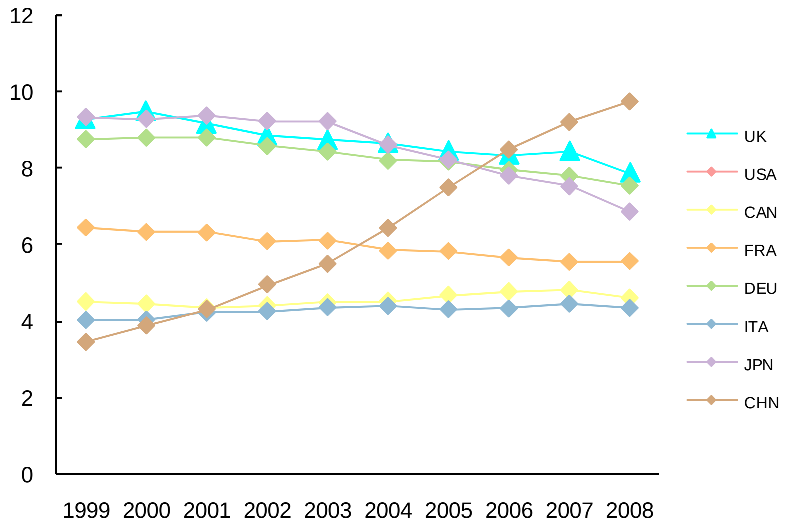
[85] Normile, D., Gretchen, V. (2010) *Max Planck Tests the Korean Waters* Science **328**:pp. 414-415.

global quality scale than the possible benefits in the future of research that might get you a Royal Society Fellowship.

Growth in research-emergent nations

Annual reports for the UK government confirm that the UK has retained a significant share (shown here as a percentage) of world outputs but the most significant line in the graph below (note the USA is not shown) is the rise of China. This increase in volume is so great and so rapid that it visibly shrinks the share of papers produced by others.

Figure 8. National share (as %) of world outputs recorded on Thomson Reuters publication databases Graph of G7 plus China taken from Indicator 1.01 in Performance of the UK Research Base, BIS[86] *China's growth suppresses all other shares.*



China's growth is fuelled by a quadrupling in GERD over the ten years from 1999 to 2008, driven by GDP growth but also rising as a percentage of GDP. It passed UK GERD in 2001 and now spends more than Germany and almost as much as Japan.[87] To date the bulk of the effort has been in core technology and related physical sciences. Rapid growth is now appearing in biological and medical sciences.   The growth in Chinese research has been matched to date by an equal growth in international collaboration – this presents great opportunities for UK researchers.[88]

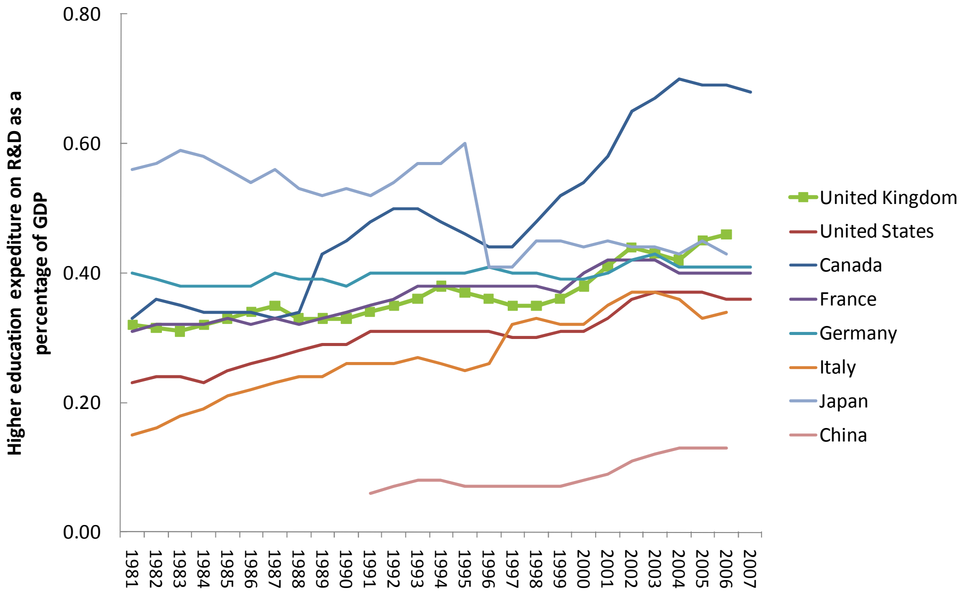
We have no data on GERD for Brazil and India. In terms of recorded volume, Brazil is also on the rise and has more than doubled its research output in the last ten years. That is driven particularly by Sao Paulo where the regional government is committed to spending 1% of rapidly expanding tax revenues on R&D. The resource availability is actually seen as a problem by Brazilian science policy leaders who have commented on the lack of competitiveness that means that Brazilian researchers are disinclined to seek funding in international fora.   India has been slower to respond to

[86] http://www.dius.gov.uk/Policies/science/science-funding/science-budget/uk-research-base
[87] Dept for Business, Innovation and Skills (Sept 2009) *International Comparative Performance of the UK research base.* http://www.dius.gov.uk/science/science_funding/science_budget/~/media/publications/I/ICPRUK09v1_4
[88] Adams, King and Ma (Nov. 2009) *Global Research Report: China* Thomson Reuters http://researchanalytics.thomsonreuters.com/m/pdfs/grr-china-nov09.pdf

opportunity but its growth has also been steep since 2000 and it doubled output between 2002 and 2008 to pass Russia. Iran, meanwhile, has increased its research output ten-fold over the same period, albeit from a low starting point, and is now more productive than Finland.

The UK has not been short of resources during the last decade. Higher education Expenditure on R&D (HERD) has risen as steeply as other countries and more steeply than most.

Figure 9. Higher education Expenditure on R&D (HERD) as a percentage of Gross Domestic Product (GDP) for G7 countries plus China between 1981 and 2007. The UK's rise has been relatively good compared to the other countries.



Source: OECD

Despite the increase in resources, the UK remains one of the most productive countries, producing about 2.5 papers per £million GERD compared to an OECD average of around 1.8. Most G7 nations are below that average. It is also productive in terms of papers per researcher.

Comparing national systems

In an earlier section (page 9), questioning whether we need universities as vehicles for research, we drew attention to studies on the relative performance of national research bases that were dominated either by universities or research institutes. The UK, Canada and Australia are examples of the former and France, Germany and Japan of the latter.

We do not need to repeat the full argument here but two points bear reiteration.

First, despite the apparent success of the CNRS and Max Planck systems, both France and Germany are shifting more of that activity onto campuses either by wholesale takeover (France) or migration (Germany). Second, the data show that the university based systems provide a more effective spread of diversity and performance across subjects than do the institute based systems although two of the three comparator countries are relatively small.[89]

[89] Adams, J (2000). *The Future of Research*, pp 169-189, in, Higher Education Re-formed, ed P Scott. Falmer Press, London. ISBN 0 750 70977 4.

People and mobility

A theme running through the different sections of this report is people, which we identify as the most important output from the university research base and a key contributor to economic competitiveness.

There is a global war for talent. Major economies used to drawing on other countries for talented young people are seeing a dwindling in inward mobility. The USA has become acutely aware of its dependency on imported foreign researchers,[90] previously more than happy to continue US residence but now seeing improving research prospects in their home country. The UK has benefitted from the flow of researchers inward from the Commonwealth and, more recently, from Eastern Europe. However, the discontinuation of the Overseas Research Students Awards Scheme in England and Wales,[91] reductions in Foreign and Commonwealth Office-funded scholarship programmes[92] and current UK immigration policy are likely to reduce this inward flow of talent in future years.

The US reaction was initially one of seeking to continue to draw on foreign talent and then to provide it with golden handcuffs but that has not been sustained as a viable policy option. It is probably inevitable that every country has to accept that talent is increasingly mobile and that domestic development is the bedrock of any policy. The most important thing is therefore two-fold: ensure that the domestic production of talented people equipped for the knowledge economy is high, and ensure that the environment remains attractive to draw in as many people as are motivated to move elsewhere.

The importance of academic mobility to knowledge flows, the intellectual vitality of the university and higher education more broadly has been investigated from a range of perspectives. Transatlantic academic mobility in the form of educational and cultural exchange has a long history. The direction of flow has changed over time, but has benefitted enormously from formal scholarships and awards such as the Rhodes, Commonwealth, Fulbright and other similar schemes[93] [94]. Such schemes often had overlapping purposes and served to reinforce other policy objectives for education or wider cultural diplomacy.[95] [96]

The roots of internationalisation or 'border-crossing activities between national systems of higher education' are surprisingly deep and have only more recently been absorbed into wider world trends and growing global competition.[97] At one level academic mobility is about facilitating the process of

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[90] US Academies (2007) *Rising Above The Gathering Storm: e*nergizing and employing America for a Brighter Economic Future. Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology. Committee on Science, Engineering, and Public Policy.

[91] http://www.orsas.ac.uk/

[92] http://www.fco.gov.uk/en/about-us/what-we-do/scholarships/

[93] Kenny , A.J.P. (2001) *The History of the Rhodes Trust: 1902-1999*. Oxford University Press.

[94] Johnson, W. and Collegian, F.J. (1965) *The Fulbright Program: A History*. Chicago: University of Chicago Press.

[95] Bu, L (1999) *Educational exchange and cultural diplomacy in the Cold War*, Journal of American Studies, **33**(3): pp. 393-415.

[96] Smith, D.N., Baston, L., Bocock, J. and Scot, P. (2002) *Americanization and UK higher education: towards a history of transatlantic influence on policy and practice*, Journal of Education Policy, **17**(4): pp. 443-461.

[97] Teichler, U. (2004) *The changing debate on internationalisation of higher education*, Higher Education, **48**: pp. 5-26.

knowledge transfer. At another it is about engaging in broader processes of internationalisation, Europeanisation and globalisation.

