

Summary of issues

Higher education (HE) staff in science and engineering departments are at the forefront of scientific and technical research efforts, and are also central to the education and development of science and engineering students and future researchers. Ensuring that universities are able to recruit and retain quality staff is therefore vital to the UK's future supply of highly-skilled scientists and engineers. However, problems have been identified with the quality of some taking up employment as postdoctoral researchers and then as permanent members of academic staff. It appears that this is not an attractive career path for many of the brightest PhD graduates. This is both harming the UK's research base and causing recruitment and retention difficulties for universities.

The problems affecting postdoctoral and other contract research staff (CRS) are:

- **lack of a clear career structure and uncertain career prospects** associated with work on a short-term contractual basis is a major barrier to the recruitment and development of postdoctoral researchers;
- **unsatisfactory training** in the skills required either in an academic career or in a business research environment means that CRS are poorly prepared for potential careers; and
- **increasingly uncompetitive salaries** act as a disincentive to work as a contract researcher.

Furthermore, **low levels of pay and consequent recruitment and retention problems for permanent academic staff**, coupled with an ageing cohort of academic staff in some disciplines and reports of a decline in the quality of applicants for academic jobs, are also of concern.

This chapter proposes that the recruitment, retention and development of skilled scientists and engineers within HE should be supported through:

- the development of **a range of career trajectories and clear career structures** for those employed as CRS, including greater use of permanent contracts for researchers;
- the inclusion of **earmarked funding for training and professional development** in all grants or contracts that provide for the employment of CRS;
- **enhanced salaries for CRS** funded by Research Councils, particularly in disciplines where there are shortages due to high market demand, and greater possibilities for salary progression within contract research; and
- **more market-related salaries for key academic staff**, which should benefit scientists and engineers, particularly those engaged in research of international quality.

Higher education staff

5.1 Scientists and engineers play a wide range of roles in Higher Education. Those employed in a teaching or research capacity can be broadly divided into:

- academic staff, who may be involved primarily with research, teaching or a combination of the two;
- academic-related staff, typically involved in research work on a short-term contractual basis, and commonly referred to as Contract Research Staff (CRS) or – for those CRS with doctorates – postdoctoral researchers.

5.2 There are around 100,000 full-time and over 14,000 part-time academic staff in UK Higher Education Institutions (HEIs), and around 37,000 researchers, of whom 30,000 or so are CRS and approximately half work in science, engineering and technology (SET).¹⁷⁷ A range of factors currently operate to inhibit the recruitment, retention and development of both CRS and academic staff. The sections below analyse these factors and make recommendations for action.

The funding of research in higher education

Research in Higher Education is funded through two routes, the 'dual support system'. One route for funding is the Quality Related (QR) system, the amount of which is related to institutions' RAE (Research Assessment Exercise) research quality ratings. The second funding route is through research funding from the Research Councils and other Government, charity and private sector sources. Such research funding tends to be awarded on the basis of competitive processes which often include peer review. In a top research-intensive university, funding from Government is approximately a 50:50 mix of Funding Council and Research Council/project funding.

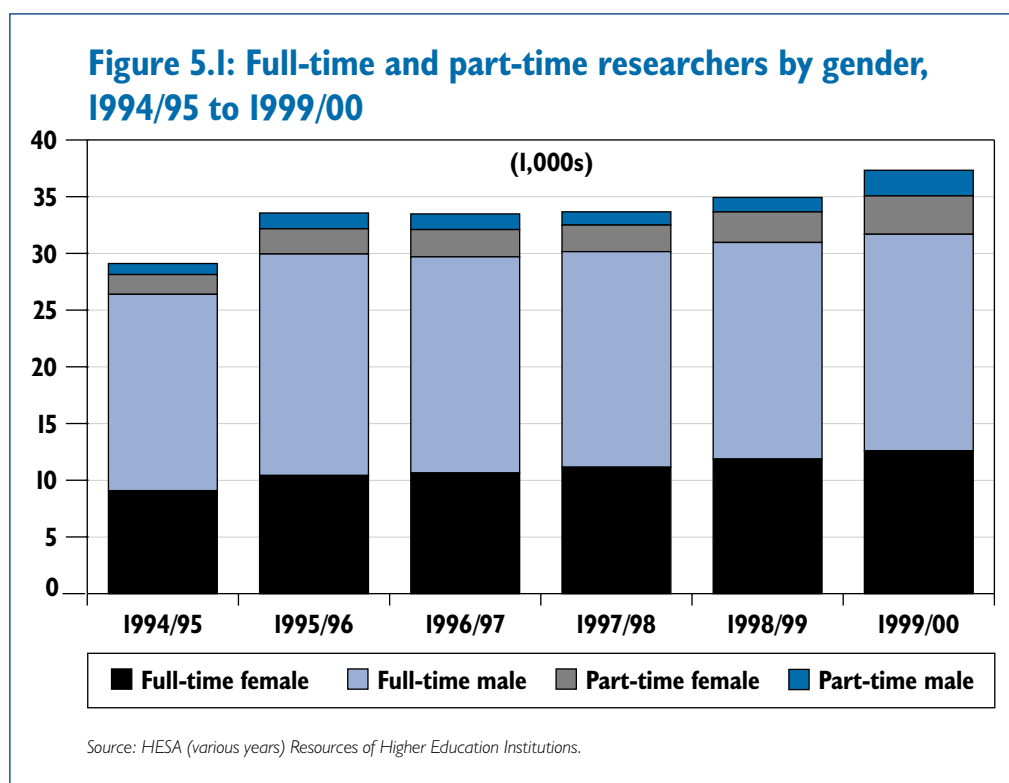
Contract research staff

5.3 The Review is principally concerned with the high-level research skills possessed by postdoctoral researchers ('postdocs'), but this chapter also considers some issues associated with CRS more generally. In SET subjects, the overwhelming majority of academic staff have doctoral qualifications such as a PhD and worked as a postdoc before becoming a permanent member of staff.

¹⁷⁷ including mathematics.

