

PROFESSOR NIGEL THRIFT

VICE-CHANCELLOR

UNIVERSITY OF WARWICK

**RESEARCH CAREERS IN THE UK:
A REVIEW**

Executive Summary

- i. Researchers form a fundamental element of the supply of skills which will be required if the UK is to maintain its leading position in the world.
- ii. The UK government is concerned that research careers are not always perceived as attractive by the best graduates. This review seeks to establish whether this is the case and, if so, why the situation exists and what can be done to improve matters.
- iii. Although the review concentrates on researchers working within higher education, it recognises that the UK's research base is diverse, consisting of researchers not only in academia but also in the public sector, business and industry and the third sector.
- iv. The evidence suggests that it is crucial for government, research councils, universities and industry to understand that the supply and development of the next generation of world class researchers is affected both by the initial attractiveness of research careers *and* the retention and the advancement of the most talented researchers (from the UK and overseas) at subsequent levels.
- v. Equally, the evidence shows that today's researchers are part of a research architecture which spans the globe. Researchers are more mobile than ever before and a "brain drain" of both promising and elite researchers from the UK continues to be a clear and present danger. The report highlights that international competition will continue to intensify and the UK may be left vulnerable if it does not take more decisive action in certain areas.
- vi. The review adopts a longitudinal approach to research careers starting from when pupils in school start to make early choices about the direction of their career through to the influences on the careers of the most senior researchers.
- vii. The review focuses most attention on the early stages of research careers, paying special attention to the influences on pupils' in secondary schools, continuing through the higher education experience, into doctoral research, finally focusing on early and mid-career researchers.
- viii. The Review concludes that the current system is working reasonably well. Thus it does not propose a complete overhaul, nor does it seek to override any of the developments currently in train. Rather, the review attempts to identify those pinch points at which the current system is not as effective as it might, and a set of policies which might improve the situation.
- ix. In particular, the review identifies a need for the UK government, universities and research councils to establish a more sophisticated understanding of the supply and demand of researchers across all sectors and disciplines so that policies can be better targeted.
- x. The message of the review is straightforward. Many initiatives are currently either in place or being put in place but they need stitching together and supplementing in order to provide coherent policy that covers all stages of the research career. For the health of the UK research base 15 years from now, it is imperative that this process is started.

Recommendations for Government

- 1) Government should establish mechanisms to develop a more sophisticated long-term understanding of the supply of and demand for researchers across all sectors and disciplines.
- 2) Government should work through existing programmes and international relationships between universities, learned societies and professional bodies to identify and support talented young scholars from around the world.
- 3) Government should work in partnership with universities and industry to extend existing scholarships for high-quality international postgraduate students wishing to study in the UK.
- 4) Government should establish a working group comprising senior stakeholders with an interest in university-business collaboration, and specifically the transferability of researchers, to take forward a Lambert Agreement Round 2.
- 5) Government should consider the introduction of industry match-funding awards for early career researchers.

Recommendations for Research Councils, Grant-Awarding Bodies and Subject Associations

- 1) Subject associations should work in partnership to promote careers in research at an early stage by working more intensively with school teachers to inform them of the possibilities for their pupils.
- 2) Research councils should work with universities, research institutes, charities and industry to develop a national Research Experiences Programme for undergraduate students.
- 3) The Roberts funding for universities should be sustained over the long-term to ensure high-quality researcher development programmes become embedded across the sector.
- 4) The research councils should develop consistent mechanisms to record the demographic characteristics of their researcher communities and track successful early career researchers across specific disciplines in order to inform future funding strategies for early career researchers.
- 5) Research councils and grant-awarding bodies should consider the provision of awards of longer-duration for early career researchers, providing high-quality performance is demonstrated.

Recommendations for Universities

- 1) Universities should consider whether the widening participation agenda applies to postgraduate study and, if so, what might realistically be done to improve matters.
- 2) There should be wide dissemination of the good practice which already exists in some universities with regard to holistic support for postdoctoral and early career research staff.
- 3) Universities should consider whether they could do more to encourage greater transferability of researchers between academia and industry where appropriate.

CONTENTS		Page No.
PREFACE		4
PART 1 – INTRODUCTION		6
1.1 The Brief		6
1.2 Policy-Making Bodies		6
1.3 Key Reports		7
1.4 Current Context		7
1.5 UK Comparative Position		8
1.6 Demand for Researchers in the UK		9
1.6.1 The Demand for Researchers in Academia		10
1.6.2 The Demand for Researchers in Business and Industry		11
1.6.3 Understanding Future Demand		12
PART 2 – RESEARCH CAREERS: A LONGITUDINAL PROFILE		13
2.1 Raising Awareness of Research Careers and Attracting Young Talent		13
2.1.1 Pupils in Schools		13
2.1.2 Undergraduate Students		14
2.2 Postgraduate Research Students		15
2.2.1 Trends in the Recruitment of Postgraduate Research Students		15
2.2.2 UK-Domiciled Research Students		17
2.2.3 International Research Students in the UK		18
2.2.4 Widening Participation in Postgraduate Research		20
2.2.5 Postgraduate Research: Motivations and Expectations		23
2.2.6 Progression Routes of Postgraduate Researchers		24
2.2.7 Gender Disparities		25

2.3	Early and Mid-Career Researchers	26
2.3.1	The Postdoctoral Experience	26
2.3.2	Female Researchers	29
2.3.3	Grants and Awards for Early Careers Researchers	30
2.3.4	Transferability of Researchers between Industry and Academia	31
PART 3 - CONCLUSIONS		35
3.1	Attracting and Retaining the Best World Talent	35
3.2	Concluding Remarks	35
3.3	Acknowledgements	36
3.4	Sources	37
APPENDICES		
Appendix 1	Year-on-Year Increases in Doctoral Students by Subject Area	40

List of Figures and Tables

Figures:

Figure 1	Longitudinal Profile of Research Careers	5
Figure 2	Researchers Per Thousand Total Employed 2007	8
Figure 3	Researchers Per Thousand Employed (Selected Countries 1980-2006)	9
Figure 4	Staff by Research Type Employment Functions - UK Sector Totals	11
Figure 5	Age Distribution of Academic Staff in 2003/04	11
Figure 6	Student FTE Postgraduate Research – UK Sector Totals	16
Figure 7	Percentage Change in the Number of Doctorates Awarded between 1995/96 and 2003/04	16
Figure 8	Doctoral Students by Subject Area and Domicile (2006-7)	17
Figure 9	Year-on-Year Percentage Growth in PhD Qualifiers by Domicile	18
Figure 10	Total Research Students by Institution (2006)	20
Figure 11	UK Domiciled Research Students by Institution (2006)	21
Figure 12	Percentage of Full-Time Undergraduate Entrants from NS-SEC Classes 4.5.6&7 (Russell Group and UK Sector Total)	22

Tables:

Table 1	What Do PhDs Do? – Trends	10
---------	---------------------------	----

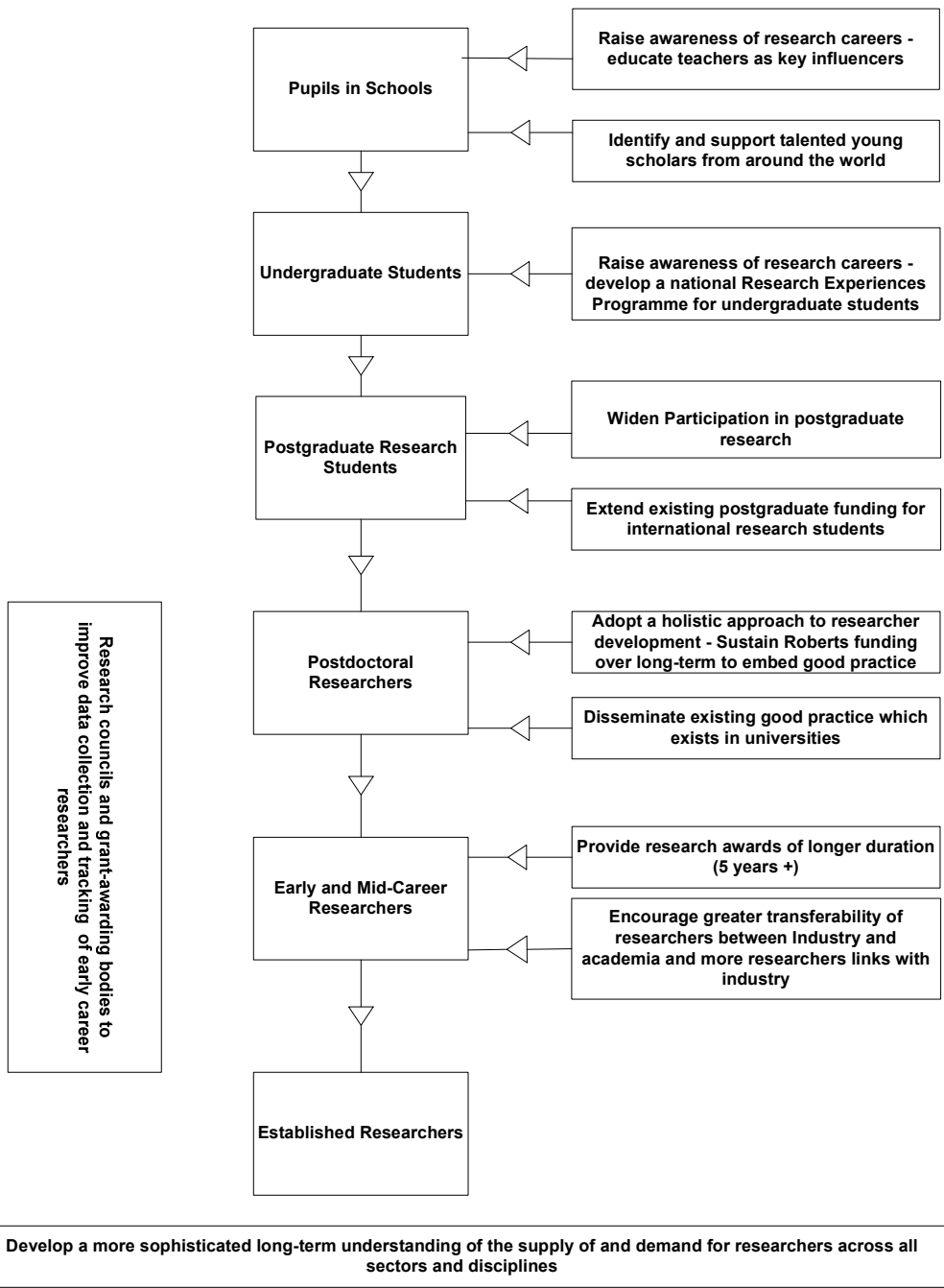
PREFACE

Researchers form a fundamental part of the supply of the skills required to make sure that the UK maintains its leading position in the world. Yet that supply is still too often taken-for-granted. This report considers the mechanisms that underpin that supply and how they might be better integrated and, where necessary, upgraded.

The report rests on three main principles. First, that research careers must be understood as a process unfolding over time. The report therefore takes a longitudinal approach to research careers in the UK, an approach which, for example, understands the initial attractiveness of research careers *and* the retention and the advancement of the most talented researchers (from the UK and overseas) at more senior levels as being part of the same problem. Second, that the UK's research base does not exist in a vacuum. The report therefore understands today's researchers are part of a research architecture which spans the globe. Researchers are more mobile than ever before and a "brain drain" of promising talent and elite researchers from the UK remains a clear and present danger. Third, that the UK's research base is diverse. Therefore, although the report predominantly addresses the state of research careers in higher education, it also acknowledges researchers working in government and the health service, research institutes, business and industry, as well as the growing body of researchers working in a third sector composed of various non-governmental organizations like charities, social enterprises, and think tanks.

The current system of developing researchers in the UK is working reasonably well. Thus this review does not propose a complete overhaul, nor does it seek to override any of the developments currently in train. Rather, the review attempts to identify those pinch points in the current system where it is not working as effectively as it might, and formulates policy which will help to ensure the UK's continuing research eminence 15 years from now. The report is in three main parts. The first part summarizes the general situation and includes an explanation of the brief, an overview of policy-making bodies and key reports, an assessment of the current context, an analysis of the UK's comparative position, and an appraisal of the demand for researchers in academia and industry. Following a longitudinal course, the second part of the report identifies key stages in the development and career progression of researchers where targeted interventions could support the development of a stronger research community in the future. The review focuses on the stages leading from pupils' experience in secondary schools through the experiences of early career researchers. These stages are those at which new interventions and policies are likely to have most influence. There is currently a much lower risk of established researchers dropping out of the system, not least because they are generally in positions of greater security. Figure 1 illustrates the key stages addressed by the report and the interventions and policies proposed at each stage. Finally, the third part of the report highlights the wider importance of attracting and retaining the most senior researchers from around the world in the UK and concludes with key messages from the review.

Figure 1: Longitudinal Profile of Research Careers



PART 1 - INTRODUCTION

1.1 The Brief

The UK government is concerned that the doctoral, postdoctoral and subsequent stages of research careers are not always perceived to be attractive by the best graduates. This review seeks to examine whether this is truly the case and, if so, to understand why the situation exists and what might be done to improve matters.