Teichler argues that these terms incorporate some core similarities. They express, for example, the 'long-distance transport of knowledge in higher education and a more complex setting of multi-level actors and other forces'.[98] However, each also has a slightly different focus. Hence internationalisation tends to stress border-crossing activities within a framework of national systems of higher education. Globalisation takes this further and assumes a breaking down of borders and national systems. Europeanisation takes a regionally disposed view of either internationalisation or globalisation.[99]

Whatever the drivers, however, it is clear that expectations of academic roles and activities are changing with an increased emphasis on new specialisms and inter-disciplinary collaborations.[100] Career paths, preparation for roles and working lives are changing in line with these expectations. Resourcing approaches that are still rooted in national systems are a facet of the picture. However, the appearance of common forces of transformation associated with globalisation and marketisation are beginning to change the balance of national particularities, similarities and differences experienced by academics. Moving between them, therefore, is an important facet of that experience.[101]

Bennion and Locke's study of The Changing Academic Profession posits 'a link between the international mobility of academics during training and preparation for the profession and their current level of international research collaboration'.[102] The argument is that contact with academics in different national settings, together with exposure to indigenous knowledge, language and culture during the early career stages 'might develop a greater propensity to future international intellectual exchange'.[103] Some evidence, rather inconclusive, is presented, but the authors make a plea for more detailed national studies investigating the effects of early career experiences on international mobility and collaboration.

Another study of academic mobility has highlighted the continued restraints on the emergence of a European academic labour market.[104] Despite the creation of research networks and projects within Europe, national markets remain important and place several obstacles in the way of the development of European careers and internationalised recruitment. The study concludes that for most post-docs, foreign experience is conceived primarily as a personal strategy aimed at improving recruitment chances within their own country.[105] Nevertheless, one of the cultural characteristics of an academic career is that transnational career patterns are 'within a normal range of options'.[106]

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[98] Ibid.
[99] Ibid.
[100] Bennion, A. and Locke, W. (2010) *The Early Career Paths and Employment Conditions of the Academic Profession in 17 Countries*, European Review, Vol. 18, Supplement no. 1, pp. S7–S33.
[101] Ibid.
[102] Ibid.
[103] Ibid.
[104] Musselin, C. (2004) *Towards a European academic labour market? Some lessons drawn from empirical studies on academic mobility*, Higher Education, **48**: pp. 55–78.
[105] Ibid.
[106] Hoffman, D.M. (2009) *Changing Academic Mobility Patterns and International Migration: What Will Academic Mobility Mean in the 21st Century?* Journal of Studies in International Education; **13**(3): pp. 347-364.

The dynamics of academic mobility vary across systems and societal contexts. One conclusion is that early or formative periods in career development are crucial to understanding propensities and timescales for undertaking periods of working in other countries and universities.

Nevertheless, it is important to note that the impact of different forms of mobility or scholarly exchange remains an under-researched topic. Although it is possible to quantify the formal flows and links, the underlying informal networks or connections are much more difficult to identify and measure.[107] The comment of one Swedish scholar returning from a period of study in the USA is revealing of the problem: 'America does change people…but in ways so subtle that it is hard to describe'.[108]

Studies for the Higher Education Policy Institute (Oxford) show that the UK's most highly-cited researchers are almost invariably mobile. They are people who have spent at least one extended period overseas (most often to the USA or other Anglophone country), usually after completing their first degree in the UK. This is not a brain-drain, however, because the majority of such people return to the UK for long-term employment. There is in fact a net gain in the UK-USA balance.[109]

Other countries are aware of the homing instinct and of the gains from mobility. The Netherlands, Switzerland, Canada and Australia all gain from their researchers' tendency to move out, gain experience and network contacts elsewhere and then return home. The Swiss have run a long-term programme specifically to promote such mobility because of the access that this gives them to international networks.

UK researchers have been much less mobile generally. While the highly-cited have moved, the tendency of UK postgraduates and post-doctoral researchers has been to stay at home resulting in a disproportionate number of European visitors to the UK compared to the number of UK research visitors to other European countries. It has been suggested that the establishment of a single EU-wide pension scheme to make movement easier for researchers could help to remove one obstacle to mobility.[110]

Global data are less clear but the evidence appears to support the general thesis, that UK researchers are reluctant to gain experience outside the Anglophone network of countries.

This is a tendency that seems to work at every level in the higher education system, if we look at the data on the percentage of tertiary education students studying in another European country. Note in the set of graphs below that the scale on the UK chart runs from 0-1% whereas that for other countries runs to higher levels.

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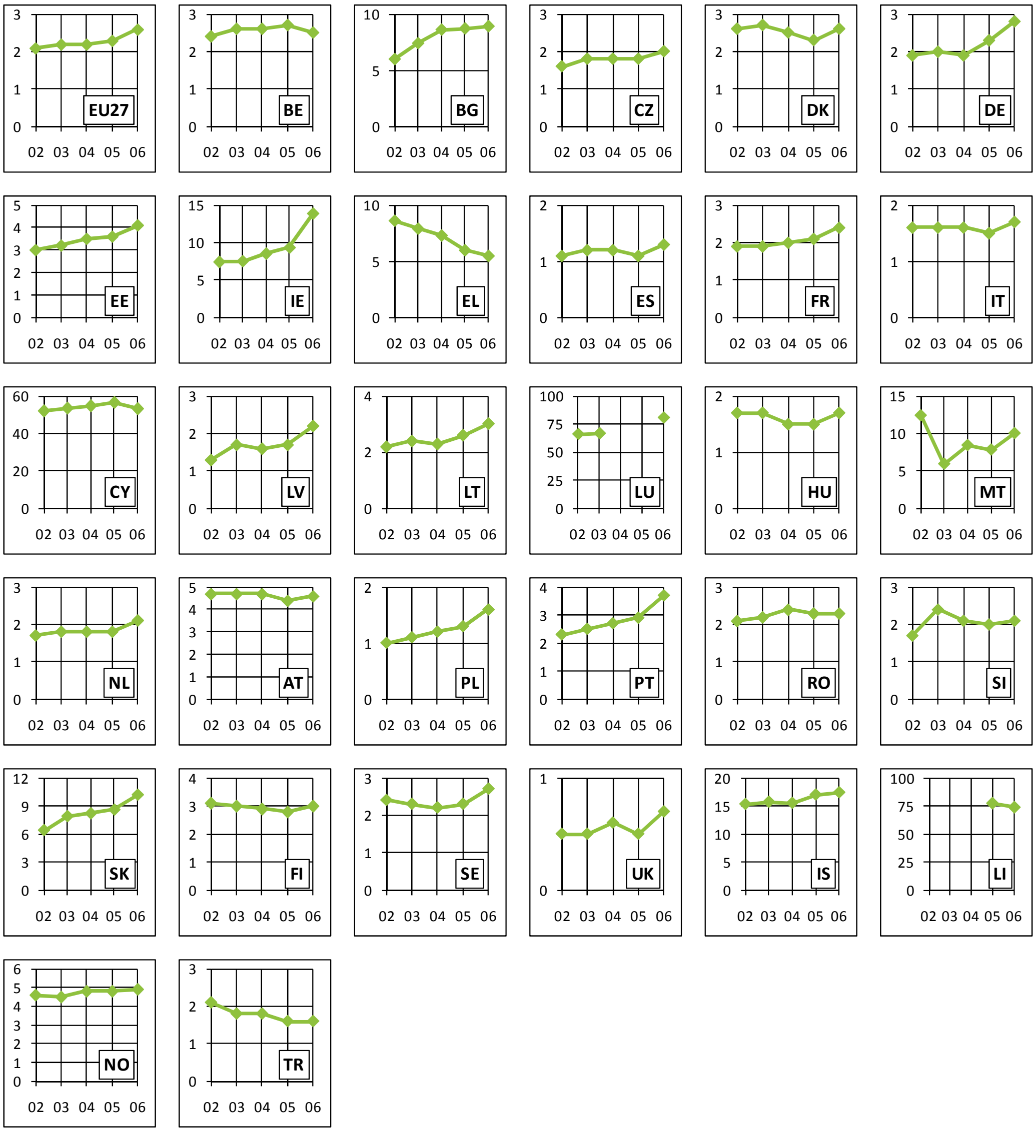
[107] Smith, D.N., Baston, L., Bocock, J. and Scot, P. (2002) *Americanization and UK higher education: towards a history of transatlantic influence on policy and practice*, Journal of Education Policy, **17**(4): pp. 443-461.

[108] Blanck, D. (1992) *The impact of the American academy in Sweden*, in R. Lunden and E. Asard (eds.) Networks of Americanisation. Aspects of the American Influence in Sweden. Uppsala: Almquist & Wiksell International: pp. 80-93.

[109] Evidence (2005). *The impact of academic mobility on UK academic research*. Supplementary Report B; careers of UK and International researchers. Report to HEPI, Oxford. Available from the HEPI web-site.

[110] An editorial entitled *Singular vision* in Nature **465**: p268 (2010) discusses European Commissioner for Research, Innovation and Science, Máire Geoghegan-Quinn's announcement of a plan to enhance European research on 11th May 2010.

Figure 10. The percentage of domestic students that travel to study abroad within the EU. The data show that the UK has an unusually low level of mobility.[111]



Approximately 2.6% of tertiary education students in the EU spend at least part of their studies in another EU member state, candidate country or an EFTA/EEA country, which is higher than 2.1% in 2002. The United Kingdom has the lowest proportion of students studying abroad – 0.7% in 2006. Martin Davidson, the chief executive of the British Council, recently highlighted the same issue at a Council for Industry and Higher Education meeting in May 2010 saying that while 50,000 international students come to the UK each year only 15,000-20,000 UK students go abroad.[112]

These data, taken alongside those on general collaboration patterns, may suggest that the UK has some work to do in persuading its researchers that they should consider their own mobility in collaboration and not always seek to attract collaborators to the UK. There should be a stronger

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[111] Source: Eurostat, UOE as reported in: *Education, Audiovisual & Culture Executive Agency*, European Commission (2009) Key Data on Education in Europe 2009, data for 2002-2006.

[112] As reported in Fearn, H (2010) *UK influence abroad at risk from lack of overseas* study in Times Higher Education 3rd June 2010.

two-way process that diversifies the experience of UK researchers and enables them to engage more with other cultures than currently they do.