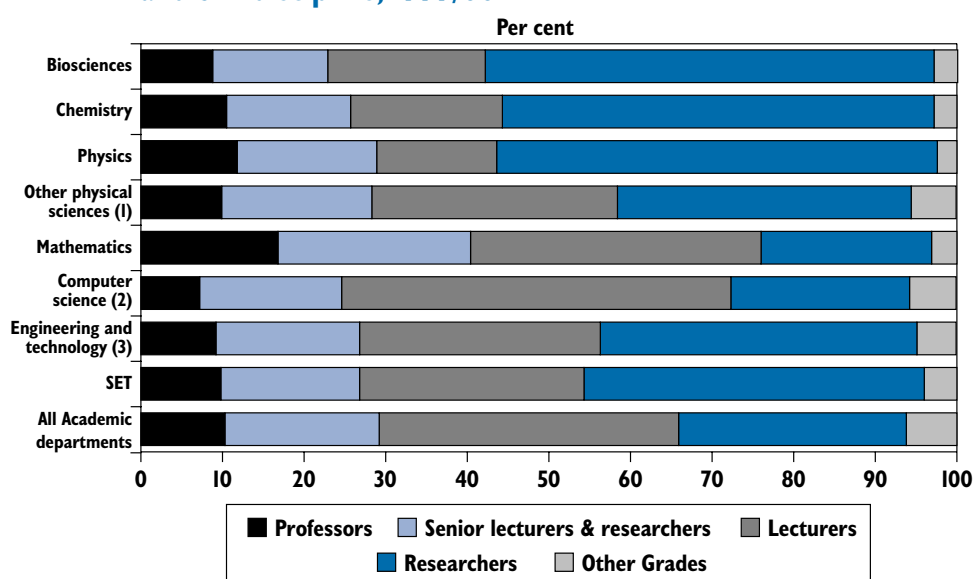
5.4 A typical university research group consists of one or more Principal Investigators (usually a member of academic staff who leads the research and co-ordinates the activities of the group), one or more postdocs, and a number of PhD students. Within this group, the postdocs would conduct research on a specific topic under the supervision and direction of the Principal Investigator, and would often be involved in informal mentoring and instruction of PhD students or undergraduate project students working within the group. Many also have a role in university teaching, for example as demonstrators (assistants and safety monitors) in laboratory classes, for which they are paid separately.

5.5 The reduction in the number and size of UK corporate research laboratories, paralleled by a rise in the amount of contract research undertaken in universities, has led to a significant increase in the number of contract researchers. Figure 5.1 shows the rise in the number of researchers employed by HEIs in recent years, as well as a shift towards greater female employment: an increasing proportion of women are employed as CRS by all groups of subject funders, and the majority of CRS funded by UK-based charities, government bodies and health & hospital authorities are women.



5.6 Figure 5.2 shows that contract researchers across all disciplines represent 28 per cent of full time staff, but for SET subjects, this rises to 42 per cent. The proportions are particularly high for biosciences (55 per cent) and physics (54 per cent).

Figure 5.2: Percentage breakdown of full-time staff by grade and SET discipline, 1999/00



Source: HESA Cost Centre data in HESA (2001) *Resources of Higher Education Institutions 1999/00*.

Notes:

(1) a combination of 'Earth, marine & environmental sciences' and 'General sciences'.

(2) a combination of 'Information technology and systems science' and 'Computer software engineering'.

(3) a combination of 'General engineering', 'Chemical engineering', 'Mineral, metallurgy & materials engineering', 'Civil engineering', 'Electrical, electronic and computer engineering', 'Mechanical, aero & production engineering' and 'Other technologies'.

5.7 Contract research offers a number of key advantages. In particular, the project-based nature of contract research means that staff resources can be better directed towards topics of current relevance and importance, as identified by the Research Councils and other funders. The system is important in providing staffing flexibility in the university system. The national and international mobility encouraged by the range of short term positions on offer facilitates cross-fertilization of ideas and the development of innovative approaches and team working skills.

5.8 Despite these advantages and the rising numbers of CRS employed by the HE sector, the Review's consultation process revealed a range of concerns affecting the recruitment, retention and development of CRS, particularly postdoctoral researchers. The process of entering an indefinitely long series of postdoctoral research positions in order to pursue an academic career was seen as particularly unattractive for many of the best PhD graduates. Key issues identified include:

- **a lack of a clear career structure**, together with the uncertain prospects associated with work on a short-term contractual basis. This stems largely from the fact that the roles and numbers of contract researchers today no longer reflect their origins as a small elite group of post-doctoral Fellows. A consequent lack of a coherent career trajectory – both for individuals pursuing future careers in academia and those who move across to industry – is a major barrier to the recruitment and development of many skilled scientists and engineers;

- **inadequate training** for individual CRS. The immediate pressure of conducting research often means that training is not funded by research sponsors, provided by research institutions and/or taken up by individual researchers. This, combined with a lack of training in the skills required either in an academic teaching career or in a corporate research environment, means that CRS are poorly prepared for potential careers; and
- increasingly **uncompetitive salaries**. As well as acting as a disincentive to work as a contract researcher, low salaries may also act as a downward influence on salaries offered to newly qualified SET postgraduates in the private sector. Together, the low salaries offered to CRS and the consequentially lower salaries offered by the private sector may in turn provide a disincentive to study for a PhD and to pursue a research career.

Career structure

- 5.9 The Review's consultation process indicated significant concern with the lack of any clear career structure associated with contract research. This both acts as a disincentive to employment as a contract researcher and means that those involved in contract research are often ill-prepared for future employment, both within and outside academia.
- 5.10 Of the 30,000 contract research staff in UK universities, approximately one third are under the age of 30, one third aged 30-34 and one third aged 35 or over. Around 45 per cent of CRS have held other fixed term contracts (i.e. their previous work was as a contract researcher) and about one third of CRS enter contract research directly from a PhD.

The Research Careers Initiative

In 1996 representatives of institutions and the principal funders of research in the UK agreed a Concordat on Contract Research Staff concerning the management of staff appointed on fixed term contracts to carry out research in UK universities and colleges. The Research Careers Initiative (RCI) was subsequently set up to monitor progress towards meeting the commitments of the Concordat, under the chairmanship of Professor Sir Gareth Roberts FRS, then Vice-Chancellor of the University of Sheffield and now President of Wolfson College, Oxford and responsible for this Review.

The RCI identifies and encourages good practice in the career management and development of contract research staff. The secretariat of the Research Careers Initiative is shared between OST (for the funders) and Universities UK (for institutions). The RCI has issued a series of reports and good practice guidelines concerning contract researchers. This has led most universities to review and to some extent improve their procedures and their pattern of employment of CRS.¹⁷⁸

¹⁷⁸ Further information on the Research Careers Initiative (RCI) is available from <http://www.universitiesuk.ac.uk/activities/rci.asp>

5.11 Individuals working as contract researchers have many different career aspirations and needs. Drawing on the Academic Research Careers in Scotland (ARCS) survey,¹⁷⁹ the Third Report of the Research Careers Initiative identifies three broad types of CRS:

- **career starters**, typically in their first or second contract, who enter contract research to gain experience leading to a continuing academic position or a more permanent research career, and typically stay as CRS for only a short period;
- **career researchers**, who have worked as CRS over a longer period and wish to remain in research, ideally in an academic environment; and
- **job entrants**, who may enter contract research as a job, but not explicitly to make a career in research, and who may or may not remain in research or in related academic work.