Thus, the brief was to:

1. Ascertain whether there is evidence to suggest that research careers are seen as relatively less attractive when compared with other career options available at key decision points and, if so, what specific issues give rise to this effect
2. Consider whether existing incentives exert sufficient positive influence on graduates, such that the supply of quality researchers is maintained
3. Determine whether research careers are sufficiently flexible (either in the context of research assessment or the expectations of host institutions), in allowing researchers to gain the necessary breadth and depth of experience and skills.

1.2 Policy-Making Bodies

There are several policy-making bodies with an interest in UK research and research funding. Some of these are government-based departments such as the Department for Innovation Universities and Skills (DIUS) and the Department for Business, Enterprise and Regulatory Reform (BERR). National policy is not only influenced by UK requirements but also by policy-making at European Union (EU) level.¹

The Council for Science and Technology (CST) is the UK government's top-level independent advisory body on science and technology policy issues. CST's remit is to advise the Prime Minister and the First Ministers of Scotland and Wales on strategic issues that cut across the responsibilities of individual government departments.

Of all the policy-making bodies in the UK, arguably the most important agent in the research sector is Research Councils UK (RCUK). RCUK exercises important influence on policy-making through its representation of seven research councils which have responsibility for supporting research in the major academic disciplines. There are also a number of powerful learned societies, trusts and charities, including the Wellcome Trust, The Royal Society, The British Academy, The Leverhulme Trust, Cancer Research UK, The British Heart Foundation and Diabetes UK. These trusts and charities provide significant levels of funding and a wide range of grants and fellowships and are highly influential within the UK research arena.

It is also important to mention the recently established Vitae (incorporating UK GRAD and HERD). Vitae works closely with the sector to support and enhance professional development for researchers in the UK (specifically postgraduate research students and early career researchers). Its Researchers' Portal is set to become a key information and

¹ Such as the European Charter for Researchers and the Code of Conduct for Recruiting Researchers.

dissemination point. In addition, Vitae supports the Rugby Team, a sector-led working group which reviews the effectiveness of skills development for postgraduate research students and early career researchers and is developing a policy framework.

1.3 Key Reports

The nature of the supply and development of the UK's next generation of world class researchers has been analysed and well documented, particularly in the past five years. The report by Sir Gareth Roberts *SET for Success*² identified a number of issues regarding the supply of people with skills in science and technology and made a series of recommendations. The Roberts Report took forward the earlier work of the Research Careers Initiative³ and the 1996 Concordat on career management of postdoctoral researchers. A number of actions to address the issues raised by the Roberts Report have since been implemented, including the so-called 'Roberts Money' for the development of wider skills amongst PhD students and postdoctoral researchers in universities.

The Leitch Review of Skills⁴ highlighted the importance of PhDs and post doctoral researchers as a critical resource for the UK and the Warry Report⁵ on the economic impact of research councils made further recommendations about the training of researchers. RCUK's Research Careers and Diversity Strategy (2007)⁶ seeks to address the goals of the Science and Innovation Investment Framework and sets out a range of planned future developments, including a longitudinal study of research students and a wider debate on the attractiveness of the PhD and the structure of early stage career paths.

Most recently, the Council for Science and Technology published *Pathways to the future: the early careers of researchers in the UK*⁷ which forms part of a larger study by the Council in to the vitality of UK research and its readiness to face the challenges of the future.

1.4 Current Context

It is widely acknowledged that the Roberts Report was a milestone in the UK's thinking about the importance of research careers which provided a set of highly influential policy recommendations. It is clear that much progress has been made in recent years, specifically in the areas of: skills development for PhD students; the provision of more generous postgraduate stipends; and in constructing a framework to improve the terms and conditions for contract research staff, especially through the recently launched revised Research Concordat). The Concordat sets enhanced standards for the career management and conditions of employment of researchers in universities.

Vitae (formerly UK GRAD and UK HERD) is championing policy development, sharing practices and building an evidence base. It is also working to establish access to training opportunities and resources for research staff. Vitae will play a significant role in working with research councils to support universities in implementing the new Research Concordat. form a significant part of how research councils will help universities implement the new Concordat, particularly the aspects relating to staff development.

² Gareth Roberts, *SET for Success* (2002).

³ Research Careers Initiative, *Final Report 1997-2002* (2003)

⁴ Sandy Leitch, *Prosperity for all in the global economy – world class skills* (2006)

⁵ Peter Warry, *Increasing the economic impact of Research Councils* (2006)

⁶ RCUK, *Research Careers and Diversity Strategy* (2007)

⁷ Council for Science and Technology, *Pathways to the future: the early careers of researchers in the UK* (2007).

Because of the undoubted need to make critical improvements in a few key areas activity has tended to be quite sharply focussed and to some extent has reached a plateau. There has been much policy but successful implementation has been somewhat harder to achieve. A complex and dauntingly wide range of issues remain in play which cannot, of course, be solved through this review alone. The points of potential ‘talent loss’ are many, influences (beyond funding, salaries and contract conditions) are often intangible, and it would be naïve to assume that there are no tensions over availability of resource.

1.5 UK Comparative Position

The Lisbon Strategy (set out at the EU Lisbon Summit in 2000) suggests that Europe needed 700,000 new researchers by 2010 and the OECD has made similar projections regarding the population of researchers in science, engineering and technology subjects. This is a challenging target, particularly when set against a background of modest growth in the number of the total number of postgraduate research students in the UK. At present, the number of researchers per thousand total employed in the UK lags behind the EU and OECD (Organisation for Economic Co-operation and Development) average, and is behind a number of other European competitors, as well as the US, Japan, Australia and New Zealand and Korea (Figure 2). Perhaps more concerning is data which indicates that the proportion of researchers per thousand employed in the UK has increased only slightly over the last 25 year period, whilst in some major competitor countries the proportion has increased significantly (Figure 3). That said, it is widely acknowledged that UK scientific research punches well above its weight and recent figures for research output and share of world citations show that the UK is holding its own despite intense competition.⁸ However, these data can provide only a snapshot of a past point in time. As this report will highlight, the world does not stand still. International competition will continue to intensify and the UK may find itself in a vulnerable position if it does not take further action.

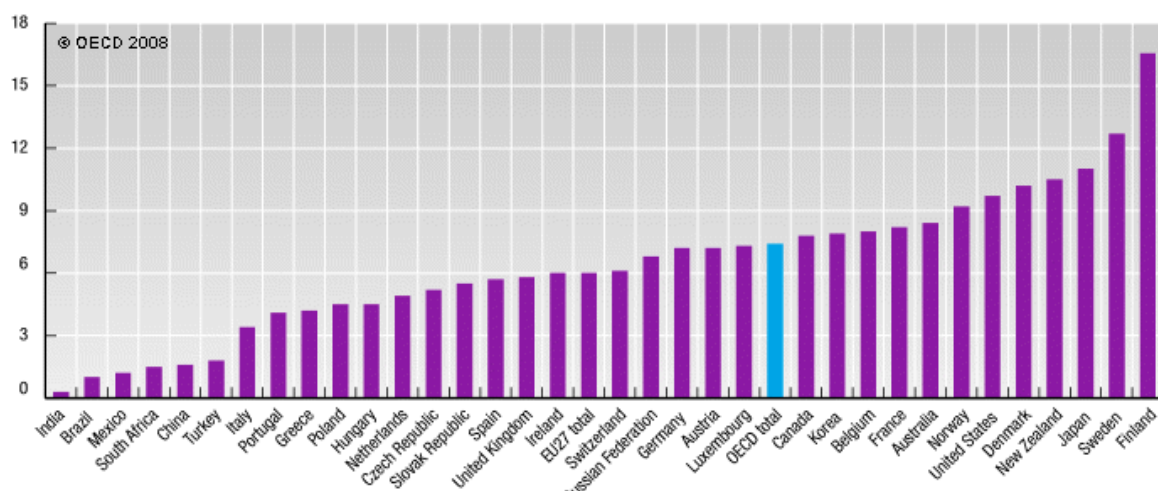


Figure 2 Researchers Per Thousand Total Employed*

Source: OECD Science, Technology and Industry Scoreboard 2008 (OECD Factbook 2008).

*Per 1000 total employed Full Time Equivalent, Figures 2006 or latest available.

⁸ Evidence (for DIUS), *International Comparative Position of the UK Research Base* (2008).

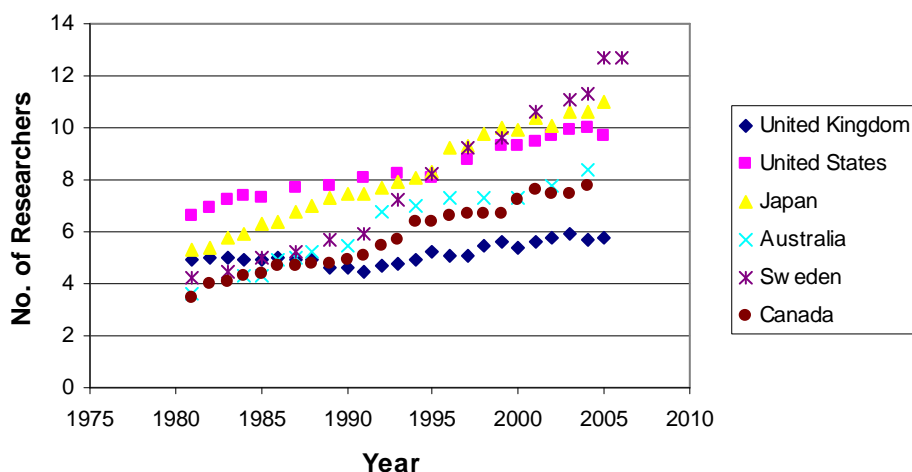


Figure 3 Researchers Per Thousand Total Employed* (Selected Countries 1980-2006)
 Source: OECD Factbook 2008.
 *Full-time equivalent.

1.6 Demand for Researchers in the UK

It is a stark reality that almost all of the work on research careers over the last decade has focussed solely on issues of supply. It is surely important that, in order to be effective in mobilising universities and industry to work in partnership with government in this area, strategies must also be informed by comprehensive and regularly updated intelligence about future demand. Yet this simply does not occur at present. Thus, Richard Brown, Chief Executive of the Council for Industry and Higher Education, has argued that ‘... we need a clearer fix on future demand for post-grads from business, the not-for-profit and public sectors (including academia)’.

A recent report by the British Academy⁹ urged government departments to draw on the knowledge of a wide variety of academic sources and enhance mechanisms for anticipating future policy scenarios and solutions. If government and other institutions are to draw on the sophisticated evidence base that academic research can offer, then a good understanding of the demands for future research (and researchers) is imperative.

Table 1 illustrates the proportion of UK doctoral graduates from 2003-2005 that entered each major employment sector. These figures (*from What do PhDs Do?*) are interesting as they illustrate that trends in sector employment are fairly consistent, at least over this short period. Not unexpectedly, education is the main employer, but other sectors such as 'health and social work' and 'manufacturing' also employ substantial numbers of researchers. However, such data has limited value in providing a real understanding of the demand for researchers in different sectors or the alternative career routes of doctoral graduates, not least because it is only first-destination data.

⁹ The British Academy, *Punching Our Weight: the humanities and social sciences in public policy-making* (2008).

‘What do PhDs do - Trends’

Year of graduation	2003	2004	2005
All education	47.8%	49.7%	50.0%
Finance, business and IT	9.1%	9.3%	9.0%
Health and social work	15.5%	16.1%	17.0%
Manufacturing	16.5%	14.0%	13.8%
Public Administration	5.7%	5.5%	5.0%
Other	5.4%	5.3%	5.2%

Table 1 Employment sectors entered by UK-domiciled doctoral graduates (2003-2005), based on Standard Industrial Classifications (SIC)

1.6.1 The Demand for Researchers in Academia

The demand for research staff in academia is driven by a number of factors including the health of the discipline as a whole, the demographic makeup of current personnel and likely student numbers in the future. The total number of staff in research-type employment in the UK higher education sector has been relatively static over recent years (Figure 4). However, some technical subjects have experienced decreases in student numbers reflected in reduced staffing levels. The RCUK Health of Disciplines Report (2008)¹⁰ highlights concern over the future state of disciplines such as engineering, chemistry, physics, economics, modern languages and others.

UUK has recently undertaken detailed analysis to develop demographic projections of future student demand for higher education. The study concluded that there would be a significant reduction in UK-domiciled full-time undergraduates between 2010 and 2019¹¹. Furthermore, there is no indication of an upturn in the proportion of young people gaining two or more A-levels as a basis for admission to higher education. Whilst this work does identify some scope for additional recruitment in other areas it shows that the UK-domiciled student population is likely to shrink considerably. This shrinkage gives rise to concerns for research careers both in terms of future supply and for demand, given that a reduction in student numbers may lead to difficulties for some universities in supporting their academic communities at even the present scale.