The language factor may be key here, where English is the research 'lingua franca'. Visits to the UK provide research and language experience; visits from the UK provide research experience but the language aspect is less valuable. The British Academy position paper "Language Matters"[113] highlights the findings of a RAND Corporation report into concerns that UK-born and -educated researchers lack foreign language skills. The report concludes that that there has been a decline in supply of UK-born researchers with language skills at the same time as "the demand for language skills from non-language-based [humanities and social sciences] disciplines is increasing". This it attributes to three reasons:

- deficient language teaching and learning at school;
- perceived global dominance of English;
- the failure of many state schools to promote language learning, although provision tends to be better in the private school sector.

The British Council have also identified a language deficit as an issue. Chief Executive Martin Davidson is quoted as having said "The UK may soon be the last monolingual culture in the world […] without people who are comfortable working in an international context, the UK's international influence is bound to decline over time".[114]

Scenarios

The evidence suggests that the UK's research future is likely to be more assured as a strong and leading member of a regional, European research network.

Further restructuring of the French and German research bases will increase the competition that the UK faces within Europe, but will also provide more and more worthwhile opportunities for regional collaboration.

There are evident risks that as regional networks grow elsewhere in the world then the UK will find itself progressively excluded if countries lack the capacity to engage with many partners. It is already a surprisingly marginal partner for some key economies and it is being outcompeted by European competitors, if that is the right perspective.

It is suggested that the UK has relied on its research leadership when many partners are looking for a much more pragmatic, functional relationship with tangible support for core research rather than an entry to research excellence. UK universities may therefore want to rethink the way they approach new partners and the range of assistance that they can offer.

What is almost certainly required is a greater willingness to go to the partner rather than expect the partner to supply postgraduates to come to the UK. Incentives for staff and students to engage in

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[113] British Academy (2009) *Language matters*
http://www.britac.ac.uk/templates/asset-relay.cfm?frmAssetFileID=8055

[114] As reported in Fearn, H (2010) *UK influence abroad at risk from lack of overseas* study in Times Higher Education 3rd June 2010.

collaborative activity at overseas sites, and thereby gain the cultural experience and the detailed knowledge of what is being done and why, is very important.

It seems inevitable that the overseas postgraduate market will decline. However, closer and longer term partnerships are one way of shoring up the relationship that stimulates students to come to the UK. It reduces the sense of alienation and increases the likelihood of finding compatriots.

Re-balancing quantity and quality of UK university research

The UK university research base has grown significantly over recent decades and performs at an internationally high standard. Excellence is not uniform, however, and there is an argument that growth in capacity has exceeded growth in core resources. The system may be over-trading, projects may have been funded at sub-optimal levels in order to increase volume, and too many people may be working within the system without enhancing the average outcome.

Introduction

It should be obvious that research investment is not intended solely to produce a lot of activity but to produce activity of exceptional quality. It is simply not worth buying research that is not internationally competitive. All considerations of investment and of the future trajectory of the research base must therefore take into account the capacity of the research base but the underlying structure and dynamics that contribute to the value of the activity.

Not all research can be world class. There is no system that maintains uniform excellence across all its parts. But a system that does not strive to be excellent, and to manage all its processes to achieve that quality standard, will fall short of its potential and that will have wider impacts for the economy as well as for the status of UK universities.

Issues that are therefore important to consider include:

- How much investment has been made relative to the size of the system?
- Are these resources adequate to achieve excellence?
- How are the resources distributed? (e.g. by funding mode, by region, by institution)
- Does this pattern of distribution support policy objectives regarding people, regions and the economy?
- What would be the effect of any reduction in current levels of investment?
- What would be the effect of any changes to current patterns of investment?

Research assessment

This report is not about the RAE but it is worth noting the significant body of evidence which suggests that the process of assessment has had benefits structurally in research management and in incentivising researchers, directly or indirectly, to improve the quality of what they do.

Formal assessments of university research have been going on since 1986 and a whole generation of researchers have now grown up under this system. RAE results are used by the UK HE Funding Councils to allocate QR. With each successive RAE the process has moved on. The most significant change for RAE 2008 was the move from awarding a single grade to a whole department or research unit to the use of more sophisticated 'quality profiles' showing the spread of research quality across a department. This results in recognition of 'pockets of excellence' within departments or institutions which otherwise would otherwise receive little or no QR.

In 1996, German university rectors met in Bonn to consider the effects of research assessment on the UK university system and to debate whether they should accept government proposals for such a system in Germany. They concluded that there was little doubt that the RAE had given the UK a competitive advantage, that it had driven improvements in university research performance. Nonetheless, they were equally clear that they had no intention of accepting such an assessment system for their own institutions.

The adoption of university research assessment in other countries reflects the widespread recognition that the UK had a strong policy lead in this area and that this lead gave a benefit to the UK research base. That lead will disappear as other systems receive the same stimulus.

Resourcing and system scale

UK university research is characterised by a highly self-motivated culture without which the quality and the effectiveness of the system could not arise. People are allowed to do what they do best, which is their own thing. A contingent problem with this is that the system has a relatively low-key management culture and the research base has developed little overt management capacity, although the competency of UK researchers as managers is acknowledged across the EU.

Management capacity has evolved progressively through the 1990s, driven in part by research assessment. We have documented elsewhere the emergence of nominated senior research managers, the creation of research committees with oversight and then allocation functions, the creation of relevant strategic funds and the development of resourcing systems linked to quality indicators. Many universities now have well defined research oversight structures at institutional, faculty and departmental levels. These structures focus on monitoring rather than direction but they can identify weakness and help to channel guidance. What they do not do is represent any overt management because the system (probably rightly) rejects directing the activity of individual investigators. As a consequence they also lack constraints and cannot impose or operate a formal business model in regard to research projects, where decision making is left to the judgment of the principal investigator (PI).

Most PIs acquire project management skills, but the pressures on the researcher are not about successful delivery of research projects in a business sense. Performance drivers favour a rising research profile, which is best underpinned by increased research activity to enable increased research output. That can lead to a preference for more research contracts rather than better research contacts where better would mean contracts that were carefully scoped and fully funded to meet their objectives. Because the institution effectively underwrites the contracts there is no penalty for taking on work that is under-resourced, leading to what is termed 'over-trading' or stretching the capacity of the organisation beyond the workload it is resourced to deliver.[115] Indeed recent Transparent Approach to Costing (TRAC) data show that despite the introduction of full economic costing (fEC) there remains a £2billion deficit for research. Some of this may be down to

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[115] **What is overtrading?** Overtrading takes place when a business accepts work and tries to complete it, but finds that fulfilment requires greater resources of people, working capital or net assets than are available. This is often caused by unforeseen events such as manufacture or delivery taking longer than anticipated, resulting in cashflow being impaired. Overtrading is a common problem, and it often happens to recent start-ups and rapidly expanding businesses. [BusinessLink, April 2010]

problems with TRAC, and fEC is still 'work in progress', but the residual deficit is cause for concern. It is therefore a question as to what benefit accrues from a plethora of badly-funded researchers?

This phenomenon is not restricted to individual investigators. It is culturally pervasive. In the absence of overt management at many levels the development of the system has been through diffuse internal pressure which has tended to prioritise growth. More activity – postgraduates, contracts and publications – has been valued ahead of more support for the best activity. Many committees experience the pressure to award more grants at cost to better funded grants. Researchers experience real or inferred pressure to shave marginal costs, and while this may help to make efficiency gains it should be done in a way that does not encourage research to be under-resourced.

From an external perspective, the UK university system appears to be playing as if investigators were in a market system but where they have none of the penalties and therefore realities of a market. Unless university managers are prepared to impose real budget limits and terminate projects that over-run their costs then this behaviour will continue.

Project under-resourcing and institutional over-trading lead to compromised outcomes. We cannot assert that the research outcomes would have been better had they been properly funded but is a reasonable suspicion that we are buying more not better. The further problem is that it is increasingly expensive to compete at international level. The cost of raising very good research to excellence is high. It is easier, but pointless, to raise modest research to national competence. The UK needs less indifferent research, not more, yet a lot of recent research has markedly low impact, even within the top universities.

Researcher numbers approximately doubled in the ten years to 2009. Over the same period the volume of UK publications increased by approximately 50%. This was underpinned by a real growth of HERD of about 41% (OECD data using constant prices).

It is unclear whether the system benefits from a plethora of badly funded researchers, and the data raise a number of questions. Full economic costing has not led to a restabilisation of research effort with properly-funded laboratories operating at a satisfactory level of capacity to deliver uniformly high quality. Why does the system not operate self-governance that favours quality and full support over quantity and thinly-drawn resources?

Similar questions apply at system level. What was the purpose and what has been the benefit of doubling researcher numbers in a decade? Has the standard of recruits been maintained, and what are all these researchers going to do? And has this growth been the result of previous waves of growth at postgraduate level, with additional PhDs pushing up the demand for research careers? Would the system be better off with fewer better funded research students?

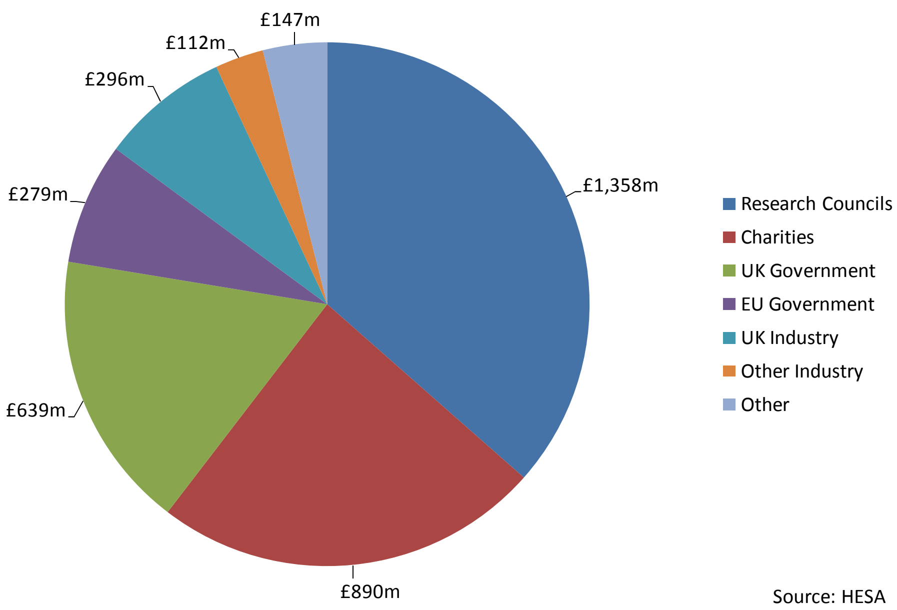
The balance of funding

In the UK, university research funding has been characterised by a dual support system widely recognised as having contributed significantly to the flexibility and strategic development of the UK's research base. Dual support provides a stream of generic, core resources (from the UGC, now the HE Funding Councils) to establish a platform research environment (now funded as QR) alongside a stream of specific resources (from Research Councils) for individual projects on that platform. The advantage of the dual streams is that the core allows institutional management significant flexibility and strategic leverage.[116] [117]

However, as research funding has evolved, the relationship between core and specific funding has changed. This has gradually eroded the original benefits of the system and is perhaps a further indicator of the extent to which over-trading has crept into the system.