5.12 Other groupings are also possible. The most able postdoctoral researchers who aim at academic jobs often use the short-term contract system to arrange a series of short, often international posts which duplicates in an *ad hoc* way the more formal job rotation often found on graduate training schemes. This group of CRS can be thought of as ‘high fliers’ who aim at careers in academia (or, sometimes, business R&D), and is a subset of the ‘career starters’ group described above. Career starters who do not meet their own aims for contract research can often become career researchers, and it is important to distinguish between the ‘willing’ career researcher who actively embraces the contract research ethos and the ‘unwilling’ who regard contract research as second best to a desired career in academia or in business.

5.13 Surveys for the Research Careers Initiative suggest that “a large proportion of research staff remain intent solely on academic research careers”, while “a proportion” (particularly in some, unspecified, subject areas) intend to move out of HE in due course. The academic career expectation in SET is that a good postdoctoral researcher will fill a couple of postdoc positions (ideally in prestigious research groups, and preferably at least one outside the UK) and then take up a lectureship at a research-intensive university. Postdocs or other CRS not following this career trajectory (those who are not ‘career starters’ in the terminology above) often believe they are treated as ‘inferior’ by the HE system, where most academic staff in SET are the product of precisely such a career path. It is undoubtedly true that many long-term contract researchers have tried and failed to obtain appointments as academic staff. However, other CRS see their roles as skilled research workers, and have no desire to teach or to fulfil any of the other obligations of the typical academic. Both groups are concerned that their research is not perceived as valuable, and that they are marginalized and expendable. Perhaps as a result, a number become disillusioned with research as a career.

¹⁷⁹ For details of the project and initial results see <http://www.warwick.ac.uk/ier/shefc/shefcpub.html>

5.14 These uncertainties are magnified by the series of short term contracts often (but not necessarily) associated with contract research funding. The Bett Report¹⁸⁰ recommended that the sector's dependence on these short-term contracts be reduced. A joint working group of employers, via the Universities and Colleges Employers' Association (UCEA), and trade unions has developed a good practice guide covering this issue,¹⁸¹ although this report simply refers to the RCI when talking about contract researchers. The Academy of Medical Sciences has also made recommendations on good practice.¹⁸² In addition, the Government will shortly be implementing the EC Directive on Fixed Term Work, which will limit the number and extent of repeat short-term contracts, although the exact nature of the UK regulations is still out for consultation.¹⁸³

5.15 Reflecting these factors, this Review believes that contract research posts should generally be seen as having a transitional rather than semi-permanent status; in other words, people usually should not remain on a series of short-term research contracts for a long period of time, particularly within a single institution. The Review concludes that three different career trajectories for contract researchers subsequent to their initial postdoctoral position should be encouraged. The researcher's manager and/or supervisor should discuss the researcher's most probable future trajectory as part of his or her regular staff appraisal. Once the probable trajectory has been established, this should be used to determine the types of training and careers opportunities that are taken up by the individual. These trajectories reflect the differing types of CRS identified in the Academic Research Careers in Scotland (ARCS) survey; each will have differing contractual status and expected career outcomes.

- **The Industrial trajectory** – contract research, especially that funded by business, potentially involves broader or more applied research than that involved in a PhD, thus providing a better preparation for a corporate research career. At the same time the current dominant aspirations and training provision amongst CRS are focussed on a career within the HE sector. The industrial trajectory would require awareness-raising by institutions and potential employers, and extra training in skills relevant to potential employers including the provision of supervisory and managerial experience. Those choosing to follow this trajectory would probably be employed on short-term contracts for a short period of time, then move into employment in industry. In time this, rather than the Research Associate trajectory, should come to be regarded as the 'default option' by CRS. Here schemes such as RAIS (Research Assistants Industrial Secondments) may provide a useful model.¹⁸⁴

¹⁸⁰ *Independent review of higher education pay and conditions: Report of a committee chaired by Sir Michael Bett*, Stationery Office, May 1999.

¹⁸¹ *Fixed-term and Casual Employment in HE a Guide to Good Practice*, UCEA (2000).

¹⁸² *Non-Clinical Scientists on Short Term Contracts in Medical Research: A report on career prospects and recommendations for change*, The Academy of Medical Sciences, February 2002.

¹⁸³ DTI (2002) Final Consultation on the Draft Fixed Term Employees (Prevention of Less Favourable Treatment) Regulations 2002; closing date for the consultation is 15 April 2002.

¹⁸⁴ RAIS aims to encourage the transfer of knowledge gained by Research Assistants working on existing research grants and provides training in an industrial environment. There are two variants to the funding scheme: one follows on from a collaborative grant, while the second involves a start-up company set up by a university to exploit EPSRC funded research. In both cases the scheme covers the salary costs of the RA for 12 months.

- **The Academic trajectory** – although a research-active teaching role is the desired career objective of many (though by no means all) postdoctoral researchers, only a minority actually achieve this goal. Better appraisals and career advice early on in a researcher’s career should be aimed at identifying those with the potential for an academic career. This trajectory may require institutions to underwrite the salaries of those so identified in order to recruit or retain them, but the basis of employment should remain the short-term contract, to match the needs of research funders and encourage the mobility of potential academics.
- **The Research Associate trajectory** – there are a group of contract researchers who want to continue with a research career and do not want to pursue an academic career. This track would principally apply to those who have developed specialist knowledge of specific research equipment or methodologies (e.g. mass spectrometry or NMR) and provide an ongoing support/enabling function within a research group or groups. Importantly this trajectory should not be seen as the default, and entry should be highly selective. Here the emphasis would be on the provision of permanent contracts underwritten by research contracts being held by university departments, which could in some cases assign individuals to other research projects if a particular line of funding were to cease.

5.16 Achieving this vision for all these trajectories will require better training and development, a greater range of salaries and a clearer career progression for CRS, in line with the recommendations made below. Contract research should not become a permanent career option, but a preparation for a range of careers that reflect the skills possessed by contract researchers.

5.17 A number of the CRS interviewed by the Review Team were strongly in favour of a career track for all researchers, which ran in parallel to the established academic career track. The benefits of such a system would be a greater degree of transparency about future career and a better-defined salary progression, thus rendering contract research more attractive to new entrants and more secure for long-term CRS. A typical aspiration of someone arguing for a parallel research career track was to continue doing research without being burdened by administrative or teaching responsibilities.

5.18 While the Review is in sympathy with these aims, clearly there are a number of difficulties with the establishment of a ‘parallel track’ for all CRS:

- the intrinsic variability of contract research income and topic, although it can be compensated for to some extent by institutions, would make it very difficult to establish all or most current CRS on permanent contracts,¹⁸⁵ and doing so would reduce the responsiveness of the UK's research capability to new and emerging areas of interest;
- the existence of a career structure would therefore lead to informal expectations of continued employment which will not be realisable for all staff. As the RCI's best practice guidance on the employment of CRS warns: "That false expectation is much more unfair to all CRS in the long run than facing up to hard choices for individuals in the short run. It will inevitably lead to researchers leaving HE employment feeling, to a degree, disenchanted and less likely to carry their research skills into the wider economy"; and
- although many institutions employ a few research-only academic staff (Research Fellows, Readers etc.), it appears that many of these are drawn from the 'career starters' or academic trajectory rather than from current long-term CRS, so a career progression based on similar posts might not be of value to many CRS.