At the other end of the spectrum, as the UK’s population ages, it is unsurprising that the number of academic staff aged 50 years and over has generally increased (Figure 5). What is perhaps more concerning is that in all academic disciplines the percentage of researchers under the age of 35 has decreased. This figure indicates that there is a decline in young researchers securing permanent academic jobs. But, as many studies into the health of the nation’s research base have found, there is considerable variation between disciplines and the picture is accordingly complex. Discipline-specific capacity building strategies will, of course, be necessary. However, despite indicating that problems may be being stored up for the UK’s research base, it is difficult to know the exact scale of these problems without more detailed modelling of future demand and supply.

¹⁰ RCUK, *Health of Disciplines Annual Report* (2008).

¹¹ Nigel Brown and Brian Ramsden (for UUK), *The future size and shape of the higher education sector in the UK: demographic projections* (2008).

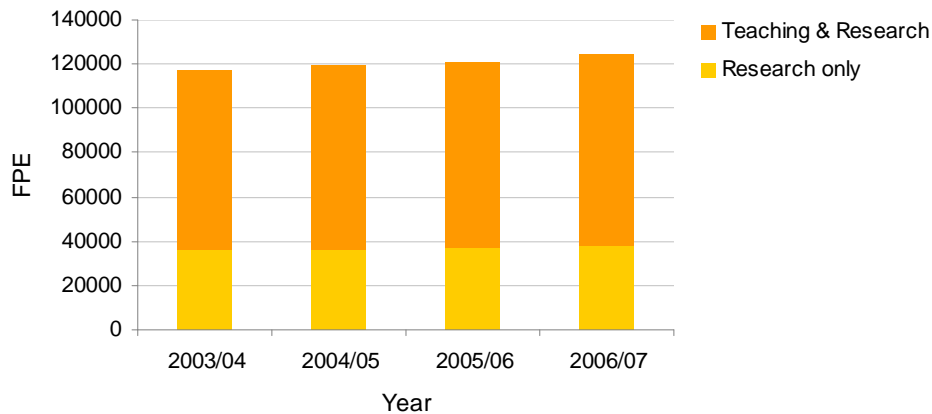


Figure 4 Staff* by Research Type Employment Functions – UK HE Sector Totals

Source: HESA 2006/7

*In published analyses staff counts have been divided amongst their activities in proportion to the declared FTE for each activity. This results in counts of Full Person Equivalents (FPE).

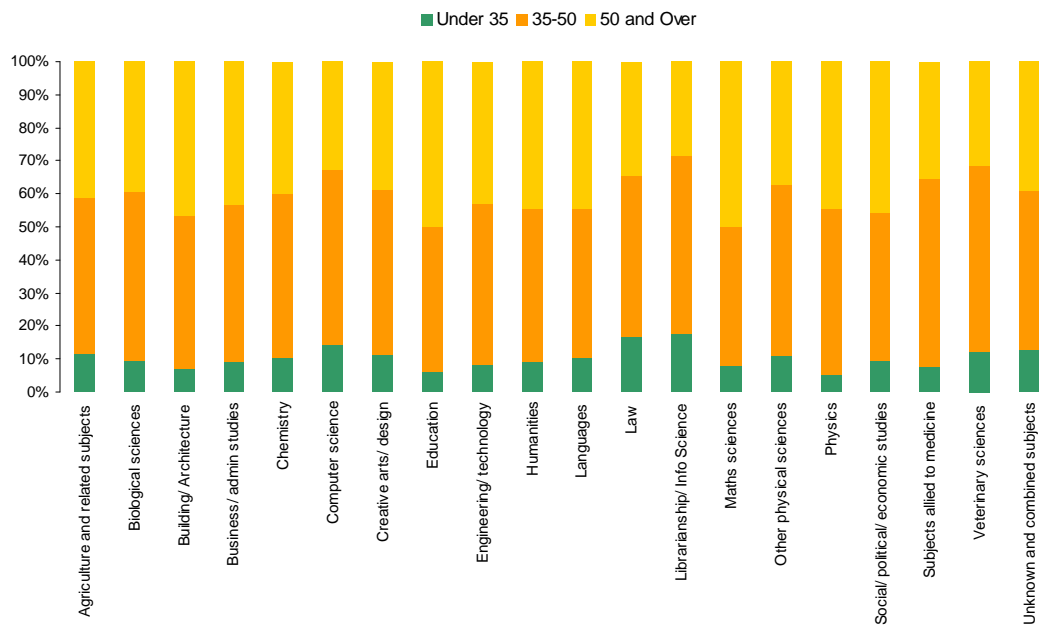


Figure 5 Age Distribution of Permanent Academic Staff in 2003/04

Source: RCUK Health of Disciplines Annual Report 2006

1.6.2 The Demand for Researchers in Business and Industry

Demand for postgraduate researchers in business and industry depends largely on the sector and organisation itself. Thus, for some companies a post-graduate degree is necessary even to get over the first hurdle, For example, companies such as Glaxo SmithKline, Astra Zeneca and Pfizer demand research chemists who have an MSc or higher degree.

RCUK has shown that demand for researchers in some disciplines from commerce and industry is high (it cites the demand for particle physics and astronomy researchers, trained social scientists and for researchers in the pharmaceutical industry, and the environmental and service industries). However, it has acknowledged that these are often very specific research

positions which make direct use of particular skills. Wider evidence suggests that, in general, employers within business and industry do not make a conscious attempt to recruit staff with a postgraduate research qualification and often recruit them only by default through their normal graduate selection processes (Souter, 2005¹²). In a report for the Economic and Social Research Council Purcell and Elias¹³ concluded that “even among independent research institutes.....employers reported a preference for candidates with Masters degrees rather than those who had gone on to complete a PhD”.

1.6.3 Understanding Future Demand

Our current understanding of the demand for researchers is confined to intelligence from only a small range of sectors and organisations. There is little or no understanding of future demand. Furthermore, we do not know to what extent different sectors and organisations seek ‘home grown’ talent as opposed to an international talent pool.

A recent report by the RAND Corporation into the competitiveness of US science and technology¹⁴ may provide some useful parallel insights. The report found that there was no significant premium for US-born science and engineering employees and concluded that there was, therefore, no market preference for native versus foreign-born science and engineering workers. The report surmised that shortages in US workers may continue to be mitigated by international recruitment which, in turn, would allow the US to draw on the best and the brightest from a global rather than a domestic pool of talent. However, the report questioned whether this left the US vulnerable to external competition over time.

The RAND report warned that the US should not be complacent and recommended that a funded, chartered entity should be established and made responsible for periodically monitoring, critically evaluating, and analysing US science and technology performance and the condition of the workforce. The UK would similarly benefit from more sophisticated monitoring of the UK’s research workforce and more detailed analyses would be able to inform appropriately targeted interventions in the future.

Recommendation:

- **Government should establish mechanisms to develop a more sophisticated long-term understanding of the supply of and demand for researchers across all sectors and disciplines.**

¹² Clair Souter, *Employers’ Perceptions of Recruiting Research Staff and Students* (2005).

¹³ Kate Purcell and Peter Elias, *The employment of social science PhDs in academic and non-academic jobs: research skills and postgraduate training* (2005).

¹⁴ Titus Galama and James Hosek (RAND Corporation), *US Competitiveness in Science and Technology* (2008).

PART 2 – RESEARCH CAREERS: A LONGITUDINAL PROFILE

2.1 Raising Awareness of Research Careers and Attracting Young Talent

The UK must nurture the talent of the future and so the first stage of the longitudinal profile of research careers begins at the start of the educational pipeline – with pupils in schools.

2.1.1 Pupils in Schools

Recent research by Purcell et al (2008)¹⁵, explores when and why students make decisions about higher education and their future career. The study found that most students have a clear idea of what they want to do with their degree when joining university. Extending the focus farther down the educational pipeline is, therefore, imperative.

The first stage which this review focuses on is therefore pupils in schools - the potential researchers of the future. There are, of course, many different influences on pupils' decisions about their career and future study but the opinions of teachers and the guidance offered within schools are a key factor in such decisions. There must be more done to help school teachers understand the opportunities offered by, and routes into, research careers. There are a plethora of programmes and activities to promote science, technology, engineering and mathematics (STEM) and other strategically important subjects to school pupils and their teachers, often delivered in parallel with aspiration-raising and widening participation initiatives. Such programmes include student mentoring and tutoring, workshops and residential programmes, visits into universities and research institutes, curriculum support, work experience opportunities, guidance materials and continuing professional development for teachers and much more. However, educating teachers about a broad range of research careers across a variety of disciplines is perhaps more complex.

Initiatives such as the Researchers in Residence programme¹⁶, which places PhD students and early career researchers in secondary schools, are supported by many of the research councils. Established programmes of this type could provide a useful vehicle through which to provide targeted information and guidance for teachers regarding research careers. However, at present the Researchers in Residence programme has a strong science focus and the programme could be extended to encompass researchers in the arts and social sciences. Those researchers currently working within schools could be provided with further training and information to enable them to provide general and/or discipline specific guidance about research careers to the teachers (and the pupils) with whom they work. There are also some good examples of public, private and charitable organisations working in partnership to develop continuing professional development opportunities for teachers¹⁷. Such programme could be extended to encompass guidance for teachers and information to promote the range of careers in research. The subject associations which represent professionals involved in the teaching of a specific discipline or other area of common interest could provide another useful vehicle for promoting information about research careers to teachers in schools.

¹⁵ Kate Purcell et al, *Applying for Higher Education – the diversity of career choices, plans and expectations* (2008).

¹⁶ Researchers in Residence is delivered by a consortium led by the University of Edinburgh and is funded by the RCUK and The Wellcome Trust.

¹⁷ An example is The Wellcome Trust Project ENTHUSE.

It is not only pupils in UK schools that should receive more consideration. Countries like Singapore have identified that competitive advantage lies not only in the talent of its own people but also in attracting the best young minds from around the world. A* STAR, a government organisation dedicated to charting the success of the country's development in Science and Technology, has established the Young Researcher Attachment Programme. The programme aims to attract and nurture talented young people from around the world through what is a highly structured programme which places young students in the top secondary schools and junior colleges, and goes on to support outstanding scholars through their university studies through to completion of a PhD. Opportunities for young researchers involved in the programme include vacation research internships and other practical opportunities to develop research skills. The ultimate aim is to create a multi-national research and development hub in Singapore.

Whilst the A*STAR programme may be viewed by many as too rigid and open to the evident problems of such early identification of the country's next generation of researchers, the concept of establishing a programme to identify, nurture and attract the world's best research talent at a young age should not be dismissed. The University of Warwick, for example, has recently established its International Gateway for Gifted Youth (IGGY) which is successfully building an international community of the best young scholars from around the world. The UK government should take a long-term view and work with universities to identify talented researchers at an early stage (through initiatives like IGGY, international research competitions and other mechanisms), provide the appropriate development opportunities and other more coordinated scholarship support to attract young talent from around the world into UK research.

Recommendations:

- **Subject associations should work in partnership to promote careers in research at an early stage by working more intensively with school teachers to inform them of the possibilities for their pupils.**
- **Government should work through existing programmes and international relationships between universities, learned societies and professional bodies to identify and support talented young scholars from around the world.**

2.1.2 Undergraduate Students

Activities to raise awareness of research careers and attract young talent must be carried forward into higher education. The next important stage is obviously undergraduate study.

Many high quality graduates will be lost to research prior to even graduating. Some will be attracted by high starting salaries outside of sectors often connected with research. For others it may be a lack of interest in pursuing their subject as an academic profession or a simple lack of awareness of careers in research. Evidence from university career advisers, postdoctoral researchers and studies of PhD students indicates that many undergraduates are unclear about what a research career could offer. If the UK is to attract more high calibre graduates into research careers more must be done to raise awareness amongst universities' undergraduate communities. It has already been noted within this report that the experience, information and recommendation provided by the host institution and tutors within that

institution at undergraduate level is of key importance in encouraging students to undertake postgraduate research.

Individual universities are making a significant contribution through various undergraduate research schemes and there are already some elective vacation programmes¹⁸ but there is clearly room to do more. In the US, the National Science Foundation runs the Research Experiences for Undergraduates Programme which includes various disciplines and research ‘sites’ spanning universities, community colleges, museums and Research Institutes. In the UK, a national programme of this type could offer an extensive range of research opportunities for undergraduates to gain experience across different research environments.

There is an obvious opportunity to improve the information and guidance provided to undergraduate students regarding research careers and to provide it at a much earlier stage. RCUK has taken steps to illustrate the wide range of careers enabled by research training and have already developed a small number of career profiles but, if successful, this approach needs to operate on a much more significant scale. Feedback from current postdoctoral researchers indicates that ‘softer’ incentives should be emphasised, such as the opportunity to work at the cutting edge of research; to be innovative and creative; to work with intellectual freedom; to pursue a passion and to make a difference. These incentives should be emphasised equally with financial considerations which are not held in as strong regard when compared with other career choices.