UK university research benefits from a plurality of grant and contract funding streams which encourage diversity of activity within the same research department, and often within a single group. Any researcher is free to acquire funds from Research Councils, charities, industry, national and local government, the European Framework Programme and other overseas sources. Universities have successfully diversified their research support. Research Council funding currently accounts for only about one-third of total research grant and contract income. Charities account for a further large slice.

Figure 11. The breakdown of income from research grants and contracts awarded to UK universities



The Funding Council stream of the dual support system is not intended to provide support for this entire portfolio. UGC funds were initially intended to provide a platform for the Research Council component but that cover has been stretched in more recent times to include charity awards. Whether that is appropriate is unclear. This is mostly medical research and it is often unclear how this is costed or managed. Furthermore, some charities can only fund a relatively small community and the level of competition for such grants is therefore potentially smaller than elsewhere in the system and the peer review and quality controls may be weaker.

Other income is expected to be acquired on the basis of full economic costing for each project. It is reasonable to expect any business to operate some 'loss leaders' to attract prestigious or novel

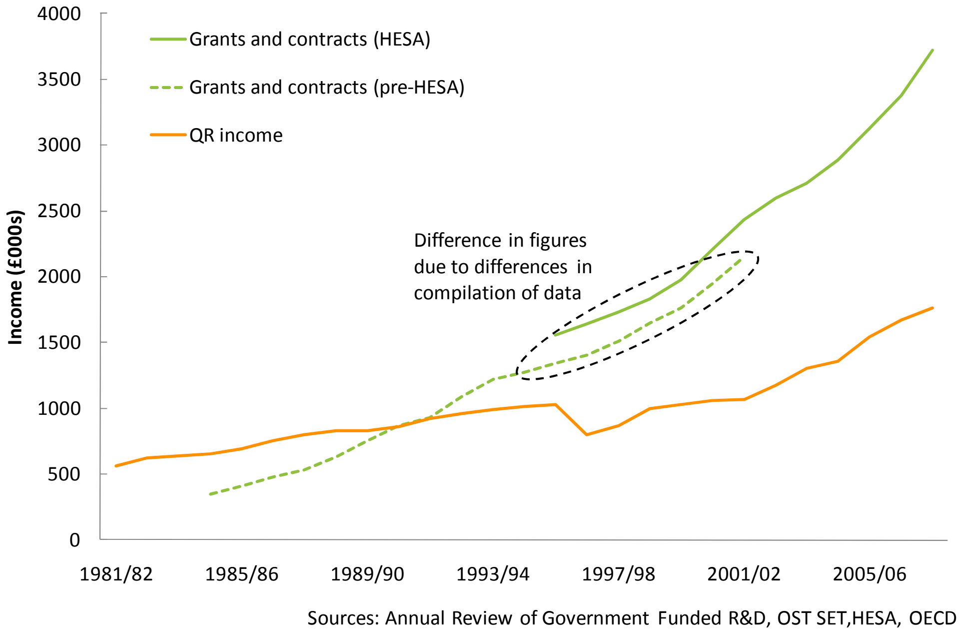
[116] Adams J and Bekhradnia B (2004). *What future for dual support? Evidence* report to the Higher Education Policy Institute, Oxford.

[117] UUK and HEFCE (2009) *Securing world class research in UK universities – exploring the impact of block grant funding* http://www.universitiesuk.ac.uk/Publications/Documents/WorldClassResearch.pdf

clients but generally government and business should expect to pay the real cost of the research they commission. For business, in particular, it is reasonable that innovative work drawing on significant intellectual capital and leading to increased profitability would be fully compensated.

Unfortunately, researchers may not always properly cost their projects and clients are not always prepared to pay real costs. The underpinning QR funds are drawn ever thinner. Over thirty years, the grant and contract portfolio has grown faster than the core funding and cannot now play a serious part in both compensating for funding shortfalls and enabling management room for manoeuvre.

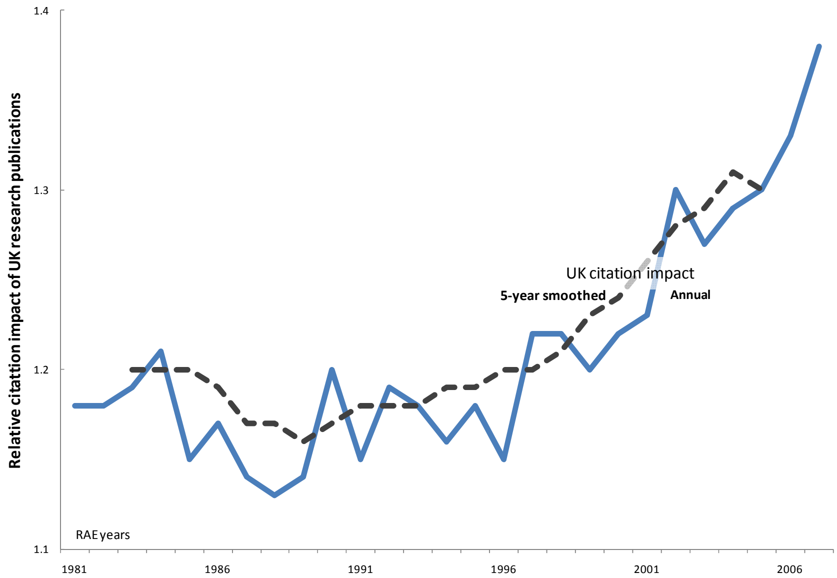
Figure 12. The relative growth of core QR research income awarded in the Funding Council block grant and the research income acquired through specific grants and contracts.



Research evaluation was introduced in 1986. This meant that the generic resources distributed to the university research base were progressively more selectively distributed to those institutions with units that performed well in each assessment exercise.

Over the same period the quality of the UK research base has progressively increased. This association between assessment and performance may be due to a number of factors, of which improved research management focus may be one. Enhanced competiveness within the system may be another. But a consequence may be the tendency referred to above to take on additional research opportunities at any cost.

Figure 13. The change in the average citation impact of the UK during the period when university research assessment was introduced and implemented. The first RAE was in 1986.



The resources are not distributed evenly across the system. They are clearly concentrated in a relatively small number of institutions. The 'golden triangle' refers to just five institutions in Cambridge, Oxford and London (Imperial, University and LSE) and they acquire an exceptional share of total available resources.

Figure 14. The breakdown of research income to UK universities by sub-sector.

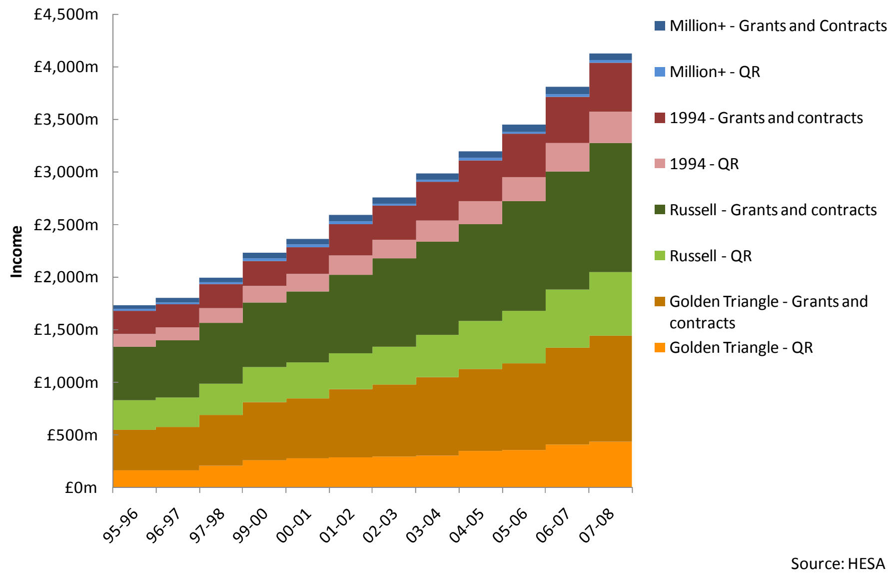


Table 2. Distribution of research income by sub-sector in 2008

	Funding Council QR	Grants and contracts, total
Golden triangle	£87m	£200m
Russell Group – 5	£30m	£61m
1994 Group	£15m	£24m
Million+	£1m	£2m

Source: HESA

Selectivity and diversity

The degree of concentration and the growing relative scarcity of resources provoke a series of policy questions. Should the degree of resource concentration be promoted as a benefit to competiveness or reduced?