5.19 As outlined above, the Review is firmly in favour of a more permanent career structure for what have been termed 'Research Associates', long-term CRS who play a valuable role in supporting and enabling the UK's research. The case that this need extends to all current CRS is less convincing; anything which de-emphasises preparation for jobs outside academia would be a retrograde step. However, HEIs should consider whether offering more academic posts with a strong or exclusive research orientation might be appropriate. For those CRS who have the desire and the potential to enter academic careers, there is a case for better development into academic roles. One possible way to assist this is by developing new research or academic Fellowships.

5.20 As part of developing the academic trajectory a clearer path into academic lectureships should be developed, along similar lines to the US tenure track system or the former Assistant Lecturer scheme in this country.¹⁸⁶ There is value in using the postdoctoral system to gain a wide range of international research experience, but clear paths need to be marked out and advertised for movement from undergraduate or postgraduate study to employment as a member of academic staff. One tool for achieving this would be the establishment of more five-year Research Fellowships, like those offered by the Royal Society and the Wellcome Trust, and/or junior academic posts that give holders the opportunity to build their expertise and reputation in teaching, research and other relevant activities such as knowledge transfer.

¹⁸⁵ In larger departments and institutions the overall level of research grant income is relatively stable, which makes it easier for the institution to employ a core of 'research associates'. The constraint in this situation is whether the research associates are able to apply their skills effectively across a range of research topics and fields, as the portfolio of grant-supported work changes.

¹⁸⁶ The German Bundestag and Bundesrat recently agreed to establish up to 3,000 three-year junior professorships with €60,000 each, predominantly aimed at people in their early thirties (*i.e.* the same age as many UK postdoctoral researchers). Detailed information is available (in German only) at http://www.bmbf.de/3992_4066.html.

Recommendation 5.1: Academic Fellowships

The Review believes that there should be a clearer path for those who have completed PhDs into academic lectureships. This should be achieved through creating Fellowships that allow those involved to move from principally research-based work towards the role of lecturer, with an added role of reach-out to schools (for example, becoming a Science and Engineering Ambassador) and helping to widen access to higher education. The Review therefore recommends that the Government provide funds to establish a significant number (the Review believes 200 a year) of prestigious academic Fellowships to be administered by the Research Councils. The Fellowships should last for five years and should be designed to prepare people explicitly for an academic career, to be distributed and awarded on the basis of academic excellence across the range of subjects considered in this Review. The Research Councils should work with the funders of similar schemes (for example, The Royal Society and the Wellcome Trust) in introducing these Fellowships.

A possible model for prestigious academic Fellowships

Fellows would serve a probationary period of two or three years, on satisfactory completion of which the HEI would be obliged to offer a permanent academic post to the Fellow at the end of the Fellowship (as occurs with Wellcome Trust-sponsored Fellows). Over the five year period, the Fellows would progressively move from primarily conducting research to take on the teaching and PhD supervisory roles associated with a lecturer. All Fellows would, as part of their role, be involved in reaching into schools and widening access to higher education in SET and all should qualify to be Science and Engineering Ambassadors.

- 5.21 To reinforce the parallel industrial and research trajectories, similar initiatives to the academic Fellows should be developed in these areas.

Recommendation 5.2: Industry secondments for postdoctoral researchers

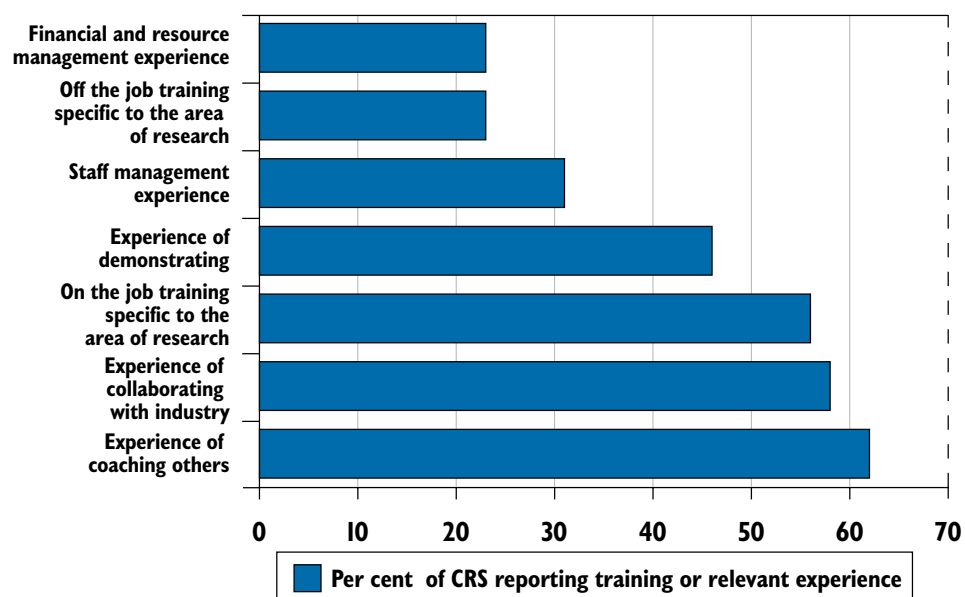
The Review recommends that HEFCE and the Research Councils evaluate schemes such as the Research Assistants Industry Secondments run by the EPSRC as the basis for a wider mechanism for encouraging postdoctoral researchers into industrial careers, and as a mechanism for knowledge transfer.

Training for Postdoctoral Researchers

- 5.22 The consultation revealed significant concern about the level of training provision for contract researchers. From the perspective of HEIs, the principal desired output of a postdoctoral researcher is research, primarily in the form of (joint) publications. However, this near-exclusive focus on research output generally leads to an under-emphasis on training and continuing professional development (CPD) for and by postdoctoral researchers.