Recommendation:

- **Research councils should work with universities, research institutes and industry to develop a national Research Experiences Programme for undergraduate students.**

2.2 Postgraduate Research Students

2.2.1 Trends in the Recruitment of Postgraduate Research Students

Doctoral or Masters study is the accepted route into most research careers and the supply of highly qualified postgraduate research students is clearly an important factor in maintaining the health of the UK research community. Adams et al (2005)¹⁹ concluded that the research output of academics is positively correlated with the number of doctoral students present. Thus, the supply and retention of postgraduate research students, particularly in the academic sector, is of paramount importance not only for the future supply of researchers per se but also for the performance of those established researchers working within the UK. The recruitment and subsequent progression of postgraduate researchers is, therefore, the next key stage which was considered by the review.

There has been only modest growth in the number of the total number of postgraduate research students in the UK (Figure 6). The number of postgraduate research students

¹⁸ For example, the Undergraduate Research Opportunities Programme, Imperial College London, Leeds Undergraduate Research Enterprise, Leeds University Medical School, Undergraduate Research Bursaries, Nuffield Foundation, Reinvention Centre, University of Warwick, URSS, EPSRC and BBSRC Vacation Bursary Programmes.

¹⁹ James D Adams et al, *Research, Training and the Productivity of the Academic Labor Force – Preliminary Findings* (2005, working paper).

actually increased in all disciplines except veterinary science and some combined studies in the period 1996/97-2004/05 (Figure 7) but more recent growth has been minimal.

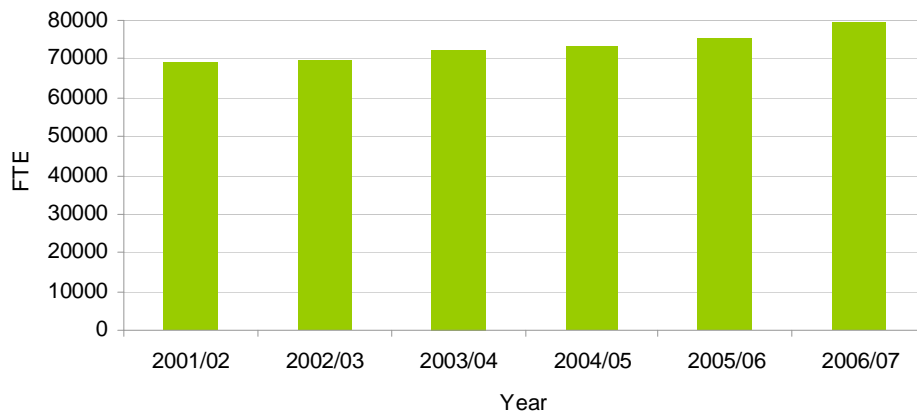


Figure 6 Student FTE* Postgraduate Research – UK Sector Totals
Source: HESA 2006/7

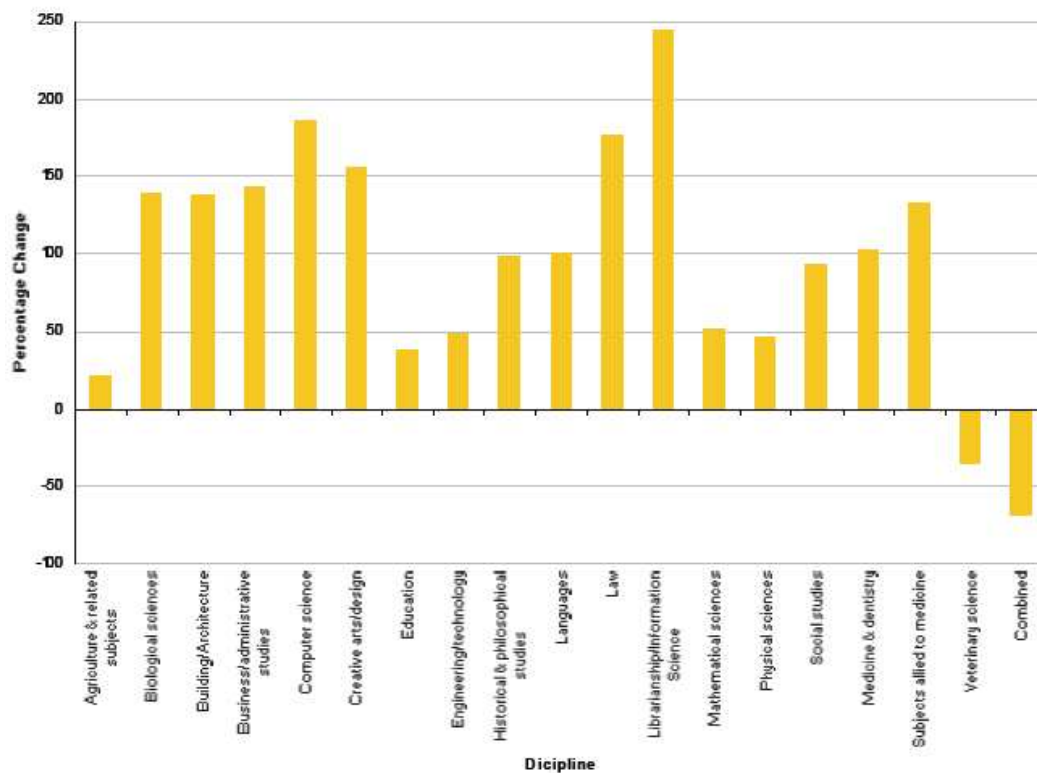


Figure 7 Percentage Change in the Number of Doctorates Awarded between 1995/96 and 2003/04

Source: RCUK Health of Disciplines Annual Report 2006

2.2.2 UK-Domiciled Research Students

Whilst it is imperative that the UK attracts the best researchers from around the world, there are increasing concerns about the decline of UK-domiciled graduates choosing to pursue postgraduate and then postdoctoral research.

The number of registered PhD researchers in the UK has continued to rise only slightly and the rate of growth has noticeably slowed. Growth in overall doctoral student numbers can be mainly attributed to non-UK domiciled students, particularly non-EU students, who now make up a considerable proportion of doctoral students in all subject areas (Figure 8). Any growth in UK-domiciled doctoral graduates is considerably lower than the growth rate of international PhD qualifiers (EU and non-EU domiciled), as shown in Figure 9.

There are also notable variations in the age profile and progression route of UK domiciled PhD students. For example, a large number of PhD researchers in the arts and humanities have previously worked or had an alternative career before embarking on doctoral research. Researchers in the biological and physical sciences are much more likely to start a PhD immediately following first-degree graduation. Again, arts and humanities students were also more likely to undertake a Masters en route to a PhD (What Do PhDs Do?, 2004)²⁰.

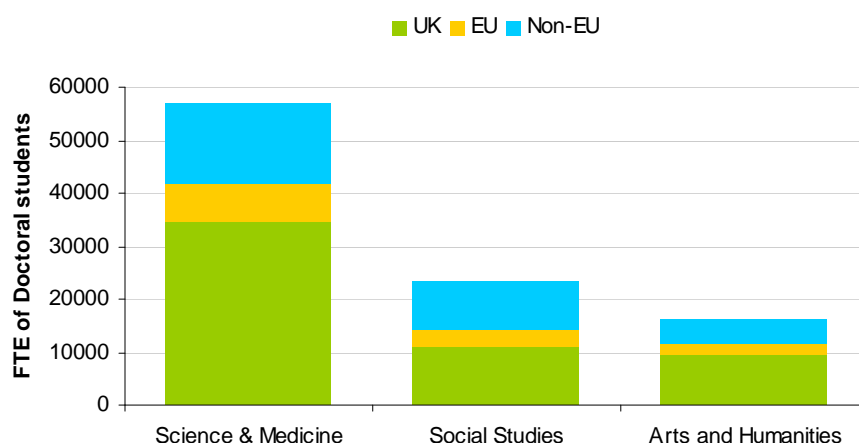


Figure 8 Doctoral Students by Subject Area and Domicile (2006-07)

Source: HESA

At present, the decline in the supply of UK research students in some subject areas is mitigated by growth in international recruitment (see charts in appendix 1) and longitudinal data suggests particularly worrying trends in some disciplines. For example, the Royal Academy recently reported that registrations for science doctorates by UK students had dropped from 65% to 57% of all science PhDs over the last 10 years - compared with a 79% growth in doctoral degrees overall²¹.

²⁰ UK GRAD Programme, *What Do PhDs Do?* (2004).

²¹ Royal Society, *A Higher Degree of Concern* (2008).

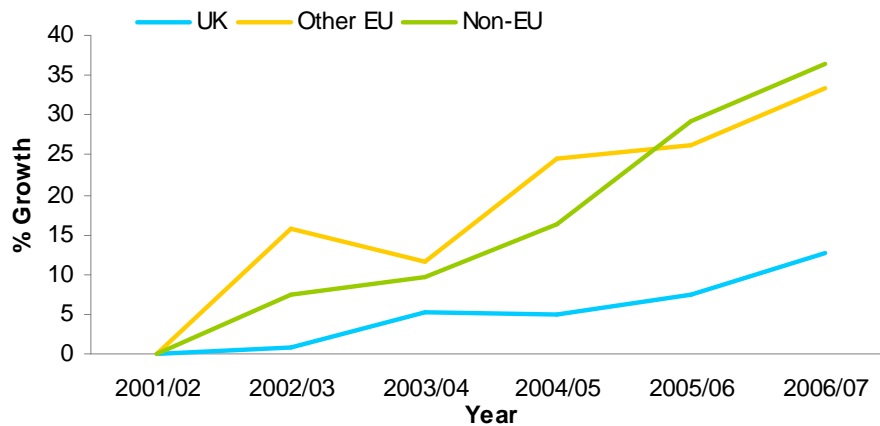


Figure 9 Year-on-Year Percentage Growth in PhD Qualifiers by Domicile

Source: HESA

2.2.3 International Research Students in the UK

The UK has approximately 15% of the international market for research students making it a global leader and the most successful country in recruiting international research students at present. Almost half of all postgraduate research students in the UK are now international students (including those from EU countries). There are obvious benefits in that this international cohort contributes to the UK's research output, helps augment the knowledge base of the country, heightens the UK's capacity for innovation and enhances the nation's position in the international economy. But the picture is not a consistent one. There is considered to be an under-supply of international research students in some subjects whilst others experience significant oversupply. Furthermore, the UK is heavily dependent on postgraduate recruitment from just seven countries, with particular dependence on the Chinese market (Kemp et al, 2008)²².

As importantly, international research students are the focus of increasing attention from competitor countries and new competition poses a threat to future recruitment. The US remains the UK's main competitor and the success of recent recruitment drives has seen US international student recruitment grow by 10% in one year (Kemp, 2008). Other EU member states are also targeting postgraduate research students. Many European universities do not charge fees and therefore can have a fundamentally different relationship with postgraduate researchers. The US, EU member states, and Australia and New Zealand have all developed attractive packages designed to win greater share of this vital market. Currently, less than 10% of international postgraduate research students in the UK are supported financially, although support from overseas governments, especially in the Middle East, is growing. Around 40% of international postgraduate research students are recruited within the host country so there is also an important supply-side relationship with the international undergraduate market. The greatest single influence on international students' decisions about postgraduate research is having previously studied at the host institution. Again, personal recommendation, either by a friend or a tutor, holds great weight (Kemp, 2008).

²² Neil Kemp et al, *The UK's Competitive Advantage: The Market for International Research Students* (2008).

A recent report by UUK²³ found that international students provided a vital market for many strategically important subjects in the UK. In 2005-06, more than a fifth of students enrolled on all courses in strategic subjects such as engineering, mathematics, computer science, physics and chemistry, came from outside the UK – at postgraduate level this proportion increased considerably with international students representing nearly half of those joining courses in these areas. Professor Geoffrey Crossick, Chair of the strategy group which produced the UUK report, argued that the findings underscored the importance of international students, both for the renewal of disciplines and in underpinning the UK's world-class research base.

A study by researchers at the University of Warwick²⁴ found strong evidence of a funnelling of overseas talent into the US at the PhD entry level. Only 25% of the sample of leading researchers had obtained their first degree in the US yet 87% obtained their PhD there. This suggests that countries may lose potential research talent to large receiving nations such as the US prior even to the doctoral study stage. It is all too apparent that competitor countries (the US, Canada, Australia, China, Japan, Singapore) are implementing programmes to actively retain PhD graduates and attract high calibre researchers from overseas at all career stages. There are a whole range of programmes internationally which the UK can learn from. Programmes to retain highly skilled graduates, such as those pursued by the Australia, are not new but the UK should take note of the increasing proliferation of such efforts by competitor countries. Seen in this light, recent decisions to phase out the Overseas Student Awards Scheme (ORSAS) and curtail the number of Chevening scholarships may prove to be somewhat short-sighted. Such moves may damage universities' ability to attract the best and brightest to the UK.

Current data on the destinations of international postgraduate research students following graduation is weak and this should give rise to real concern. Some indications suggest that around 40% of international research students would like to remain in the UK after completing their studies. It will become increasingly important for the UK to understand this potential loss of talent and develop strategies to retain high quality doctoral graduates in the country's research base. At present, public funding in this country is directed towards the retention of early career and PhD level researchers from the UK. However, this emphasis fails to recognise that the UK attracts some of the world's best undergraduate and postgraduate students and we should do more to secure this talent on a more permanent basis.