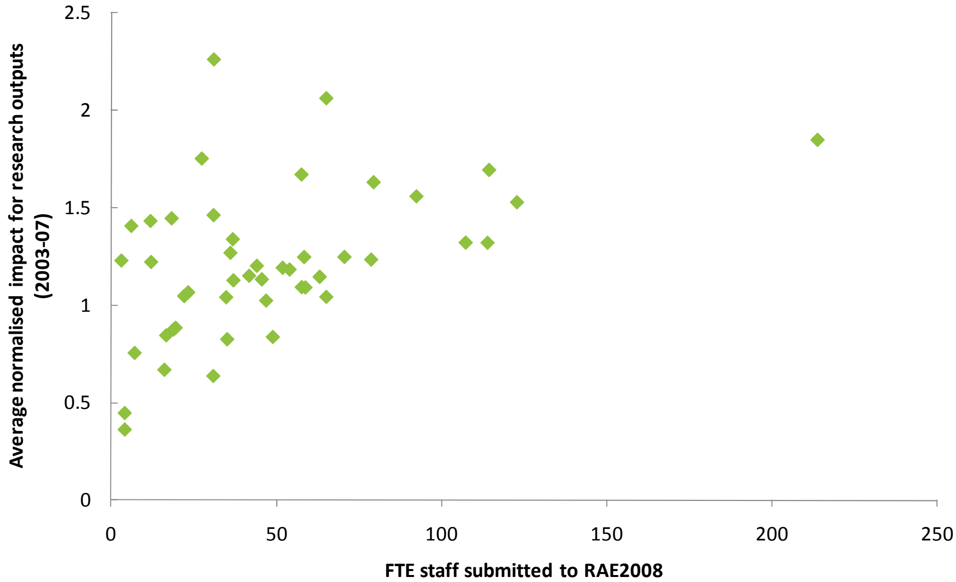
Economic forecasts suggest some inevitable increase in selectivity and increased competition for funds. If research continues to increase in costs then individual research grants must increase in size to be viable and that means fewer grants. How might selectivity be modified through policy?

One argument frequently put forward is that benefit accrues through scale. Not only is there little evidence for this but the argument is usually labelled wrongly anyway as 'critical mass' which would properly refer to some minimum size threshold for effective performance. There is in fact no argument for concentration on scale alone.

Extensive analysis shows that while larger units (in terms of research staff) generally have high average impact and high relative income there are smaller units that perform equally well. If the data are analysed only statistically then correlations emerge because it is very rare for a large unit also to have poor research performance, probably because it is managerially infeasible to support such a unit. Observation of the same data shows the spread of good units across the size spectrum, and the spread of performance among small and medium units.

The graph here illustrates data for UoA14 at RAE2008. Each icon represents an individual university that made a submission to the RAE. The units with the highest citation impact for their publications over the prior five-year period are in fact among the smaller units submitting to the RAE.

Figure 15. The average citation impact of universities across their biological science publications compared to the number of staff they submitted in UoA14 in RAE2008



Data & Analysis: *Evidence*, Thomson Reuters

Although we reject the general argument about a strong dependency in scale-related performance, we find that a meta-analysis across UoAs does indicate a relationship of some kind between larger units and relatively high citation impact (as a proxy for performance). It is not strong, and it would not be a sound basis for policy in itself but it requires explanation.

There is evidence from studies by the European Commission and by SPRU (University of Sussex) that research groups of around eight people are frequently associated with relatively good performance, while smaller teams tend to be under-resourced and large teams tend to split. Very large departments are made up of groups of smaller research teams and co-location may provide synergistic benefits. Thus, some scale benefit may emerge within the system driven by diversity but not by size alone. The real presence and the functional nature of such diversity remain unevaluated.

In our evaluation of national research performance we have drawn attention to the role of diversity in the research base as a whole. Diversity of performance across subject areas provides the capacity to respond to unforeseen opportunities, so it makes the research base flexible and dynamic. Specialism and resource concentration on a few, selected areas can provide short-term boosts to performance but this is not necessarily sustained as priorities shift. Capacity takes time to grow, and to disperse. The UK research base is characterised by a relatively high degree of diversity, researcher-driven rather than policy-driven, that has helped to sustain the UK's overall competitiveness. It is important that this is maintained since we cannot predict where new threats and opportunities will arise.

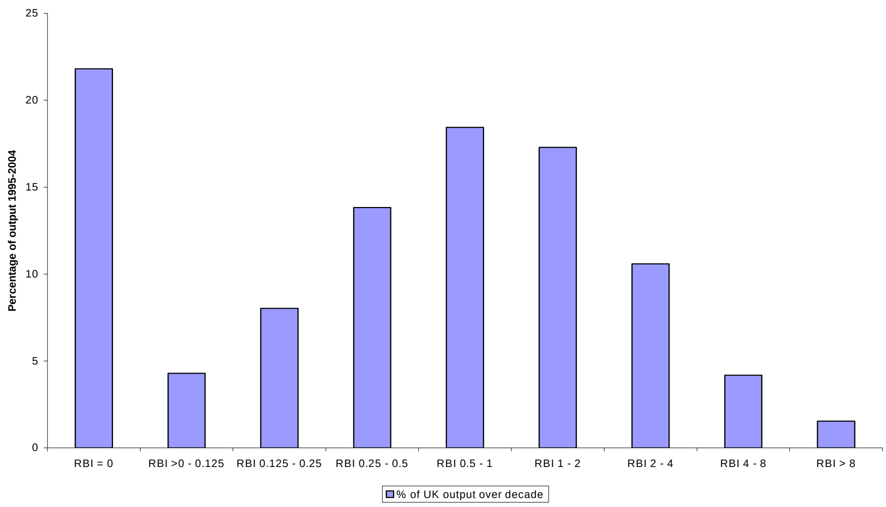
Diversity is also present nationally across regions. The UK has a network of high quality research capacity that means that no region lacks a major university with significant research capacity and a substantial annual output of trained and highly skilled people with research competency. This is a further strength that deserves some safe-guarding since it enables retention and attraction of knowledge-based industry to any part of the country.

Distribution of excellence

The UK's average research performance indexed by citation impact is high, often second only to the USA. But the average is only a single data point which covers many hundred thousand papers in any ten-year sample.

We can also look at the distribution of quality across publications. The Impact Profile® below takes a ten year sample of the UK's output of journal articles and reviews (not notes, editorials and marginalia which are less likely to be cited) recorded on the Thomson Reuters 'Web of Science'. Each paper's citation count is normalised for the year and field in which its journal is published. It is evident that despite the average (which is skewed by very frequently cited papers) the UK median is well below world average and many papers are uncited. Some of those will be relatively recent publications that will be cited later, but about 10-15% of publications in the UK (this varies by field) will never be cited, even by their authors.

Figure 16. The spread of citation impact, as a proxy indicator of output quality, across a ten-year sample of UK publication output. Only a small part of UK output has exceptional academic impact whereas much is cited less frequently than world average.

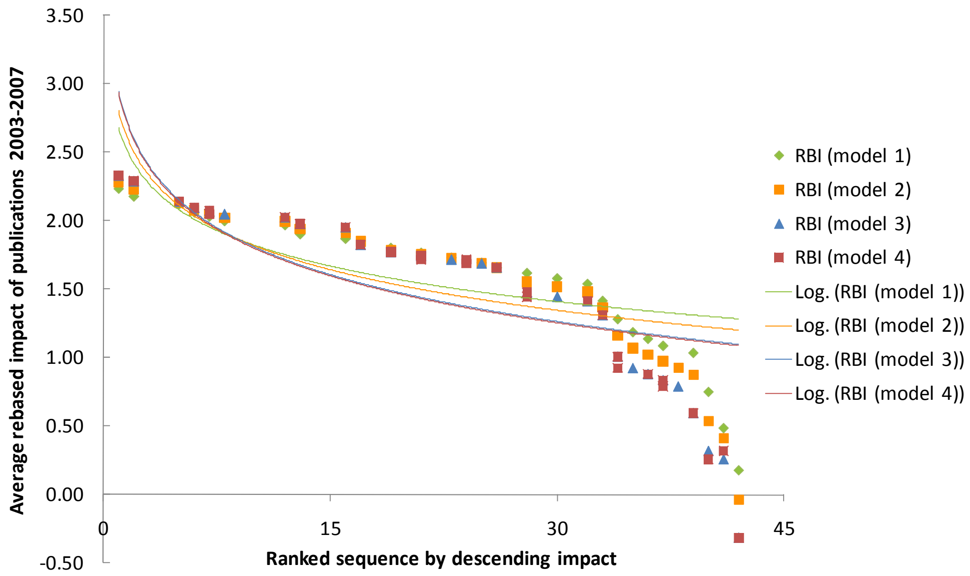


This spread must not to be taken to indicate either that the UK is 'worse' than we thought or that it is exceptional. The USA has a similar profile. But this does show that there is a significant amount of research activity that is less than exceptionally regarded by other academics in the same field. Not everything we do is world class.

The spread of excellent, good and weak research is uneven at all levels. RAE2008 revealed small pockets of excellence in departments, sometimes in institutions, where most research was more modestly graded. Other data show that in most subject areas there are a few units with outstanding average performance, units which spread across the middle-ground of UK performance and are often above world average, and units which perform less well.

The data below are for UoA19 Physics. They illustrate two things. First, the presence of a few units of very high impact, with an average more than twice the world average. This is accompanied by a 'platform' of units of progressively lower impact but nonetheless of clearly above world average performance. Finally, there is a sharp drop into a 'tail'. The graph includes four different versions of a model that explores the effect of altering current funding allocations on the projected impact of these units. This shows that while a more concentrated pattern of funding would certainly impact on the tail this has no benefit to the platform and it is difficult – though not impossible - to raise the peak much further.

Figure 17. The spread of performance, indexed as citation impact, across Physics units submitting to RAE2008, modelled under a series of scenarios to explore the likely effect on impact of more selective funding models.



Data & Analysis: *Evidence*, Thomson Reuters

This pattern is then replicated at institutional level where, as noted above in regard to income, five HEIs stand out ahead of the rest while the middle ground is contested by a diversity of institutions from different interest groups.

It is difficult to establish what benefit is obtained from continuing to distribute funds across the system as a whole if activity which is globally competitive is actually constrained to just some institutions. No analysis on the contribution of different institutions to the UK profile has been made. The golden triangle have both excellent and less good outputs, but it is not certain whether less successful institutions have a similar spread of both poor and excellent papers.

Funding scenarios

It might be argued that the UK research base has become too big. It is over its 'natural' capacity and people and activity are being supported that make little contribution to beneficial national outcomes. It is producing more research but not always better research. It could be able to provide a better return to and receive more support from government if it reduced capacity and focussed resources on the high end among students, researchers and institutions.