- 5.23 There is evidence from the Research Careers Initiative that postdoctoral researchers do not tend to develop the full range of skills needed to be effective academics or to obtain jobs in R&D. In fact, postdoctoral experience, unless it is in a directly relevant field, seems to be a barrier to employment. Employers generally regard postdocs as likely to have been ‘captured’ by the ethos of ‘pure’ curiosity-driven research, in the negative sense that they are either unaware or actively unsympathetic to commercial constraints and directions on research.
- 5.24 The third RCI report concludes, on the basis of surveys of CRS (the results of which are set out in Annex 4 of the RCI report), that only a little over half of CRS (56 per cent) received on-the-job training specific to their research topic in 2000, and only 20-25 per cent received off-the-job training. This is despite the RCI guide to best practice, which states that funders should contribute to long-term research training of CRS.¹⁸⁷ Two-thirds of CRS survey respondents had not received any staff management experience, although 60 per cent or more had experience of coaching others. Nearly 50 per cent had experience of demonstrating (helping run laboratory classes for students) and around 45 per cent had experience in explaining their work to non-scientists. Similarly, a decreasing proportion of CRS (29 per cent in 1997, 23 per cent in 2000) gained experience of financial and resource management during their contract, and the proportion experiencing collaboration with industry also declined slightly, from 32 per cent in 1997 to 28 per cent in 2000. Despite this, around 60 per cent of respondents thought that collaboration with industry was “very useful”.

Figure 5.3: Training or relevant experience reported by CRS in 2000



Source: September 2001 RCI report, Annex 4.

¹⁸⁷ Report from RCI Group on Career Management and Career Structure of Contract Research Staff: A Guide to Good Practice. RCI Working Group on Career Management, 1998.

5.25 While the proportion of CRS receiving training has remained low and even declined, the availability of training has increased dramatically over the period covered by the surveys. Training in communication skills was available to 22 per cent of respondents in 1997 and to 42 per cent in 2000, although only 58 per cent of those to whom it was available in 2000 took part. Similarly, the availability of supported learning on intellectual property rights had grown from 6 per cent of respondents in 1997 to 16 per cent in 2000, with non-take-up of 44 per cent in 2000. These figures are illustrated in Table 5.1 below.

Table 5.1: Training provision and uptake by CRS

Training type	Availability (per cent)	Uptake (per cent)	Proportion with training (per cent)
Communication skills	42	58	24
Intellectual property rights	16	56	9
Teaching in HE	31	64	20
Project/finance management	18	49	9
IT training	50	69	35

Source: Research Careers Initiative, 2001.

5.26 A major constraint on training is finance. Some research funders are apparently unwilling to count training and development as legitimate uses of project funds. Only half of survey respondents received a regular (at least annual) appraisal of their work and personal development, although those who did almost always found them 'very useful' (39 per cent in 2000) or 'moderately useful' (44 per cent).

5.27 The RCI and the Bett Review of higher education pay and conditions¹⁸⁸ both recommended an increase in training and appraisal for CRS. This Review fully endorses and supports these recommendations. However, despite the improvements noted above, much more must be done to ensure that all CRS receive appropriate training and appraisal. Funders of CRS need to take this requirement fully on board in providing resources for research projects.

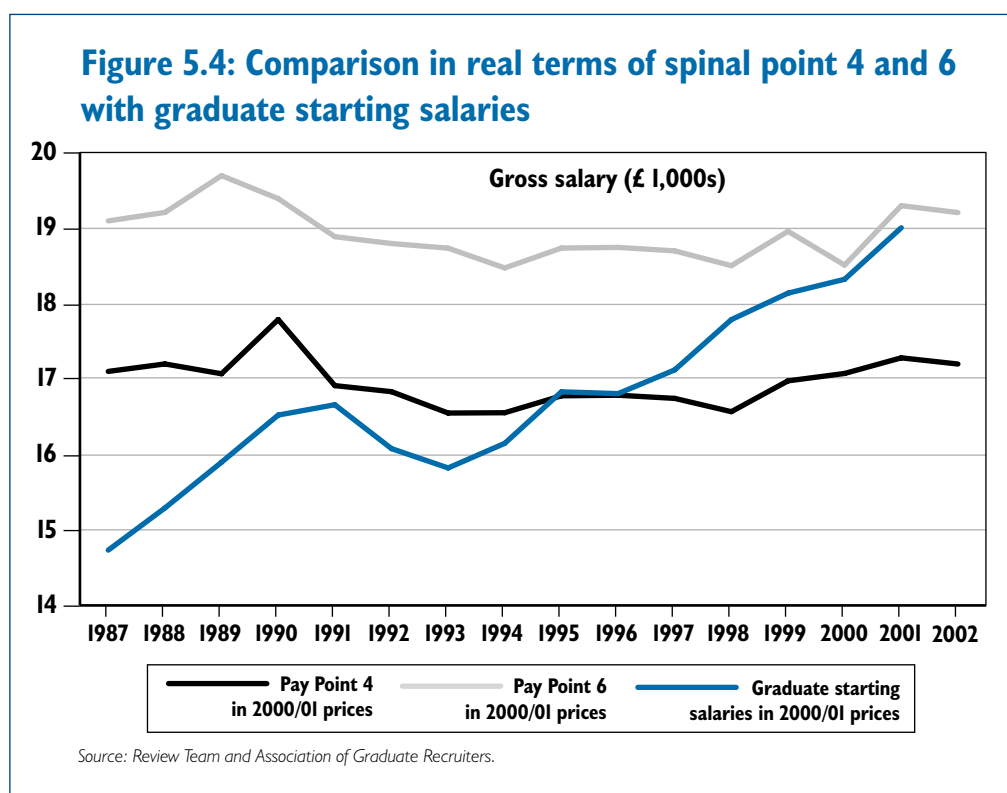
Recommendation 5.3: A vision for postdoctoral researchers

It is important for postdoctoral researchers to be able to develop individual career paths, reflecting the different career destinations – Industrial, Academic and Research Associate – open to them, and that funding arrangements reflect the development of these career paths. The Review believes that enabling the individual to establish a clear career path, and a development plan to take them along it, is critical to improving the attractiveness of postdoctoral research. The Review therefore recommends that HEIs take responsibility for ensuring that all their postdoctoral researchers have a clear career development plan and have access to appropriate training opportunities – for example, of at least two weeks per year. The Review further recommends that all relevant funding from HEFCE and the Research Councils be made conditional on HEIs implementing these recommendations.

¹⁸⁸ Independent review of higher education pay and conditions: Report of a committee chaired by Sir Michael Bett, Stationery Office, May 1999.

Salaries for Contract Research Staff

- 5.28 A further issue highlighted by the Review's consultation process was the relatively low salaries paid to CRS. Although the overall attractiveness of CRS jobs depends on a wide range of factors, including conditions of work, availability of training and work satisfaction, salary levels are an important factor in attracting sufficient numbers of able graduates to CRS posts.
- 5.29 Declining salary levels for CRS are illustrated in Figure 5.4. This shows salaries paid to researchers on spinal point 4 (the minimum appointment level for a PhD) and spinal point 6 (the minimum point for a 27 year old), against starting salaries for new graduates with a 2:1 or above offered by the Association of Graduate Recruiters companies. Salaries at both spinal points 4 and 6 fell in real terms during the early 1990s, as did graduate starting salaries. However, during the later 1990s CRS salaries remained static in real terms, while graduate starting salaries rapidly rose. By 2001, graduate starting salaries were virtually equivalent to salaries offered to 27 year old researchers.