At present, there is a small but highly successful RCUK and industry funded postgraduate award scheme (the Dorothy Hodgkin postgraduate awards) which is designed to bring outstanding students from India, China, Hong Kong, South Africa, Brazil, Russia and the developing world to study a PhD in a top-rated UK research facility. Excellence is a key tenet of the scheme, scholars must be demonstrably in the top 20% of all PhDs studying in the UK (with a first class degree from their home universities) and are placed in RAE-rated 5 or 5* research departments in UK universities. In addition, there is a shared funding arrangement between the research councils and private sector sponsors. The scheme promotes positive links with some major industrial employers for the universities and individuals involved. There is considerable scope to extend this scheme to target both international students already studying in the UK and other high calibre students from abroad. Such a scheme would help maintain both the quantity and quality of international postgraduate researchers in the UK.

²³ Universities UK / GuildHE, *Patterns of higher education institutions in the UK: Seventh report* (2007).

²⁴ Shokat Ali et al (University of Warwick), *Elite Scientists and the Global Brain Drain* – Paper presented at the World Universities Conference in Shanghai (2007).

Recommendation:

- **Government should work in partnership with universities and industry to extend existing scholarships for high-quality international postgraduate students studying in the UK.**

2.2.4 Widening Participation in Postgraduate Research

During the course of this review it has become clear that very little is known about the socio-economic and demographic makeup of those UK students who go into postgraduate study. When compared with the now extensive knowledge of undergraduates with regard to factors such as gender, ethnicity, social class and disability, many questions concerning what, when and why students enter postgraduate study, and particularly postgraduate research, remain unanswered. There is still little in the way of appropriate data to allow an analysis of postgraduate participation at national level either by the funding councils or research councils. Some more recent studies and reports have, however, started to raise the issue of widening participation in postgraduate study as a point of concern (Gorard et al, 2006²⁵, Stuart, 2008²⁶).

The distribution of all research students (UK and overseas) in UK universities has continued in established patterns, with the majority of PhD researchers concentrated in the pre-1992 universities, which historically have a stronger research base (Figure 10).

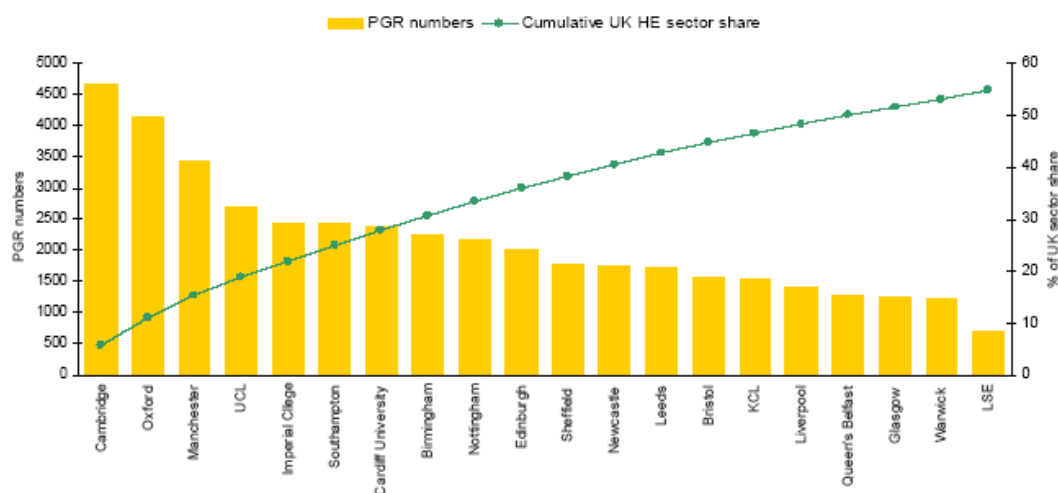


Figure 10 Distribution of All Doctoral Students by Institution (2006)

Source: HESA

²⁵ Stephen Gorard et al, *A Review of Widening Participation Research: addressing the barriers to participation in higher education* (2006).

²⁶ Mary Stuart et al, *Widening Participation to Postgraduate Study – Decisions, deterrents and creating success* (2008).

Further analysis shows that, when only UK-domiciled doctoral students are considered (Figure 11), the institutional distribution changes but it remains the case that around 50% of postgraduate research students are found in Russell Group institutions (with around a third concentrated in just eight institutions)²⁷. This distribution gives rise to concerns about the future socio-economic makeup of the UK research community which could result from current trends, concerns which are being echoed by some university careers services. What research there is appears to show that there is no significant relationship between class and progression to postgraduate study. However, it does indicate that prior family experience of higher education is a strong indicator. In particular, where fathers have a degree their children are significantly more likely to go on to study at postgraduate level²⁸.

Since it is the case that the majority of postgraduate research students are graduates of research-intensive Russell Group institutions, it may be the case that there is an indirect effect on the social class of research students through institution type. Wakeling (2005)²⁹ found a strong relationship between first degree institution and progression to higher study.

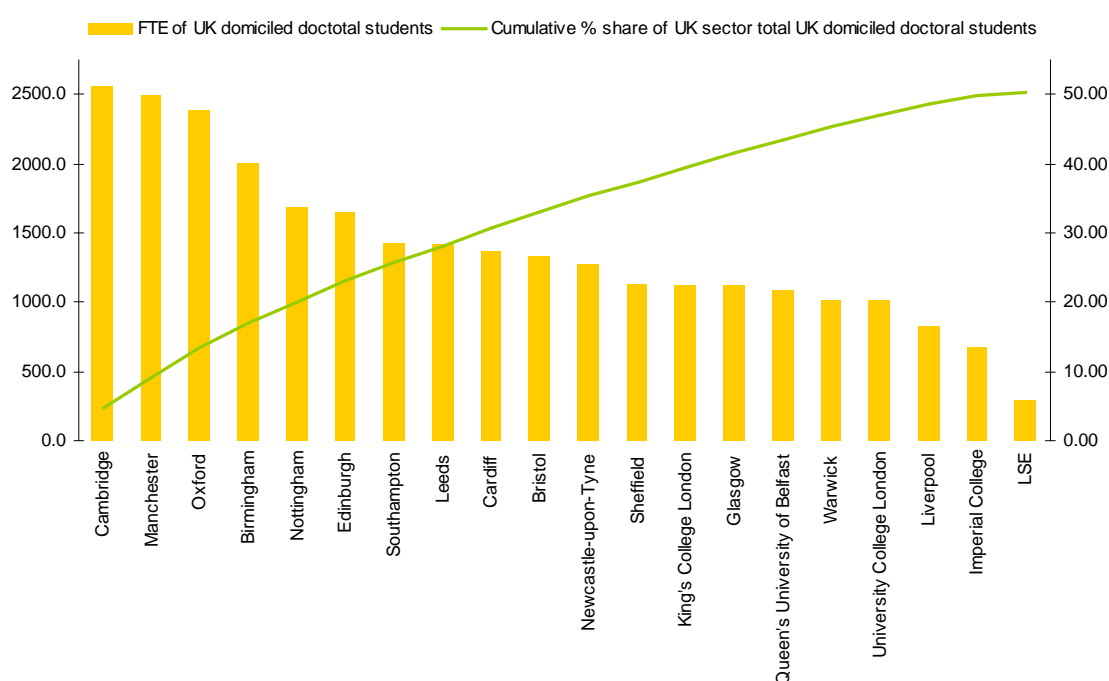


Figure 11 Distribution of UK-Domiciled Doctoral Students by Institution (2006)

Source: HESA

Whilst all Russell Group institutions are actively engaged in a range of widening participation activities, “post-1992 institutions generally perform at or significantly above their benchmarks while the English Russell Group institutions generally perform at or significantly below their benchmarks” (National Audit Office, 2008). Thus, there is a higher concentration of undergraduate students from more affluent socio-economic groups in Russell Group institutions (Figure 12). It follows that the majority of postgraduate research students in the

²⁷ Cambridge, Manchester, Oxford, Birmingham, Nottingham, Edinburgh, Southampton and Leeds.

²⁸ As for 25.

²⁹ Paul Wakeling, *La noblesse d'état anglaise? Social Class and Progression to Postgraduate Study* (2005).

UK are likely to be drawn from universities with relatively less inclusive student communities. Analysis of survey data from a sample of current postgraduate students has confirmed that the postgraduate research cohort in the UK is largely made up of students with relatively more exclusive social class backgrounds (when compared with the undergraduate student community in the UK) and that postgraduates are far more likely to have graduate and postgraduate parents and much less likely to have parents with only A-levels³⁰.

In addition, there is some emerging evidence to suggest that some graduates are being discouraged from undertaking postgraduate study due to concerns about debt from previous study and, for those who do go on to pursue postgraduate study, financial concerns may well restrict its nature. This early evidence suggests that certain socio-economic groups may be more strongly deterred by perceived concerns over debt burdens. A 2006 study commissioned by Prospects and the National Postgraduate Committee³¹ found that, whilst a high proportion of students from less affluent socio-economic groups would like to enter postgraduate study, respondents from these groups were substantially more likely to report financial concerns as having a strong influence on their mode of study, place of study and they were more likely to depend on grants and postgraduate awards to fund their study. A significant majority of those not intending to pursue postgraduate study cited cost, debt from previous study, and undergraduate tuition fees as reasons. This research also suggests that there is a group of graduates for whom postgraduate study would be attractive if the necessary financial support was in place and perceptions of the burden of debt could be alleviated. Debt worry is a deterrent for some groups of students in taking on postgraduate study but this may not be the same as actual debt or even debt aversion (Stuart, 2007).

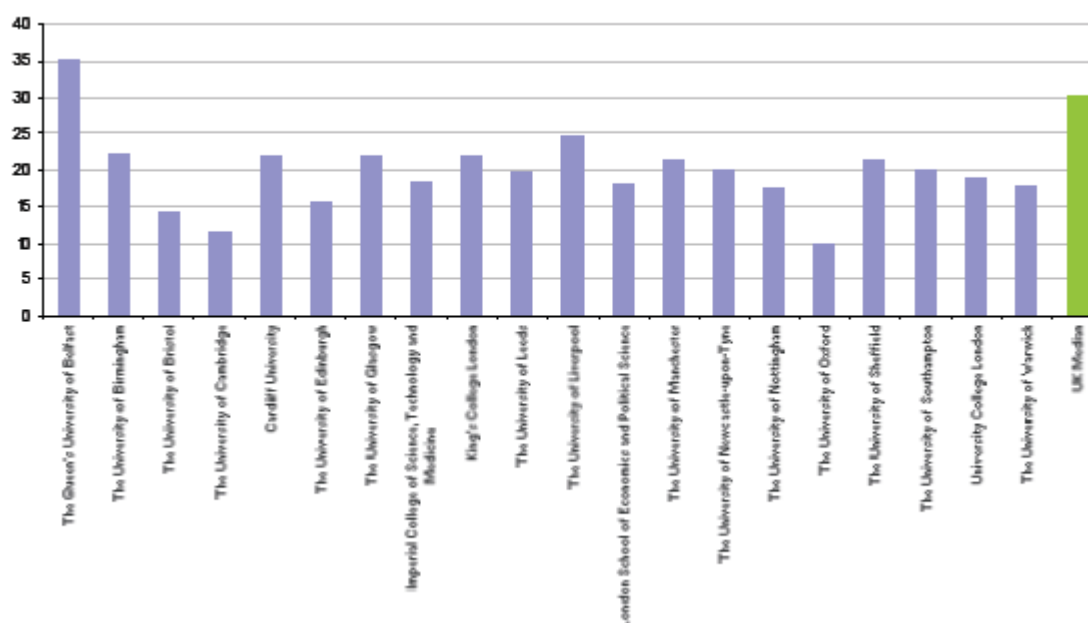


Figure 12 Percentage of Full-Time Undergraduate Entrants from NS-SEC Classes 4,5,6&7 (Russell Group and UK Sector Total)

Source: HESA

³⁰ Analysis undertaken by Dr. Paul Wakely, Department of Education, University of York (*unpublished study*).

³¹ Jenna Allen et al, *The Market Failure of Postgraduate Education: financial and funding related issues* (2006).

It is possible that this ‘escalator’ effect – caused by the greater proportion of students from more affluent socio-economic groups found in the undergraduate intake to many Russell Group institutions, a population which then dominates the recruitment pool for doctoral students - could continue to reduce the socio-economic diversity of postgraduate researchers and, ultimately, the UK’s research community. But, it must be emphasised that this issue requires further exploration to identify whether there is genuine cause for concern.

Amongst the ideas which have been put forward as counter-weights to this possible issue are: some form of debt cancellation or postponement for students from lower-socio-economic groups who wish to pursue postgraduate research; more targeted scholarship and support packages for postgraduate research students from particular socio-economic backgrounds; and a focus on aspiration-raising and guidance programmes for undergraduate students which focus specifically on postgraduate research and routes into research careers.