Most researchers would agree that resources should always be directed to the work that is most likely to produce an academically excellent outcome. However, they would prefer this to be seen to be done in an equitable fashion in relatively small packets, by peer review of project grants and through research assessment panels.

The downside is that the differential between packets is eroded. The difference between assessed grades is seen to be unduly great, so systems are changed to create more 'even' distributions. Too few grants are approved, so average grant sizes are reduced to enable more to be funded. There is a clamour for more research studentships, so the funding is spread across more awards.

There is an argument for reducing the number of packets and making each packet more rewarding. A smaller number of better funded studentships would be a way of ensuring that there was a stronger filter at the entry point to a research career and many well-motivated individuals would be redirected elsewhere in the economy at an early stage, with benefits to other sectors. A smaller number of fully-funded grants from Research Councils would ensure that successful applicants had all the resources required to deliver high quality outcomes, perhaps accompanied by more rigorous evaluation of what they delivered. And within institutions there should be a more explicit agreement to ensure that any contract, from Research Council, charity or industry is always fully costed and the funds made available. What that means is that every loss-leader contract must be matched by a more rewarding contact elsewhere, preferably within the same unit operating on sound business principles. Only by accepting that the 'business' overall has to adopt proper accounting can stakeholders be convinced that university research is not simply expecting others to pick up the bill. We cannot do everything we want to do.

Institutionally, we would ideally have a model that analysed the relative costs and benefits of shifting money between high and low performing units but research is an unpredictable process and no such model can sensibly be created for university portfolios. In the graphical illustration of our analysis for Physics (shown above: this has been repeated for other subject areas) we have analysed the effect of withdrawing research resources from units that are relatively uncompetitive by sharply increasing selectivity and weighting differences.

The funding conundrum is that, on the one hand, trawling money from the low-output end will have a deleterious effect on morale with apparently little benefit to the internationally competitive end but, on the other hand and for the research base as a whole, the objective should be to sustain the top end because if the contribution at the highest level slips then the national profile may be irreparably damaged. The small improvement in the outcome for the very peak may be worth buying because it is this 'edge' of really competitive work that can lead to the greatest economic and social impact as well as academic impact.

An alternative scenario is to shift resources from the relatively better funded centre. This would 'push out' the ranked funding curve by moving resources out of the middle to the better funded units. But this would be even more deleterious than raiding the least competitive because it would undermine research that is well above world average without producing an equivalent gain.

The gain challenge arises because the very best research is incredibly expensive. Each successive step in research becomes more challenging, and the challenge is reflected not only in intellectual but in technical and financial demands. Nonetheless, it may make sense to sacrifice a substantial amount of modest research to support a small amount of world class research if that is part of a rebalancing of current effort to secure public and policy support for the research base as a whole.

The UK benefits from a unitary system, but unmoderated logic means misery for all as well as common policies for all. It may be time to consider whether policies that have overtly differential effects and benefits may have a role.

One scenario would be to introduce the concept of capacity thresholds. For example, following the research at SPRU which indicated the optimal size for research units, it might be appropriate to set a funding threshold at a minimum of eight active researchers in a unit or some minimum of excellence. An argument against this is that it takes time to build capacity and such a regime would stifle the flexible growth of new research capacity. This raises the question of whether new and innovative units appear in isolation, possibly then being acquired by larger and established units, or whether they normally appear within existing centres of excellence. No data exist on this.

An alternative threshold would be based on a minimum level of excellence, which would rule out the allocation of odd pockets of funds to isolated elements as happened after RAE2008. A total of around 2400 submission were made at RAE2008 across all Units of Assessment. There were fewer than ten units submitted that were judged by peer review panels to have both as much as 10% 4* and yet still have less than 25% at 3* + 4*. However, there were 350 units that had just 5% at 4* and yet also 25% or more above 2*. Funding thresholds could be set to exclude either of these. Alternatively a combined threshold could be utilised with effect: some 500 units had 5% or less at 4* and less than 25% above 2*. A combined threshold of a minimum of 10% at 4* and 25% at 3* or above, below which funding would not be triggered, would therefore remove a fifth of units from the research pot. If some way were found of also discouraging these from submitting in the first place, a great deal of work could be saved.

Compensatory scenarios

This report is about research and research funding, not about the university mission as a whole. But research is pursued in the context of the whole mission and it is infeasible to identify scenarios that benefit research performance without suggesting how, in a unitary system, some differentials might also apply in a compensatory fashion to other objectives. The problem has been, after all, that all institutions have pursued what appeared to be the single most obvious variable in the system.

The most obvious shift in resources would be to direct funding for student places towards access and inclusivity and thus compensate those more effectively reward those institutions that had made this a core and successful part of their mission.

Research excellence is a concomitant part of a global profile. A removal of the cap on student fees would allow those universities that did concentrate on research excellence also to assert their wider global branding and to acquire significant resources from teaching. That is anathema to the UK's traditional approach since it implies exclusivity and access by finance rather than merit. This would therefore necessarily be conditioned by a clear programme of scholarships to enable breadth of quality intake which would in any event be a concomitant part of maintaining the brand of excellence.

The balancing policy shift to a removal of the fee cap would, as indicated, be a shift of a greater part of current student-based funds to an explicit and substantial resource system for those institutions which demonstrated commitment to an access agenda through local and regional inclusiveness, an agenda where they would face reduced competition from those choosing international competition. If any institution were able to balance both agendas successfully then they should of course be rewarded for doing so, but it seems unlikely.

There is no imposed direction here. The policy options remain available to all. But there are clear packages. Those institutions that are likely to pass the quality-capacity threshold on research and can likely charge higher fees will focus on one part of the HE mission and drive up their achievement on that agenda. Those not following this route will be freed to focus on another part of the agenda which should now be much more richly rewarded with significant public benefit and economic impact. Indeed it has been argued in the USA that it is by focusing on their strengths, and those of their staff, that universities are most likely to emerge in a strong position from the current period of fiscal tightening.[118]

[118] Auer Jones, D. (2010) *Financial pain should focus universities* Nature **465**: pp. 32-33.

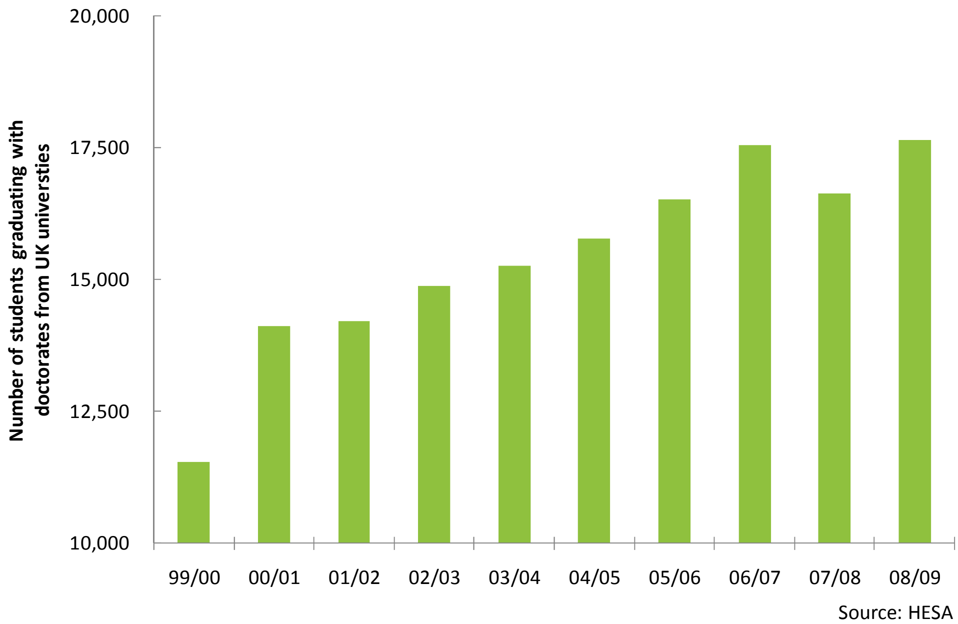
Universities and the competency of the workforce

The role of the university research base in the creation and development of a knowledge-competent workforce, and the importance of skilled and able people to the economy, has been a theme running through the previous sections of this document. Able people who have developed in a research-rich environment are, we have asserted, the most important route to impact in the broad economy. People are also the most effective mode of collaboration with partner universities in other countries. So we need more people heading out into the economy and we need more researchers heading out into the world. In both cases, their subsequent return to the university research base would be an added bonus.

People are universities' most important output

A primary output from UK universities is a supply of talented and trained individuals. At the highly-skilled levels these are people who have worked and trained in the research base; a richer research environment will be associated with cutting-edge knowledge awareness and competency.

Figure 18. The number of doctoral students graduating from UK universities has increased by over 50% between1999/00 and 2008/09.



This attribute is one of the ways in which the university-based system can outperform an institute system. People who have undertaken advanced research training in universities then spread out through the economy, with huge potential to add value in knowledge exploitation to employing organisations.

Critically these individuals are also able to articulate real world problems back to former colleagues in universities. If industry has a problem in making use of what the research base produces that may arise in two ways. It may find it difficult to identify and articulate the problem in the first place, which makes it difficult to conduct a dialogue with universities. It may find it difficult to acquire and exploit the knowledge that would provide a solution because it lacks the innovative capacity.

So industry needs more skilled and research-competent people. It needs to attract them by providing appropriate salaries and career structures, and it then needs to use them in the right place and with sufficient empowerment. One of the explicit ambitions of the Science & Innovation Investment Framework 2004-2014[119] is for a "strong supply of scientists, engineers and technologists"[120] and we are currently at the point within the economic cycle (given the state of the world and UK economies) when nationally we should be investing heavily in research training. Other commentators[121] concur with this conclusion, suggesting that a prime determinant of the way in which countries emerge from the current financial crisis will be their stock of human capital and their consequent ability to re-structure in response to new conditions.