- 5.30 Falling real salary rates have a number of detrimental effects. Most significantly, fewer of the best PhD graduates are attracted to postdoctoral research posts as salaries fall relative to those available elsewhere. Additionally, although there is evidence that newly qualified PhDs are willing to take lower salaries from employers who allow them to continue some curiosity driven research and academic publishing,¹⁸⁹ lower salaries may also be depressing private sector salary offers and thus reducing the overall attractiveness of undertaking a PhD.

¹⁸⁹ Do scientists pay to be scientists?, S Stern, NBER working paper 7410, October 1999.

Recommendation 5.4: Postdoctoral researchers' salaries

In addition to establishing clearer career progression, the Review recommends that Research Councils should significantly increase salaries – particularly starting salaries – for the science and engineering postdoctoral researchers it funds, and sponsors of research in HEIs and PSREs should expect to follow suit. The Review considers that the starting salary for postdoctoral researchers should move in the near future to at least £20,000, and that further increases should be available to solve recruitment and retention problems in disciplines where there are shortages due to high market demand (for example, mathematics).

Permanent academic staff

- 5.31 Academic staff are largely responsible for training the next generation of students at undergraduate and postgraduate level. The quantity and quality of academic staff employed by HEIs is therefore critical to the future supply of highly qualified scientists and engineers. In addition, those supervising and conducting research play an important role in supporting successful innovation within the UK.
- 5.32 The Review's consultation process revealed a range of concerns affecting the recruitment, retention and development of academic staff. Besides the disincentive to embarking on a university career created by the prevalence of short-term contract research work – addressed in the previous section – and other problems with the education supply chain addressed in previous chapters, key issues identified include:
- a **shortage of quality applicants** for many academic jobs;
 - an **ageing demographic profile of academic staff** in SET – with many older staff in physical sciences and mathematics in particular; and
 - **low academic salary levels**, operating to inhibit the recruitment and retention of scientists and engineers, particularly in areas with high housing and living costs.
- 5.33 It appears that HEIs have difficulty recruiting and retaining top-quality scientists and engineers, a problem which is exacerbated by the demographic profile of academic staff in these subjects (a large proportion of staff are over the age of 55) and in part caused by paying salaries which cannot compete with those on offer in some other countries (notably the US and Canada) and jobs outside the higher education sector.

Quality of applicants

- 5.34 The Review's consultation process identified a decline in the quality of new applicants for academic jobs, as perceived by universities. Measuring this is extremely problematic. Possible indicators include salary level, number of applicants per post, level of qualification and, for academic researchers, publication record.¹⁹⁰ Quantitative data on most of these indicators are not available, while salary level is not useful because UK pay scales are set through national bargaining. However, a number of surveys¹⁹¹ suggest that academics have been increasingly forced to appoint people of a lower standard than normal or to leave posts unfilled. Reports of problems appear to be particularly widespread in IT,¹⁹² engineering,¹⁹³ medicine, economics, law and business studies. Some of these surveys also indicate concern within universities at the ability of newly-appointed academic staff, in comparison with staff in other countries.
- 5.35 This largely anecdotal information, coupled with the evidence of rising demand in the physical sciences and engineering presented in Chapter 1 and the divergence between graduate salaries and CRS salaries (Figure 5.4) is consistent with the idea that the quality of new academic staff has fallen slightly. It is difficult to make any firmer statement than this on the basis of available information.

Demographic profile of academic staff

- 5.36 The consultation process indicated that an ageing demographic profile among academic staff is an area of significant concern. This changing profile has the potential to create major staffing difficulties in future years, particularly if SET subjects are to expand as part of reaching the Government's target of 50 per cent participation in HE.
- 5.37 The average age of institutionally-funded academic staff is increasing, with 16 per cent due to retire within the next 10 years in 1999/00, compared with 14 per cent in 1994/95. The change in age structure has been most noticeable in mathematics, where the percentage aged 55 and over has risen from 18 per cent to 25 per cent. In chemistry, the proportion of academic staff aged 55 and over has fallen slightly, although staff in this age group still represent a quarter of wholly institutionally funded academic chemistry staff. The proportion of female academic staff is projected to increase in all SET subjects in the next 10 years.

¹⁹⁰ *e.g.* in the sense measured by the Research Assessment Exercise (RAE), which includes patent activity.

¹⁹¹ *Recruitment and Retention of Academic Staff in Engineering Faculties*; Radio 4 Today Programme survey of Russell Group Vice Chancellors, 19th January 2002; *Staffing University Computing Faculties*, BCS, January 2002.

¹⁹² A survey by Metra Martech for the British Computer Society indicated that 13 per cent of computing departments had 20 per cent or more posts unfilled, with the major cause of shortages reported to be salary differentials between HEIs and industry.

¹⁹³ *Recruitment and Retention of Academic Staff in Engineering Faculties*, AE Long and A Toman, Institution of Civil Engineers, August 2001.

Table 5.2: Percentage of wholly institutionally funded staff aged 55+ in 1994/95 and 1999/00

	1994/95 (per cent)	1999/00 (per cent)
Medicine & dentistry	11.4	14.7
Subjects allied to medicine	9.2	11.0
Biological sciences	15.4	17.7
Chemistry	27.1	25.0
Physics	27.3	29.0
Other physical sciences	14.6	15.8
Mathematics	17.6	25.4
Computer science	8.2	12.0
Engineering	17.8	19.3
Business & administrative studies	10.5	13.6
All academic departments	13.8	16.3

Source: Based on HESA cost centre data in *Resources of Higher Education Institutions*.

A model of academic staff flows

- 5.38 To estimate the potential future impact of this changing profile, the Review worked with HEFCE to develop a model of the stocks and flows of academic staff in UK HEIs. The model was based on 1998 stock data for permanent academic staff who were either full-time or part-time and employed for over two days a week. The model also used data, collected over several years by HESA, which allows the tracking of individuals' academic careers. These data were then used to generate age-, gender-, grade- and discipline-specific profiles of recruits to and leavers from the system.¹⁹⁴
- 5.39 The model worked on an iterative basis: first it aged the population by one year, then modelled the outflows, then promotions and finally calculated the necessary inflows before starting again with the next year. The primary constraints on the model were the maintenance of the numbers with each subject of highest qualification. There were no constraints on the numbers in each grade. This meant that if the proportions in each grade were changing as a result of the flows prior to 1998, this pattern was sustained in the forecasts.¹⁹⁵
- 5.40 The expanding number of students in higher education needed to meet the Government's target of 50 per cent participation will have an impact on the number of academic staff required. However, the relationship between student numbers and number of academic staff is not simple, particularly as some

¹⁹⁴ Additionally information as to whether the staff were in a department with a RAE score of 3 and above in 1996 was used to examine the difference between research and non-research intensive staff. Individuals were classified on the basis of the discipline of their highest qualification, for ease of comparison between existing staff and postgraduates who could one day fill academic posts. The extent of transfers between disciplines, apart from transfers in and out of 'unknown', were rare, and the net flows were negligible, and it was decided not to model these flows.