Recommendation:

- **Universities should consider whether the widening participation agenda applies to postgraduate study and, if so, what might realistically be done to improve matters.**

2.2.5 Postgraduate Research: Motivations and Expectations

Evidence points to changes in the motivations for PhD study and expected career outcomes for PhD graduates over time. It is not clear that those pursuing doctoral studies always do so as a route into a “traditional” research career (Purcell and Elias 2006³²). Kemp et al (2008) surmised that “whilst the doctorate retains its hallmark as an original contribution to knowledge it is now increasingly seen as a form of training and competence in a set of skills which can be valuable in a range of employments”.

In fact, available research shows that the majority of postgraduate research students are motivated by more general factors such as an interest in pursuing in-depth study of a particular subject, the opportunity to develop specific skills and the perception that postgraduate research would provide enhanced career opportunities. Graduates pursuing postgraduate research are not driven by direct financial returns but rather by the intrinsic interest and maturing value of the area of study (Council for Industry and Higher Education, 2007, Purcell and Elias, 2006, Kemp et al, 2008). Such motivations are articulated by some current postdoctoral researchers when asked to reflect on their motivations for undertaking PhD study and entering an academic research career³³.

So, whilst pay is obviously one important consideration for graduates when making their career choice, there is significant evidence to suggest that students’ motivations for embarking on PhD study and the subsequent attractions of a research career are dominated by less instrumentalist factors. Pay is only one of the rewards on offer and there are a range of other influencing factors which should not be overlooked when developing ways in which to

³² It should be noted that this study, undertaken for the Economic and Social Research Council, focused only on graduates within the social sciences.

³³ A focus group was undertaken with a small group of postdoctoral researchers and research development staff through the Learning and Development Centre at the University of Warwick for the purposes of this review.

attract high calibre graduates into PhD study and a subsequent research career. The drivers for those undertaking postgraduate research are not generally monetary and so incentives focused only on financial reward are likely to be of limited value (at least when targeted at those who currently choose to undertake postgraduate research). It is not fully understood whether greater financial incentives would encourage more graduates generally to undertake postgraduate research, although quantitative data suggests that enhanced stipends and other forms of remuneration introduced over the last five years have not made a radical impact on the overall numbers applying.

Perception-based data on a large scale, particularly for UK domiciled research students, is scarce and further investigation of the factors influencing UK students is clearly an imperative. Data from the final stage of the *Futuretrack* study of why and how students make decisions about higher education and careers will surely prove useful when they come to hand³⁴.

2.2.6 Progression Routes of Postdoctoral Researchers

Despite some growth in the overall number of students undertaking postgraduate study in the UK, there are well-documented concerns over the future supply of researchers, particularly in STEM subjects. It is clear that simply increasing the number of postgraduate research students will not necessarily lead to a direct impact on the numbers choosing to pursue a research career and, indeed, would not ensure quality of supply.

Figures from the first UK GRAD review of postdoctoral graduates (What Do PhDs Do? 2004) show that 42-44% of all science PhD graduates are likely to remain in research occupations immediately after their PhD. However, a number of previous studies point to:

- 1) A mixed picture of the number of postdoctoral researchers who remain in academia post-study or move on³⁵
- 2) Differing levels of competition in obtaining a position in academic research depending on issues of supply and demand in particular disciplines³⁶

The UK's science and technology research base is obviously of key importance but the health of the research base in the arts, humanities and social sciences must not be ignored. Of particular concern has been the demographic profile of the academic workforce in the social sciences and especially the fear that the current level of retirement is not being matched by new recruitment and retention within the sector³⁷.

Research in academia or a commercial setting remains a prominent career choice for PhD graduates but it is not as dominant as may have been believed. Only 22% of UK-domiciled PhD graduates from 2003 were employed as post-doctoral researchers in the UK and only

³⁴ Stage 3 will survey postgraduate students.

³⁵ In general in the UK, the pure sciences and engineering have slightly higher numbers of PhD researchers progressing into postdoctoral researcher positions and in non-academic based research environments than the Arts and Humanities and Social Sciences.

³⁶ A study commissioned by the Institute of Physics found that many postdoctoral research staff did not appreciate that only a minority would secure a permanent academic position. Study undertaken by DTZ Pidea Consulting (for the Royal Institute of Physics), *Career Paths of Physics Post-Doctoral Research Staff* (1999).

³⁷ Multidisciplinary research in new emerging disciplines means that the UK is at the cutting edge of innovation at the boundaries between disciplines (Purcell and Elias, 2006).

18% worked as researchers outside of academia. Over 50% of UK-domiciled PhD graduates move out of higher education into other sectors (UK GRAD, 2004). Whilst these figures suggest a high “loss” of potential researchers directly after the PhD, this loss is more pronounced in some disciplines than others.

For some, the PhD experience itself serves to highlight the reality of a research career in academia and, whilst still a positive experience, leads to the decision to pursue non-academic jobs with more attractive conditions of employment such as better job security and the chance to develop new skills (Purcell and Elias, 2006). In general, however, very little is known about the career choices and progression of PhD students working outside of academia.

The steady decline in the numbers of UK-domiciled students undertaking postgraduate research and progressing to research careers is cause for concern, although it is currently mitigated somewhat by overseas recruitment. Perhaps one of the most critical problems lies in the transition from doctoral to postdoctoral research and in the retention of the best postdoctoral researchers (Ackers et al, 2006). Problems with progression, along with an intense international competition for researchers at all levels, could leave the UK vulnerable in the future.

2.2.7 Gender Disparities

At the postgraduate stage some gender inequalities start to become evident. The proportion of women gaining doctorates is increasing and it may be less than a decade before women make up the majority of doctoral graduates. However, distinct gender disparities exist both in the number and proportion of women in research careers.

The picture is complex across disciplines and at each stage of the research career profile. Thus, whilst women have equal representation in biology and make up the majority of researchers in the social sciences, they are less prominent in the sciences in general and particularly poorly represented at the professorial level (Artess et al, 2008³⁸). Longitudinal analysis of women in chemistry³⁹ undertaken by the Royal Society of Chemistry (RSC) has found that, although higher education is an increasingly female environment, the progression of female researchers in chemistry and some other scientific disciplines is problematic. The proportion of women in higher grade roles, such as senior lecturer and professor, is low. Although this decline is indicative of other science, engineering and technology subjects it was found that chemistry has one of the steepest declines in the proportion of women moving from undergraduate to professorial level⁴⁰.

It appears that a high proportion of women in Chemistry re-think their initial intention to pursue a research career during the course of their PhD study⁴¹. This significant change in attitude suggests that women are less likely to have a positive postdoctoral experience (this is supported by previous studies across other disciplines in the academic sciences such as

³⁸ Jane Artess et al (Higher Education Careers Service Unit), *Higher Degrees: Postgraduate Study in the UK 2000/01 to 2005/06*, (2008).

³⁹ Royal Society of Chemistry, *Planning for Success: Good Practice in University Science Departments* (2008).

⁴⁰ The decline in women moving from undergraduate (~46%) to professorial level (~6%) in Chemistry is particularly steep.

⁴¹ 72% of first year doctoral students stated that they wanted to pursue a career in research compared with just 37% of female doctoral students in their final year.

Etzkowitz et al, 2000⁴², and Whitelegg et al, 2002⁴³). The RSC study found that women were concerned about poor working conditions, emphasis on results rather than process, and isolation and segregation. The study concluded that the working environment in academic chemistry departments deters large numbers of women from remaining in research (Dickinson et al, 2008).

The academic research environment in some disciplines can be particularly off-putting for women and women may not get the same level of encouragement to pursue a career in research within some disciplines. The RSC study observed that some chemistry departments had a significantly greater proportion of female staff than most and it was found that the introduction of good management practice in these departments had had an identifiable impact on the willingness of women to apply to and remain within the department.

2.3. Early and Mid-Career Researchers

The next key stages in the longitudinal profile of a research career are those of the postdoctoral and early-career period, moving into the middle years. Whilst many would agree that there have been improvements in pay, conditions and development opportunities for postdoctoral researchers over the last 10 years, many early career researchers (particularly those in academia) still occupy a competitive and precarious career environment.

2.3.1 The Postdoctoral Experience

In his report ‘SET for Success’ Sir Gareth Roberts noted the limited support that post-graduates received, both financial and in terms of academic and personal development. The “Roberts money” and the UK GRAD Programme have gone a long way to help address this. Significant improvements have been made to the provision for doctoral students. Provision for research staff is less well developed but there is an increasing focus on the needs and experiences of postdoctoral researchers. RCUK is undertaking a major cohort study, following an entire year’s cohort of PhD students (excluding overseas students) through their studies and into employment. This longitudinal focus is to be welcomed.

A number of universities have started to coordinate the support provided by their Graduate Schools (targeted at research students) and the opportunities offered through their staff development teams (for research staff). In addition, many universities now offer specific preparation and bridging programmes as well as funding designed to aid the transition from research student to postdoctoral researcher. Such initiatives can help develop a framework for the early stages of a research career.

Despite some good practice in universities, research shows that there is a considerable period of ‘drift’ for many postdoctoral researchers and that a key decision point for those individuals is often after three or more postdoctoral positions. At this stage in their career, new researchers can be unclear about what is required of them in order to advance and often question the sustainability of their research career. Job security and control over career progression are obviously very important. Janet Metcalfe, Chair and Head of Vitae has said

⁴² Henry Etzkowitz et al, *Athena Unbound: The Advancement of Women in Science and Technology* (2000).

⁴³ Elizabeth Whitelegg et al, *Young Women’s Perceptions and Experiences of Becoming a Research Physicist* (2002).

‘... there is still a need for honesty and openness about the likelihood of ‘success’ for individuals in academic research. The role of supervisors, principle investigators and research managers is key’.

It remains the case at present that, notwithstanding the rapid increase in permanent contracts⁴⁴, many postdoctoral researchers are still employed on short-term contracts tied to a particular funding stream and/or research project. Therefore, the proportion of researchers employed on permanent contracts remains much lower than for other groups of academic staff. Of course, more universities are moving away from the use of fixed-term contracts for researchers. However, the increased use of open-ended contracts is sometimes coupled with a more routine use of redundancy. It is not surprising, therefore, that despite the high level of competition for some academic posts already noted in this report and improvements in pay and employment terms over the last decade, discussion with some postdoctoral researchers is sometimes coloured by feelings of job insecurity and the perception that they are not valued as employees of their host institutions. Some feel particularly excluded from institutional policy and decision-making. The widespread adoption of the new Research Concordat and the dissemination of best practice through Vitae will, of course, help embed further improvements over time. Yet, it should be noted that this community of researchers often has the most direct influence on postgraduate researchers through informal supervisory responsibility. The low morale and disaffection felt by some members of the postdoctoral community could well have a negative impact on the next generation.

There is some scope to improve careers support and career development structures for postdoctoral researchers in universities. This may be through stronger encouragement for more universities to introduce a process of systematic review for individual postdoctoral researchers and for this exercise to be supported by clear careers advice. At present, there is often a lack of understanding of career paths across differing academic disciplines and this could usefully be improved both through guidance for postdoctoral researchers themselves and improved information and guidance for academic supervisors. The national Research Careers Mapping tool being developed by CRAC (the Career Development Organisation) will provide useful web-based support but institutionally delivered programmes and internal structures are also vitally important.

A sense that they are valued by their employer is vital for early career researchers to maintain motivation and engagement with the organisations in which they work. More universities could adopt models of good practice and develop a holistic approach to the support which is provided for postdoctoral researchers. This could involve integrating formal training and development opportunities with improved support for communities of researchers, specifically postdoctoral staff and early career researchers. Institutes of Advanced Study, now established in a number of research-intensive universities in the UK and primarily developed to promote collaborative research projects, could provide a useful vehicle through which to support communities of early career researchers. They can offer an important ‘on-site/institution-specific’ vehicle through which to develop interdisciplinary research networks both amongst early career researchers and between early career researchers and established academic staff.⁴⁵

⁴⁴ HEFCE report the proportion of researchers staff on permanent contracts has increased from 9% in 03/04 to 22% in 06/07 (HEFCE, 2008).

⁴⁵ For example, the University of Warwick’s Institute of Advanced Study (IAS) puts a significant emphasis on creating the star researchers of the future.

A number of universities have built some very good practice in this area, often primed by the Roberts funding for researcher development. Notable examples include the universities of Oxford, Bristol, and Manchester which have all developed a holistic approach to support and training for research staff (particularly early career researchers and contract research staff). These institutional models are based on fostering good networking and representation of research staff as much as on career development opportunities, training, mentoring and funding. A more holistic approach to support for postdoctoral staff and early career researchers can have a host of benefits; enabling early career researchers to feel more connected to their university and to other researchers; providing a greater sense of career direction; exposing early career researchers to research careers beyond academia; and developing important leadership skills. There are a number of good schemes at both national and institutional level but it is difficult to evaluate what overall impact they have on the experience of today's postdoctoral researchers.