People are also the critical input

As well as being the most important output of the university research system, competent and motivated people are also the most critical input. One way in which an institution can maintain its competitiveness is by recruiting and retaining the best people. Research assessment has been shown to have been a major driver leading to much more focused management of the entire research process within universities,[122] and one key area here is sharper management attention on people (in terms of both recruitment and retention / development). Measures to address the need to develop researchers include the Concordat to Support the Career Development of Researchers[123] which has "[equipping researchers] to be adaptable and flexible in an increasingly diverse, mobile, global research environment" and "the importance of researchers' personal and career development, and lifelong learning, is clearly recognised and promoted at all stages of their career" as two of its seven key underlying principles.

We argued earlier that this becomes increasingly important as research intensive universities now enjoy a freedom to engage with global markets in terms of attracting the most able and talented researchers to the UK research base. Where UK universities can recruit from wider markets they need to be able to assert their 'brand' and their research profile and the opportunities this implies will be a key part of that message. At the same time, the global war for talent also means that institutions outside the UK are seeking to attract the best researchers currently working within the UK to move overseas.

University culture downplays its role in training people for the wider world.

A proportion of those who have undertaken research training to PhD level at universities move on to careers within academia. A larger proportion go on to work in non-university research

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[119] HM Government, *Science & innovation investment framework 2004-2014*. 2004.

[120] Another headline conclusion from the Royal Society report.

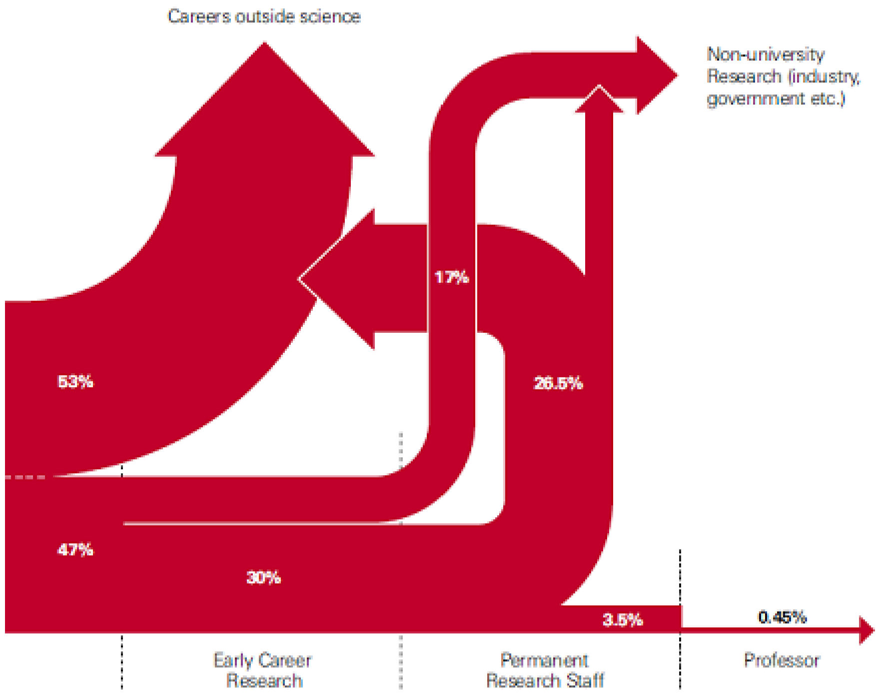
[121] e.g. Dirk Van Damme (2010) *The global economic crisis and higher education* OECD http://communications.nottingham.ac.uk/SiteData/Root/File/Resources/Lord%20Dearing%20Memorial%20Conference/Van%20Damme%20Global%20economic%20crisis%20and%20HE.pdf

[122] Higher Education Policy Unit, University of Leeds (2000) *The Role of Selectivity and the Characteristics of Excellence.*

[123] The Concordat to Support the Career Development of Researchers (2008) http://www.researchconcordat.ac.uk/documents/concordat.pdf

environments, but the majority of such individuals move into non-research careers. The diagram below[124] illustrates the transition points following a PhD and shows the flow of scientifically trained people into other sectors (based on data from HEFCE, The Research Base Funders Forum and HESA).

Figure 19. The Royal Society analysis of the career flows in and out of the science base.



The dominant culture within academia does not always recognise or support the true nature of most people's careers. The implicit – and sometimes explicit – assumption is that the best researchers should expect to stay in academia. One example of this is from the way that *The Scientific Century Report* tells us that "only a tiny proportion of PhD students can expect to end up as university professors", without suggesting that this is a probably just as well, while the Council for Science and Technology[125] suggests that following a masters degree the 'best and most committed' people proceed to a doctorate.

Too often leaving university with 'just' an MRes is portrayed as a sign of 'failure'. For many people, and in many circumstances, an M.Res. followed by two years in a non-university environment may be a more useful career track than the pursuit of a PhD. The academic community inevitably provides the environment in which young researchers make these career decisions and this needs to be done in a balanced way.

Trained people can align research with the needs of users

Another ambition for the Science & Innovation Investment Framework is for the UK to achieve "increased business investment in R&D, and increased business engagement in drawing on the UK science base for ideas and talent". People who come from, or move between universities and other

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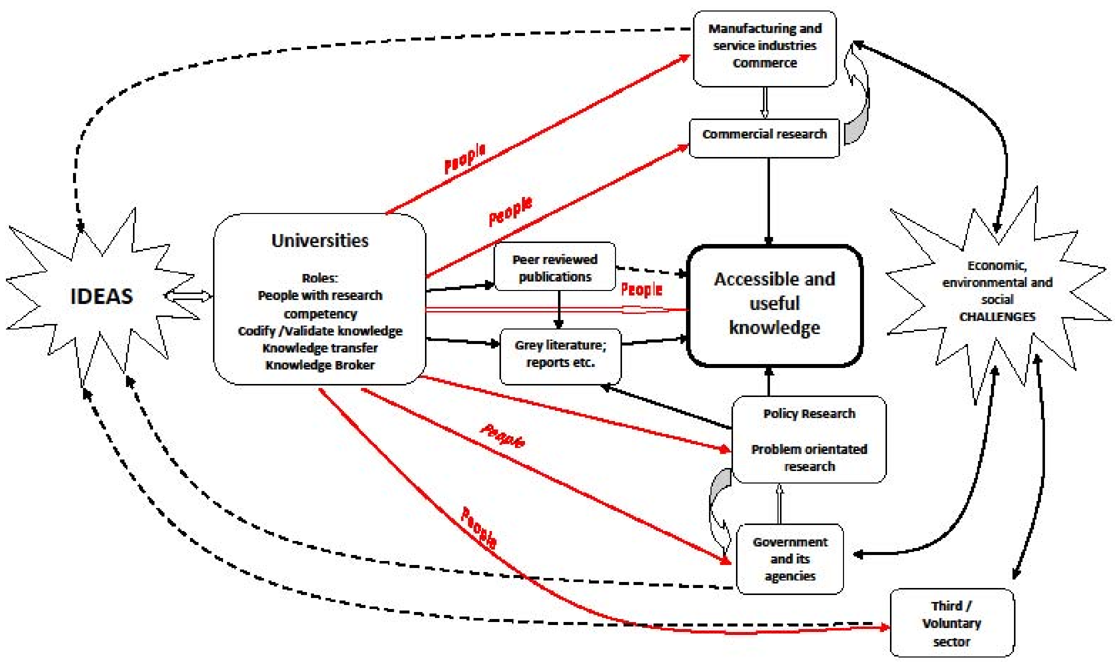
[124] From Royal Society, 2010. *The Scientific Century – securing our future prosperity* – p14
http://royalsociety.org/the-scientific-century/
[125] Council for Science and Technology (2010) *A vision for UK research*, para 56
http://www.cst.gov.uk/reports/files/vision-report.pdf

parts of the economy have a critical role in developing a more productive relationship between research users and universities in the UK. In our section on the relationship between universities and stakeholders we refer to a repeated misunderstanding in this relationship. Too often university researchers are seen (by industry and others) to be producing answers to the 'wrong' questions, while research-users have not worked out exactly what it is they need from research. With many research challenges analysing and articulating the research problem is at least as difficult as finding the answers – another reason why as a nation we should be encouraging the 'brightest and most committed' to move beyond a university environment.

The diagram below identifies some of the weaker links in the way university research engages with society's needs. It illustrates the way that trained people can short-cut these. One exception which tests this analysis is medicine. Health professionals expend considerable resource on interpreting medical research into a format where it can be quickly picked up across the health community. But the 'people' analysis holds good here, as clinicians / researchers within medical schools straddle the research / user boundary.

Figure 20. Knowledge-based links between research producers and users. The people links are stronger than other knowledge flows.



Mobility between sectors

At early career stages researchers typically move from one HEI to another, and frequently from a university research environment to a non-university research environment. It is less common (though not of course unknown) for people to move back into a university research environment from outside. This is partly because - in many disciplines - it is unlikely that an 'outsider' would perform at the highest level when measured against purely academic criteria. One challenge for the universities is to seek new ways in which they can remain engaged with the best and the brightest as their careers develop elsewhere. This can be achieved through research collaborations outside the university sector, or it could also be done by bringing people back into the university, on an occasional basis, to act as mentors from the 'real world' for the next generation of researchers .