¹⁹⁵ Further details of the modelling methodology and its results can be found in the forthcoming HEFCE publication *Academic staff in higher education: trends and projections*.

subjects will grow faster than others. Naturally, if all subjects grow at the same rate than the disciplines where the greatest number of staff are needed, identified in Table 5.3 below, would be under most pressure.

Results of the demographic model

- 5.41 Table 5.3 compares the inflows required to maintain 1998 numbers of staff to actual inflows in 1998. The modelling predicts a significant shortfall in the number of academics with an engineering qualification: the predicted necessary inflow in 2010 is 22 per cent greater than the actual inflow in 1998. In part this can be ascribed to the age profile of the 1998 stock – nearly 20 per cent of engineering staff were over the age of 55. However, the recent pattern of recruitment reflects relatively static student numbers, leading to recruitment levels below that necessary to sustain the stock of staff. Other factors are also at work. Engineers tend to enter the academic profession at a later stage than average (probably due to work in industry and/or greater postdoctoral research opportunities) and tend to retire earlier than average (probably due to the greater range of alternative employment available).
- 5.42 The modelling also suggests that about 33 per cent more mathematicians will be needed in 2010 to maintain the 1998 numbers. Here the essential problem appears to be the relatively low inflows prior to 1998, which were below replacement levels.

Table 5.3: Actual and forecast inflows by SET discipline 1998, 2005 and 2010

	Actual 1998 inflow	Forecast need in 2005	Percentage change 1998-2005 %	Forecast need in 2010	Percentage change 1998-2010 %
Biological sciences	511	407	-20	415	-19
Chemistry	133	143	8	129	-3
Physics	124	153	23	140	13
Other physical sciences	169	118	-30	128	-24
Mathematical sciences	144	213	48	192	33
Computer science	361	302	-16	314	-13
Engineering	498	632	27	610	22
Total	5,871	5,271	-4	5,337	-3

Source: HEFCE (forthcoming) Academic staff in higher education: trends and projections.

- 5.43 The model therefore suggests that greater inflows of academic staff in certain key areas will be required to maintain current levels. If student demand in these areas increases as a result of the actions recommended in this report, and the Government's work on achieving its 50 per cent target for participation in higher education, this need will be greater still. To analyse whether estimated necessary inflows are achievable, it is useful to compare these estimates with current numbers of doctoral graduates. It is recognised that in general not all academic staff have (or need to have) a doctoral qualification, and not all PhDs enter an academic career. Within SET, however,

a doctorate is almost always a pre-requisite for appointment to an academic post. One possible exception is computer science, where non-doctoral postgraduate qualifications are more common, which appears to require a large proportion of its PhD output as replacement academic staff. It may be that the pattern of qualifications for computer science staff either has changed or needs to change, with more academic staff being drawn from industry with non-doctoral backgrounds.¹⁹⁶

5.44 Table 5.4 shows that a higher proportion of both mathematics and engineering post-graduates will need to be recruited as academic staff in order to meet estimated necessary inflows.

Table 5.4: Comparison of modelled inflows and PhD output

Subject area	Actual 1998 inflow	PhD output 1998/99	Actual recruitment as percent of PhD output	Forecast need in 2010	Forecast 2010 recruitment as percent of 1998/99 PhD output
Biological sciences	511	1,706	30.0	415	24.3
Chemistry	133	873	15.2	129	14.8
Physics	124	555	22.3	140	25.2
Other physical sciences	169	480	35.2	128	26.7
Mathematical sciences	144	379	38.0	192	50.7
Computer science	361	301	119.9	314	104.3
Engineering	498	1,805	27.6	610	33.8
Total	5,871	11,338	51.8	5,337	47.1

Source: HEFCE (forthcoming) *Academic staff in higher education: trends and projections*.

5.45 These forecasts strengthen the case for improving the attractiveness both of PhD training (as discussed in Chapter 4) and an academic career, particularly as they affect certain key disciplines.

Academic salaries

5.46 The consultation process indicated growing concern at salary levels of academic staff, contributing to problems of recruitment and retention, which will be exacerbated by the increasingly international nature of the labour market.

5.47 International comparisons of the spending power of average UK academic salaries, calculated using a method developed by the National Association of Teachers in Further and Higher Education (NATFHE) based on OECD data, are presented in Table 5.5. They indicate that although UK academics are not paid as well as their counterparts in the US and Canada, they are – as a whole – neither particularly well off nor particularly badly off, with salaries

¹⁹⁶ The apparent lack of preference for PhDs shown by employers of computer scientists, mentioned in Chapter 4, is also a factor here.

falling between those of French and of German academics. Other studies¹⁹⁷ tend to present a similar picture, with academic staff in the UK earning around the same as or slightly less than their counterparts elsewhere in Europe, but somewhat less than equivalent staff in the US. However, these data do not distinguish between disciplines or between grades and quality of staff.

Table 5.5: International comparisons of average academic salary spending power, 1998

Country	Average annual salary spending power, 1998 (£)
Canada	58,289
United States	52,300
Finland	42,939
France	33,647
United Kingdom	31,210
Norway	30,511
Australia	28,654
Spain	23,365
Germany	23,005
Japan	15,481

Source: Based on work by NATFHE, using *Education At A Glance 2001* (OECD) and underlying data from www.oecd.org. The OECD Purchasing Price index, which takes benefits, taxes, exchange rates and living costs into account, was used to convert the average "compensation" of teaching and teaching/research staff in tertiary level institutions (which includes pension and other social benefits such as health care) into UK equivalents. The low placing of Japan may be due to them reporting headcount figures rather than full-time equivalents.

5.48 The Bett Review of UK higher education pay and conditions¹⁹⁸ found that pay for the most junior and most senior academic staff was low relative to comparable jobs in other sectors, and predicted recruitment and retention difficulties if pay for some groups of HE staff continued to be significantly below earnings from comparable jobs. There are similar problems in Germany.¹⁹⁹ In the case of SET and other disciplines linked to high-earning professions such as law and economics²⁰⁰ this differential is likely to be much greater.

5.49 There is evidence that HEIs are promoting a greater proportion – relative to most other disciplines and relative to previous levels in SET – of scientists and engineers to professorships and other senior posts in order to recruit and retain academic staff. Pressure for this 'grade drift' is created by the fact that UK universities, with few exceptions, operate a collective bargaining system for pay. This, in effect, sets out a common pay scale for all academic staff

¹⁹⁷ e.g. *Science Polices for the next Parliament: Agenda for the next five years*, Save British Science Society, February 2001.