There are differing views on whether the new Research Excellence Framework (REF) will generate more or less pressure to bear on early career researchers. What is clear is that the pressure to publish is unlikely to lessen. But research publication must not be allowed to become the only goal. Throughout this review it has been apparent that many early career researchers are driven by a passion for their subject, by a desire to make transformational changes to society and the advancement of science, and by recognition of their achievements. Discussions with postdoctoral researchers have highlighted that some have a strong desire to communicate their research to a wider audience of public and particularly young people. Finding more ways of including postdoctoral researchers in such activities (whilst balancing the requirements of publication) could have a range of benefits, not least in inspiring the next generation of researchers whilst providing improved job satisfaction and personal development opportunities for many early career researchers.

Vitae is positioned to play a major role in the implementation of the new Concordat for the Career Development of Researchers and aims to disseminate best practice throughout the higher education sector and research institutes. However, cultural change takes time, and the momentum of this work must be maintained over the long term. Wide dissemination of the best practice which already exists - and will surely continue to develop - is imperative. This work should be given the highest possible profile. Continuation of the Roberts Funding for researcher development in universities must also be sustained over the long-term for this work to become embedded across the sector.

Recommendations:

- **There should be wide dissemination of the good practice which already exists in some universities with regard to holistic support for postdoctoral and early career research staff.**
- **The Roberts funding for universities must be sustained over the long-term to ensure high-quality researcher development programmes become embedded across the sector.**

2.3.2 Female Researchers

It has been noted previously in this report that gender disparities in the makeup of the research community in the UK tend to increase with career progression. Thus, it is of key importance to retain and support female researchers in the early and mid – career stages.

Significant and positive cultural change in some academic departments and industrial settings will take time but there is already some good practice which is developing and being widely disseminated. The Royal Society of Chemistry and the Athena Project have published a good practice guide for university science departments. The guide suggests the introduction of continual monitoring of student and staff profiles, as well as encouraging male and female staff to apply for promotions and ensuring flexible working policies and practices are upheld. Heads of departments (whether male or female) have a major role to play in improving equality in the university system, particularly in supporting and encouraging young women to pursue research careers. A number of research institutes and universities have joined the Athena SWAN (Scientific Women's Academic Network) Charter - a scheme which recognises excellence in science, engineering and technology employment for women in higher education and research.

In order to attract and retain women in research careers, particularly at the postdoctoral stages, more universities and organisations which employ researchers will need to continue to adopt a range of practical measures which acknowledge the need for flexible working hours and requirements for maternity leave. The UK research councils are helping. They already operate re-entry grants aimed particularly at women researchers who have taken a career break. Some research councils go further. The Medical Research Council, for example, has extended the number of part-time awards. Finally, a number of companies employing large numbers of female scientists have managed to retain them. Procter & Gamble in the UK employs many women in science and research roles. The company has been consistently recognised as providing good benefits for working women.

Overall, there is a range of good practice developing in the academic sciences (where the greatest improvement is required) and its ongoing dissemination will continue to encourage the adoption of effective management practices. Trusts and research councils are increasingly responding to the needs of female researchers and providing routes back into research careers and re-entry training for those who have taken a break for motherhood or to fulfil family commitments⁴⁶. In addition, a number of research grants for early career researchers are now extremely flexible and can be extended or used on a part-time basis. Much of the literature regarding “re-entry” programmes for female researchers stresses the importance of helping women researchers keep up to date with developments in their discipline during career breaks, enabling them to keep in touch with their institution, arranging ongoing access to general skills and career development opportunities, and providing re-entry mentoring. It is the case that universities and research councils could still do more to maintain a relationship with female researchers during such career breaks.

⁴⁶ A good example is provided by the Wellcome Trust's Career Re-entry Fellowship scheme.

2.3.3 Grants and Awards for Early Career Researchers

The value, duration and allocation of grants and research awards for early career researchers is obviously an important factor in enabling postdoctoral researchers to make the crucial set into a more formal research career.

A recent report by the American Academy of Arts and Sciences⁴⁷ focused on advancing research in science and engineering and supporting early career investigators in the US. The report identified that not all funding agencies in the US collected data on early career researchers and it was, therefore, impossible to answer key questions about the size of the early career pool, the number of doctoral researchers leaving academic research each year, and how many might remain but go unfunded (American Academy of Arts and Sciences, 2008). The report also recognised that “recipients of doctorates follow a diversity of career paths.....and so there is no expectation that most should stay in academic research. Yet without the data, agencies cannot analyse or understand how they are supporting early career researchers”.

Most UK research councils and charities do have some form of grants or awards targeted towards early career researchers⁴⁸. Whilst the assessment process for these schemes remains rigorous, the emphasis is on research potential rather than track record, and therefore good research stands a far greater chance of being funded. The schemes are often time-limited to within two or three years of an applicant's first appointment, and must usually be their first submission as principal investigator. Such awards undoubtedly provide an extremely useful first step for many but it is sometimes the case that little is known about what happens to successful (and unsuccessful) applicants beyond this initial stage. In other words, early career researchers don't always receive specific attention in terms of funding considerations following their first grant submission and/or award.

Often very little is known about what happens to early career researchers after their first award or training. Some research councils do collect demographic data regarding applicants but sustained tracking of individuals and targeted interventions based on this data do not always take place. If all UK funding councils were to track consistently the demographic characteristics of their researcher communities and identify successful early career researchers across specific disciplines (as the National Institute of Health and the National Science Foundation in the US have begun to) this would contribute significantly to the UK's intelligence regarding the progression and retention of early career researchers. This step is imperative to ensure that any future interventions designed to support and retain early career faculty in the UK are targeted effectively.

Some Research Councils and universities provide seed corn funding for early career faculty to enable them to explore new ideas for which no results have yet been achieved⁴⁹. The aim of such awards is often two-fold; to both support early career faculty and to drive new innovations. Such awards provide a useful bridging fund for postdoctoral researchers, many of whom welcome the opportunity to transform new ideas from early concepts into viable

⁴⁷ ARISE: Advancing Research in Science and Engineering (2008).

⁴⁸ Examples include the EPSRC First Grant Scheme, the ESRC First Grant Scheme, the MRC New Investigator Award, the BBSRC New Investigator Scheme and the MRC New Investigators Competition.

⁴⁹ E.g. EPSRC Postdoctoral Fellowships, the Royal Society Postdoctoral Fellowships and the range of small grants schemes currently available.

research projects that can successfully compete for further support. However, the ARISE report concluded that ‘budding researchers are best served by large, multiyear awards – one-time grants of five- or six-year duration ...’ and that regular grant schemes should provide mechanisms to allow special consideration of early career faculty, including, for example new investigators and those applying for their second award.

The Wellcome Trust’s Postdoctoral Fellowships, the Royal Society’s University Research Fellowships and the Medical Research Council’s Career Development Awards all provide good examples of where awards of longer duration have been introduced for early career researchers. All UK research councils and grant-awarding bodies could consider the provision of awards of longer-duration for early career researchers e.g. more than five years, and could consider introducing measures which would allow special consideration of early career researchers in the award of other grants open to all faculty.

Recommendations:

- **The research councils should develop consistent mechanisms to record the demographic characteristics of their researcher communities and track successful early career researchers across individual disciplines to inform future funding strategies for early career researchers.**
- **Research councils and grant-awarding bodies should consider the provision of awards of longer-duration for early career researchers providing high-quality performance is demonstrated.**

2.3.4 Transferability of Researchers between Industry and Academia

There is evidence to suggest that many early career researchers and those graduating from PhDs do not attach the same kudos to a research career outside of academia and shun the commercially driven nature of research in industry. However, as this report highlights, it is a fact that only a relatively small proportion of PhD graduates and early career researchers will ever actually secure positions within academic research. There is also a suggestion that graduates and early career researchers are not fully aware of the breadth of opportunities which a research career could offer. As previously noted, more needs to be done to understand what factors affect perceptions of a research career (either in industry or academia) and how we might retain some of the best people in the UK research base, broadly conceived.

Some University careers centres have made a general attempt to produce information about a research career outside of academia. In addition, Vitae’s Researcher Portal has developed useful guidance about the breadth of research careers. However, more could be done to construct this domain and address the paucity of information and negative perceptions which exist amongst research students and some university staff. Universities should consider whether their careers centres could do more to promote research careers in industry, encourage transferability and educate both staff and students about the opportunities available outside of academic research.

One way might be to encourage greater transferability of researchers between industry and academia at every career stage. As Richard Brown, Chief Executive of the Council for Industry and Higher Education has said ‘our research on the research value chain highlights

the importance of broadening the conceptualisation of a ‘research career’ beyond academe. Research which encourages greater permeability in the boundaries between universities and outside organisations – companies, public sector research institutes and third sector organisations – makes for a more interesting career and builds networking, boundary spanning and gatekeeper capabilities which are so necessary for exploiting opportunities for the ‘demand for research’.

A number of industry representatives⁵⁰ have advocated measures to increase transferability and one commented that more should be done to ‘establish dual appointments in the more productive middle years where both industry and academia could probably benefit more’. More collaborative posts and research programmes could bring additional benefits of shared resource, increased sustainability and closer relationships between industry and academia. Universities can benefit through increased publications, income and profile which all help to bolster their standing in research assessment. However, the pressure to publish is often seen to be in conflict with the business drive for protection of intellectual property.

At present, transferability between universities and industry and vice versa is still comparatively rare. One could easily speculate on the reasons for this; very different working cultures; the more attractive package of ‘benefits’ offered by industry and limited ‘marketing’ by university departments to attract those from industry. A report by the Academy of Medical Sciences⁵¹ which focused on promoting mobility between industry and academia in biomedical science careers identified that there was a ‘prevailing perception’ amongst some academic researchers that a career in industry was second best and concluded that there was often an ‘information gulf’ between the two sectors. However, the report also found that, at least for careers in the biomedical sciences, younger researchers did find aspects of industrial careers, such as well structured training and development programmes, the potential for more rapid career progression and perceptions of greater job security, very attractive. There were also found to be somewhat conflicting views and perceptions of actual job security and the flexibility of research careers in industry when compared with those in academia, as well as issues of scientific ethics and scope for intellectual challenge in each environment.

Since publication is not a primary measure of achievement in industry, it naturally receives less emphasis than in the academic sector which is often driven by research assessment. This can be a concern for some industry researchers who are considering returning to academia but there are some examples of where the protection of intellectual property has not been an impenetrable barrier and publishing research has been encouraged by industry managers. Certain kinds of industry understand the need for more scientific interaction with universities and feel the ‘moral pressure’ to be a good citizen and undertake research into certain issues of national/global importance. However, at the same time, it is often difficult for companies to put large resources into this type of activity.

There are examples of successful dual appointments between industry and academia and vice versa but normally at the later stages of a researcher’s career: such arrangements do not appear to be common in the productive early and middle years. Collaborative arrangements are often driven by the individual researchers themselves rather than actively pursued by companies or universities. Equally, there are examples of dual appointment schemes, such as

⁵⁰ A group of senior industrialists from the pharmaceutical, healthcare, medical research and Information Technology sectors were consulted as part of this review.

⁵¹ Academy of Medical Sciences, *Research careers in the biomedical sciences: promoting mobility between industry and academia* (2007).

the RAEng Visiting Professor Appointments, which are seen by some to provide a win-win situation. But more needs to be done to understand and develop what might be the joint vision for industry and universities in establishing more collaborative posts and joint research programmes.

Universities are often open to establishing dual appointments but mechanisms could also be put in place to encourage industry to accommodate such working arrangements. Collaboration does not have to be only at the level of the individual. Longer-term (e.g. 3-10 years) collaborative projects between industry and academia involving a number of researchers who could swap about between the two sectors could bring benefits in terms of greater sustainability in research careers. Take the case of PhD and postdoctoral research. Some industrial representatives have indicated that, whilst it is true that industrial CASE⁵² students may spend three months or so in industry, this may not be long enough to provide a useful opportunity to fully experience that environment. One industrial contact commented “if the same were done with PhD students (as with industrial trainee undergraduates who spend a year in industry), then they would have the prospect of, say, a year working in industry at an appropriate industrial salary. This would give them a real feel for what a career position would feel like, some financial benefits and possibly a foot in the door for a job after completion of their PhD”. There are already some positive developments in this area. The Wellcome Trust, for example, has recently announced collaboration between industry and academia which will provide an integrated training programme. The programme brings the two sectors together and enables clinicians drawn from across a range of specialities to pursue MSc, PhD and postdoctoral research opportunities.⁵³

Alison Hodge, Director of University Partnerships at QinetiQ, feels that a range of mundane practical issues such as accommodation, concerns about pension arrangements and differences in pay are a serious barrier to the transferability of researchers and more collaborative staffing arrangements between industry and academia. She argues that what is really required is a ‘Lambert Agreement Round 2’ - a framework of terms and conditions that will facilitate interactions and promote the proactive flow of researchers between industry and academia through staff secondments, collaborative posts, student projects, joint training courses, and so on. In fact, the Academy of Medical Sciences’ report also recommended that universities, industry and research funders should develop ‘set up’ packages for researchers at all stages of their career, including early and mid-career staff.