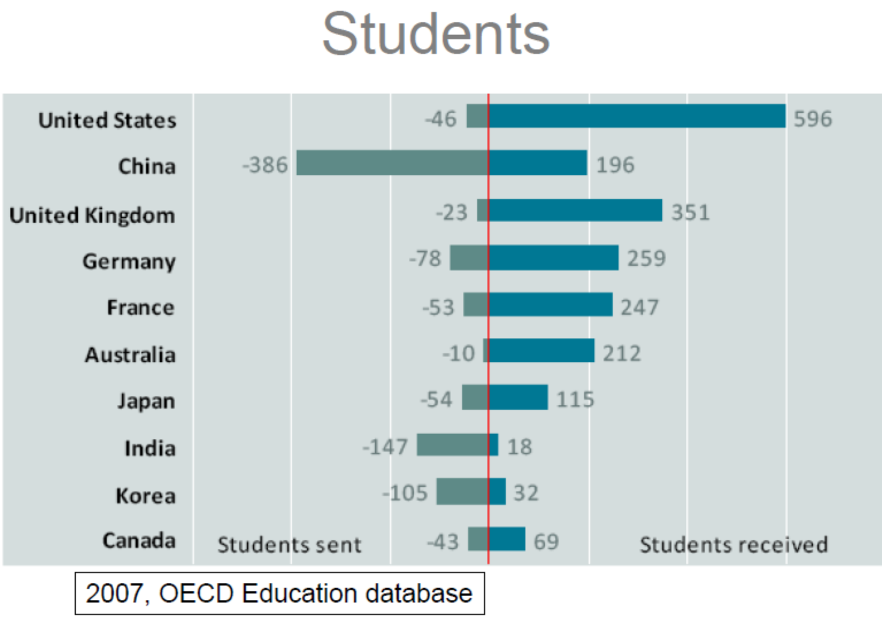
Developing a research workforce with an international perspective

We have shown elsewhere (in our study for HEPI on researcher mobility)[126] that there is a correlation between the most highly cited authors and researchers who have spent part of their career working overseas (either as a fully fledged academic, as a post-doctoral fellow or as a PhD student). Given anticipated changes in the international research environment (for example the way in which growth in Chinese research has been matched by an equal growth in international collaboration[127] - see our international section*)* it will become increasingly important for the UK research base that a much larger proportion of academic staff have substantive overseas experience, contacts in other research economies, and at least a rudimentary ability in a foreign language. The danger otherwise is that the great opportunities this sort of development offer for UK researchers will be lost.

Major cultural change is required within universities, as well as in society more generally, if the UK is to meet the ERA target of 20% of EU doctoral candidates working outside their home country.[128] In terms of this measure it would appear that the UK lags well behind most other European countries. The diagram below[129] presents data for the UK student body as a whole, but there is no reason to suppose that the pattern for post graduates is any different to that seen for undergraduates.

[126] Adams, J and Gurney, K A (2005). The impact of international mobility on UK academic research. Report to Higher Education Policy Institute, Oxford.
[127] Adams J, King C and Ma N (Nov. 2009) Global Research Report: China. Thomson Reuters, Philadelphia. http://researchanalytics.thomsonreuters.com/m/pdfs/grr-china-nov09.pdf
[128] ERAB (2009) Preparing Europe for a New Renaissance. A Strategic View of the European Research Area 1st Report of the European Research Area Board. http://ec.europa.eu/research/erab/pdf/erab-first-annual-report-06102009_en.pdf
[129] Taken from Dirk Van Damme (2010) *The global economic crisis and higher education* OECD http://communications.nottingham.ac.uk/SiteData/Root/File/Resources/Lord%20Dearing%20Memorial%20Conference/Van%20Damme%20Global%20economic%20crisis%20and%20HE.pdf

Figure 21. The trading balance in students for various OECD countries



Addressing the reluctance of UK students to study abroad will require strong incentives. One way might be to offer a premium on a three-year studentship when at least 12 months are spent studying in an overseas university. An even larger premium could be offered to those who choose to spend part of their PhD period working in one of the emerging research economies.

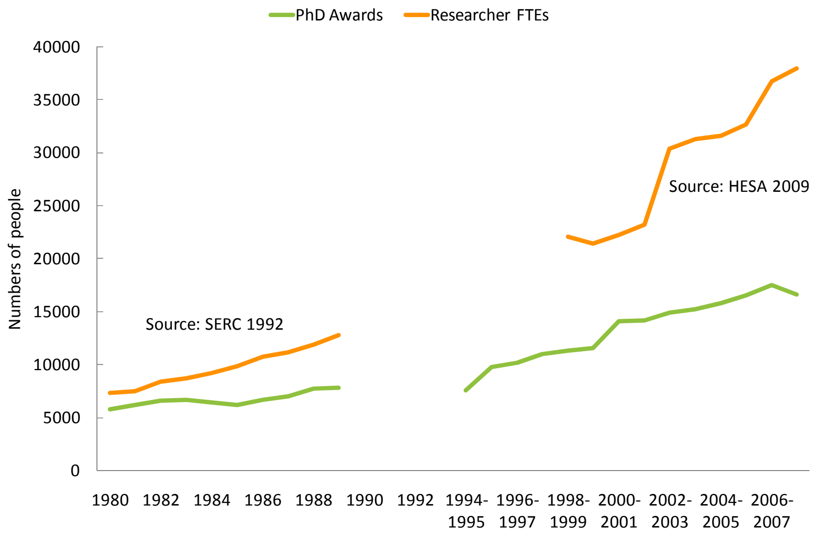
Diversity amongst research staff

The UK benefits enormously from the large number of academics from overseas who choose to work in our universities. Amongst other advantages, this is one way in which UK research maintains an international perspective. As the research base in the large emerging economies (China, India, Brazil) develops it is quite possible that a significant proportion of these individuals will choose to return to work in their countries of origin and future flows may be much reduced. The same driver may drastically curtail the number of postgraduate researchers from overseas who choose to spend part or all of their training period in the UK.

Unsustainable growth of uncertain merit

Alongside the evidence relating to insufficiency of funds and over-trading, the university research system has been naturally disposed towards growth. Increasing the number of people involved in research appears to have overridden internal considerations of quality. In cycle after cycle there are demands for expansion, of more research students, of more posts for PhD graduates, of longer research careers.

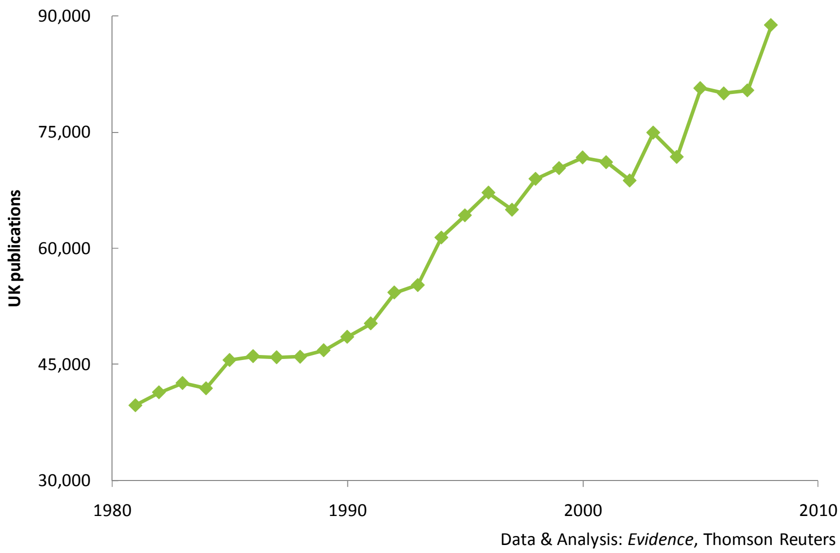
Figure 22. Numbers of PhD awards per year and FTE researchers in UK universities by year from 1980 to 2007-08.



These data raise a number of questions. Between 2000 and 2007 it can be seen that researcher capacity increased by approximately 85%. This is a rise from around 7,000 researchers in 1980, which had increased to around 13,000 researchers in 1990.[130] The progressive increase seems inexorable.

Over the period 1981-2008, the volume of UK publications roughly doubled as shown in Figure 23. Output has thus not risen in line with capacity measured by researchers. More importantly, UK research impact has increased only gradually against world average over the last fifteen years. Average world impact has increased over the same period, but it is nonetheless disappointing that this large increase in researcher capacity has not improved our position even further.

Figure 23. The volume of publications by UK authors has risen from 39,697 in 1981 to 88,824 in 2008.



[130] Atkinson H, Bond R and Mullins P (1992). *An anatomy of research personnel in UK universities*. Science & Engineering Research Council, Swindon. ISBN 1 870669 23 1.

It is unclear whether the system benefits from a plethora of researchers, some of them potentially inadequately funded, and the data raises a number of questions. What is the purpose of doubling researcher numbers in a decade? Can the quality of those involved have been maintained and has the volume of quality research (irrespective of citation impact) grown to keep them properly occupied? There must be legitimate basis for reviewing whether it is in fact desirable for the system to proliferate in this way and whether this is necessarily to the long-term benefit of the system, the economy and society or, more pertinently, the individual.

People and the future of research

Only universities can create the supply of skilled and competent people that then future economy needs. These people need to start their career development in a rich knowledge environment which can only be found in a research-strong university.

Mobile young researchers are also the most effective route to links with research users and with research partners elsewhere in the world. By travelling out into other sectors and countries and then returning they also reinforce the knowledge flow and help to build intellectual capacity about research, and about research challenges, elsewhere.

Universities must work to develop the talent they have and to clarify the opportunities that exist. There is a valid concern that universities still position academic research as the career choice for the brightest and best, which by implication allots only the less good to alternative careers. This is an unreasonable position to take. Not only does to provide a disbenefit to those who hang on in research careers beyond a point where they can make a successful transition but it also perpetuates and strengthens the demand for additional research-based positions, adding to capacity and output volume without necessarily adding to quality.

Asserting the value of alternative careers and enabling some of the very best to move rapidly into other sectors will provide a general economic and social benefit as well as supporting individual development. Such alumni may come to recognise the opportunity they have been given and seek to provide a loop back into the system.

Summary

The environment within which university research now operates is different from that in which the UK system evolved and is set to change considerably more over the coming decade. Universities will need to respond to these changes (or those that don't will surely diminish in status). The UK university research base approaches these challenges from a position of considerable strength but its historical position must not become a trap.

The core values of universities protect a culture which distinguishes university environments from other research environments. These include an innate dynamic responsiveness not found elsewhere. At the same time, university research will need increasingly to demonstrate its connection with utility, and the response to this must include a discussion on the nature of research, drawing attention - for example - to the way in which economic or social impact can derive from mission-led research.

The research base must accept that knowledge balances and financial accountability mean that it needs to rethink its external relationships, with stakeholders inside the UK and with international partners in Europe and elsewhere. The balance of resources may also need to change, not dramatically but through multiple smaller shifts. But the most important rebalancing is about people, what people gain in competence and potential while in the research base and their overarching significance as a driver in the economy. The university can gain by pushing [some of] the best and brightest to seek careers elsewhere.