The first Lambert Agreement was a result of the 2003 review chaired by Richard Lambert and sponsored by the Treasury. The purpose of the review was to highlight opportunities for university-business collaboration, identify successful collaborations which could act as role models, and offer ideas to stimulate debate and shape policy. The Lambert working group on Intellectual Property was set up following the review and it included key stakeholders such as the Confederation of British Industry, the Association of University Research and Industry

⁵² Industrial CASE awards are three and a half year postgraduate awards allocated to companies either directly or via agents (Knowledge Transfer Networks and Regional Development Agencies). The aim of the awards is to enable companies to take the lead in defining, and arranging, projects, with an academic partner of their choice.

⁵³ The Wellcome Trust Interdisciplinary Training Programmes for Clinicians in Translational Medicine and Therapeutics.

Links, UK companies, universities and other representative bodies. The working group developed five model research collaboration agreements and supporting materials to inform their implementation.

As with the first Lambert Agreement, government could establish a working group comprising senior stakeholders with an interest in university-business collaboration, and specifically the transferability of researchers, to drive this agenda forward by establishing a Lambert Agreement Round 2.

Another way to encourage academic researchers to build relationships with business and industry at an early stage in their career could be to introduce an industry match funding award for early career researchers. In the US, reports such as those from the Council on Competitiveness and the National Academy of Sciences' *Rising Above the Gathering Storm*⁵⁴, have emphasised the importance of supporting early career researchers. The recent Research for Competitiveness Act considered a series of significant research grants for early career researchers. It was proposed that the US *Award Match Programme* would be allocated through the National Science Foundation and Department for Energy Research and would provide young faculty with up to \$75,000 per year for up to five years and makes additional funds available each year provided the researcher raised one-to-one matching funds from private industry. The match awards would be granted on a competitive, merit-reviewed basis to those at the early stages of research and specifically consider the innovative and transformative nature of the research, the potential of the applicant for leadership at the frontiers of knowledge, and the creativity of the applicant and the potential interest to industry of the research. If introduced in the UK, such awards could encourage early career researchers to bridge relationships with business and industry, to develop the skills necessary in order to engage commercial partners, and to add value to activities which focus on the communication of research objectives.

Recommendations:

- **Universities should consider whether they could do more to encourage greater transferability of researchers between academia and industry where appropriate.**
- **Government should establish a working group comprising senior stakeholders with an interest in university-business collaboration, and specifically the transferability of researchers, to take forward a Lambert Agreement Round 2.**
- **Government and research councils should consider the introduction of industry match funding awards for early career researchers.**

⁵⁴ Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine. (2007). *Rising Above the Gathering Storm: Energizing and Employing America for Brighter Economic Future*.

PART 3 - CONCLUSIONS

3.1 Attracting and Retaining the Best World Talent

This review has been undertaken with the clear perspective that research is a global industry and the UK must play an increasingly international role in order to compete. Therefore, it would be inconsistent for this report not to highlight the importance of attracting elite senior level researchers to the UK. A number of studies⁵⁵ have identified a clustering effect, with the best researchers attracted to a country or institution by the presence of other top researchers. In order to attract and retain the best early career researchers (both from the UK and overseas), the UK must therefore continually seek to play host to elite researchers at more senior levels.

Whilst this review has not focussed on the issue of attracting and retaining established researchers at more senior levels, some arrangements do exist to fulfil this role. Schemes such as the Wellcome Trust's Principal Fellowships⁵⁶ are to be commended and it would surely prove beneficial to extend them in to other realms.

3.2 Concluding Remarks

Clearly the UK is dependent on brain power to survive and its future success depends in good part on getting our research and development capacity right and that, in turn, means getting research careers right. The review has focused on the educational stages and career choices leading to a research career and the experiences of early career researchers. This report has proposed a number of interventions and suggested policies which, if implemented, would help improve the supply of high quality researchers in the UK. The message of this review is straightforward. Many initiatives are currently either in place or being put in place but they need stitching together and supplementing in order to provide coherent policy at all stages of the research career. For the sake of the UK research base 15 years from now, it is imperative that this process is started, and started now.

⁵⁵ For example, Shokat Ali et al (University of Warwick), *Elite Scientists and the Global Brain Drain* – Paper presented at the World Universities Conference in Shanghai (2007). See also Larry Summers, *America must not surrender its lead in life sciences*, Financial Times (2007).

⁵⁶ Principal Research Fellowships are aimed at exceptional research scientists, particularly those currently based overseas, who wish to work in the UK and Ireland.

3.3 Acknowledgements

It would not have been possible to complete this review without the advice and expertise of a large number of people, both within my own institution and beyond.

In the University of Warwick I would particularly like to thank:

Rosalind Roke, Acting Executive Officer to the Vice Chancellor

Professor Mark Smith, Pro-Vice-Chancellor for Research (Science and Medicine)

Nicola Owen, Academic Registrar

Giles Carden, Director of Management Information and Planning

Faye Emery, Senior Assistant Registrar

Edward Harcourt, Head of Institutional Relations

Staff within the Careers Centre and the Learning and Development Centre

All of the industry representatives who make up the Warwick Forum

Also, members of the postdoctoral group who produced an extremely helpful and comprehensive synthesis report and lent their views to the review:

Alana Collis

Dawn M. Phillips

Zoe Lethbridge

Rana Jawad

Maria Sapouna

Andrew Proven

Outside the University, I would like to thank all of those actively working in this field who have offered their research findings, opinions and expertise to this review:

Richard Brown (Council for Industry and Higher Education)

Iain Cameron and Rosie Beales (RCUK)

Alison Hodge (QinetiQ)

Anil Kumar (Engineering and Technology Board)

Ian Lyne (BBSRC)

Janet Metcalfe (Vitae)

Sean McWhinnie (Royal Society of Chemistry)

Nicola Perrin (The Wellcome Trust)

3.4 Sources

- Academy of Medical Sciences. (2007). *Research careers in the biomedical sciences: promoting mobility between industry and academia*. London: Academy of Medical Sciences.
- Adams, J. D. (2005). (Department of Economics, Rensselaer Polytechnic Institute and NBER), Marsh, J. (Department of Economics, Rensselaer Polytechnic Institute), Clemmons, J. R. (Institute for Child Health Policy, the University of Florida). *Research, Teaching and the Productivity of the Academic Labor Force (working paper)*.
- Allen, J., Goodlad, S. and Redman, C. (2006). (QUAD Research) *The Market Failure of Postgraduate Education: financial and funding issues*. Scotland: National Postgraduate Committee.
- Ali, S., Carden, G., Culling, B., Hunter, R., Oswald, A.J., Owen, N., Ralsmark, H. and Snodgrass, N. (2007). *Elite Scientists and the Global Brain Drain*. Paper presented at the World Universities Conference in Shanghai, October 2007.
- American Academy of Arts and Sciences (ARISE – Advancing Research in Science and Technology). (2008). *Investing in Early-Career Scientists and High-Risk, High-Reward Research*. Cambridge MA: American Academy of Arts and Sciences.
- Artess, J., Ball, C. and Mok, P. (Higher Education Careers Service Unit). (2008). *Higher Degrees: Postgraduate Study in the UK 2000/01 to 2005/06*. London: Department for Innovation, Universities and Skills.
- Brown, N. and Ramsden, B. (2008). *The future size and shape of the higher education sector in the UK: demographic projections*. London: Universities UK.
- Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine. (2007). *Rising Above the Gathering Storm: Energizing and Employing America for Brighter Economic Future*. Washington D.C: National Academies Press.
- Council for Science and Technology. (2007). *Pathways to the future: the early careers of researchers in the UK*. London: Council for Science and Technology.
- DTZ Piedad Consulting (for the Royal Institute of Physics). (1999). *Career Paths of Physics Post-Doctoral Research Staff*. London: Institute of Physics.
- Etzkowitz, H., Kemelgor, C. and Uzzi, B. (2000). *Athena Unbound: The Advancement of Women in Science and Technology*. Cambridge: Cambridge University Press.
- Evidence (2008) *International comparative performance of the UK research base*. London: Department for Innovation, Universities and Skills.
- Galama, T. and Hosek, J. (2008). *US Competitiveness in Science and Technology*. Santa Monica, CA: RAND National Defense Research Institute.
- Gorard, S., Smith, E., May, H., Thomas, L., Adnett, N. and Slack, K. (2006). *A Review of Widening Participation Research: addressing the barriers to participation in higher education*. A report to HEFCE by the University of York, the Higher Education Academy and the Institute for Access Studies.

- HEFCE. (2008). Staff Employed at HEFCE-funded HEIs Update: trends and Priorities: http://www.hefce.ac.uk/pubs/hefce/2008/08_26/
- Leitch, S. (2006). Leitch Review of Skills: Final Report. *Prosperity for all in the global economy – world class skills*. London: HM Treasury.
- OECD. (2008). *OECD Factbook 2008: Economic, Environmental and Social Statistics* (4th Edition). Paris: OECD Publishing.
- Purcell, K., Elias, P, Adam, G., Atfield, D. and Livanos, I. (2008). *Applying for Higher Education – the diversity of career choices, plan and expectations*. A report for the Higher Education Careers Services Unit in conjunction with the Universities and Colleges Admissions Service. Coventry: Warwick Institute for Employment Relations.
- Purcell, K. and Elias, P (with Behle, H., Davies, R., Durbin, S. and Warren, S.). *The employment of social science PhDs in academic and non-academic jobs: research skills and postgraduate training*. Swindon: Economic and Social Research Council.
- Research Councils UK. (2007) *Research Careers and Diversity Strategy*: <http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/researchcareers/rcdstrategy.pdf>
- Research Councils UK. (2006). *Health of Disciplines Annual Report*: <http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/publications/hod06.pdf>
- Research Councils UK. (2008). *Health of Disciplines Annual Report*: <http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/publications/hod08.pdf>
- Roberts, G. (2002) *Set for Success: The supply of people with science, technology, engineering and mathematics skills*. London: HM Treasury.
- Royal Society of Chemistry. (2008). *Planning for Success: Good Practice in University Chemistry Departments*. London: Royal Society of Chemistry.
- Souter, C. (2005). *Employers' Perceptions of Recruiting Research Staff and Students*. Leeds: University of Leeds.
- Stuart, M., Lido, C., Morgan, S., Soloman, L. and Ackroyd, K. (2008) *Widening Participation to Postgraduate Study – Decisions, deterrents and creating success*. Report for the Higher Education Academy.
- Summers, L.H. (2007), *America must not surrender its lead in life sciences*, *Financial Times*, 29 January.
- The British Academy. (2008). *Punching Our Weight: the humanities and social sciences in public-policy making*. London: The British Academy.
- The Royal Society. (2008). *A Higher Degree of Concern*. London: The Royal Society.
- Tysome, T. (2007). *Overseas Students Aid Renewal*. Times Higher Education 14 September.
- Universities UK. (2003). *Research Careers Initiative Final Report 1997-2002*. London: Universities UK.

Shinton, S. (for the UK Grad Programme). *What do PhDs Do?* (2004). Report Commissioned by the UK GRAD Programme, produced in partnership with Graduate Prospects. Cambridge: CRAC.

Wakeling, P. (2005). *La noblesse d'état anglaise? Social Class and Progression to Postgraduate Study*. *British Journal of Sociology of Education* 26 (4), 505-22.

Warry, P (Chair) Research Council Economic Impact Group. (2006). *Increasing the economic impact of Research Councils*. London: Department for Trade and Industry.

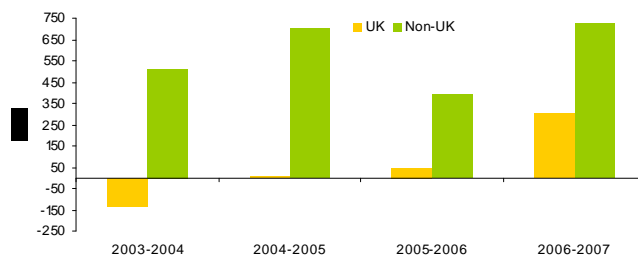
Whitelegg, E., Donovan, B., Hodgson, B. and Scanlon, E. (2002). *Young Women's Perceptions and Experiences of Becoming a Research Physicist*. Paper presented at the 12th International Conference of Women Engineers and Scientists (ICWES), July 27-31, Ottawa, Canada.

Appendix 1 Year-on-Year Increases in Doctoral Students by Subject Area



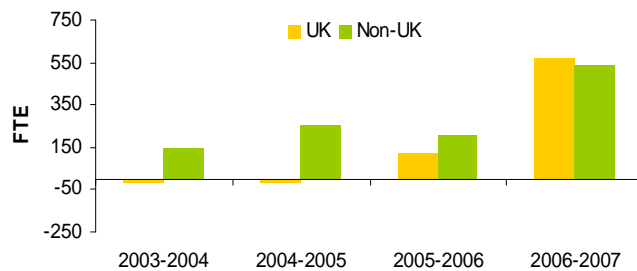
Year-on-Year Increase in Doctoral Students (Science and Medicine Subjects)

Source: HESA



Year-on-Year Increase in Doctoral Students (Social Studies)

Source: HESA



Year-on-Year Increase in Doctoral Students (Arts and Humanities)

Source: HESA