¹⁹⁸ *Independent review of higher education pay and conditions: Report of a committee chaired by Sir Michael Bett*, Stationery Office, May 1999.

¹⁹⁹ The remuneration system for university professors in Germany has recently been reformed (including the removal of a salary maximum) to improve the international competitiveness of German HEIs for excellent academic staff and for experts from industry. Details are available (in German only) from http://www.bmbf.de/3992_4066.html.

²⁰⁰ The British Academy's *Review of Graduate Studies in the Humanities and the Social Sciences* (2001) noted concerns over the recruitment of academic staff in business studies, economics, psychology, law and education.

(professors excepted) across almost all disciplines.²⁰¹ As a result, the rate of promotion is the central way in which market forces operate on academic pay levels, which creates rigidity in HE reward mechanisms and suppresses salary differentials within and between institutions, disciplines and individuals.

5.50 A similar process operates to some extent in the private sector. The Mason report on the labour market for engineering, science and IT graduates,²⁰² for example, explored the question of why the perceived shortage of scientists and engineers had not led to increased salaries across the economy as a whole. The report concluded that many scientists and engineers work for companies that “operate ‘internal labour markets’ with a preference for stable salary differentials and for internal promotion within each firm to fill senior jobs. Such employers are reluctant to respond to recruitment difficulties by raising salaries for new recruits and thus disturbing existing salary structures”.

5.51 The extent of grade drift is illustrated in Table 5.6, which shows the percentage of staff in UK HEIs in Senior Lecturer and Professorial grades (or their equivalents) rising rapidly between 1995 and 2000. Table 5.7 presents this increase in percentage terms. The tables show particularly large increases in the number of professors in physics, chemistry, biology and mathematics, as well as social, political and economic studies (which is outside the scope of this Review). This is not simply a function of age: comparison with Table 5.2 shows that the large increase in chemistry professors coincided with a reduction in the proportion of staff over the age of 55.

Table 5.6: Grade drift in UK HEIs between 1995 and 2000 by subject of highest qualification

Subject	Percentage of staff in grade 1995			Percentage of staff in grade 2000		
	Lecturers	Senior lecturers & readers	Professors	Lecturers	Senior lecturers & readers	Professors
Biology	49.9	33.4	16.7	41.8	33.7	24.6
Chemistry	45.3	35.6	19.1	37.6	35.3	27.1
Physics	44.7	35.6	19.7	33.9	37.5	28.6
Mathematical science	53.8	29.5	16.7	42.8	32.6	24.6
Other physical sciences	54.2	30.2	15.6	46.2	30.8	23.0
Computer science, librarianship & info science	72.4	21.0	6.6	66.3	23.6	10.1
Engineering, technology, building and architecture	60.1	27.4	12.6	50.5	31.3	18.2
Social political and economic studies	58.5	28.1	13.4	50.6	28.7	20.7

Source: HEFCE (forthcoming) *Academic staff in higher education: trends and projections*.

²⁰¹ There is a London weighting, and there are separate arrangements for clinical academic staff.

²⁰² *The labour market for engineering science and IT graduates: are there mismatches between supply and demand?*, G Mason, National Institute of Economic and Social Research, March 1999.

Table 5.7: Increase in senior lecturer and professorial grades in UK HEIs, 1998 to 2000

Subject	Percentage increase in senior lecturer grades	Percentage increase in professorial grades
Physics	1.9	8.9
Chemistry	-0.3	8.0
Biology	0.3	7.9
Mathematical sciences	3.1	7.9
Other physical sciences	0.6	7.4
Social political and economics studies	0.6	7.3
Engineering and technology	3.9	5.6
Humanities	5.0	3.9
Computer science, librarianship and information sciences	2.6	3.5

Source: HEFCE (forthcoming) *Academic staff in higher education: trends and projections*.

5.52 The data presented in Table 5.6 and Table 5.7 indicate that universities are using promotion as a method of recruiting and retaining staff in certain disciplines, particularly at senior levels where international competition is most visible. It is less clear that HEIs are dealing with the issues of low pay for the most junior academic staff highlighted by Bett and with the competition for staff at that level.

Conclusions on academic pay

5.53 The Review's evidence points to the following conclusions:

- There is a significant mismatch between academic salaries and those in other occupations for particular scientific and engineering-related disciplines, such as physics and computer science. This mismatch is worse than for academic pay in general. Similar mismatches are believed to exist in other disciplines beyond the scope of this review, such as law and economics. Salary and grade structures are being manipulated to alleviate the problem, causing grade drift.
- There is need to improve financial rewards in order to maintain or improve the quality and numbers of the best researchers and educators of researchers in the UK. This is especially the case in engineering, computer science and mathematics, where the demographics indicate a need for increased recruitment, but also in biology, physics and chemistry, where grade drift is most marked. These people are long-term contributors to UK productivity through original research and the training of skilled researchers.
- HEIs, aside from creating additional professorships, have not managed to deal with this situation. There are financial and cultural barriers to delivering improvements in terms and conditions

targetted on these disciplines and individuals where recruitment and retention pressures are greatest. HEFCE's human resources strategy fund has provided some resources, which have mainly been used to establish institutional HR strategies.²⁰³

- Revenues from knowledge transfer (KT) activity have improved the situation for a few but certainly not all scientists and engineers in HE, and mechanisms for promoting KT and revenue sharing from KT activity vary noticeably across all institutions.
- Additional funding for scientists' and engineers' pay is needed, particularly for the most junior and most senior staff and those engaged in research of international quality, but the need is not uniform across disciplines (or across SET disciplines) or across institutions. Instead, there is a case for greater differentiation between and within disciplines and institutions. However, it is vital that institutions do not unfairly discriminate against women or ethnic minorities in competing for staff on the basis of salary.

Recommendation 5.5: Academic salaries

As with contract researchers, there is a need for universities to improve salaries – particularly starting salaries – for many scientists and engineers. The Review is clear that universities must use all the flexibility at their disposal differentially to increase salaries, especially for those engaged in research of international quality, where market conditions make it necessary for recruitment and retention purposes. The Government should assist by providing additional funding to permit universities to respond to market pressures. As a first step, the HEFCE funding currently dedicated to the human resources strategy should be made permanent. Further additional funding for recruitment and retention, which will vary between institutions, should initially be part of a separate stream linked to the existing human resources strategy fund and appropriately focussed towards research excellence. However, once more market-based systems have been embedded, the funds should be incorporated into core funding for research and also into revised subject teaching premia.

²⁰³ See also *Rewarding and developing staff in higher education: Good practice in setting HR strategies*, HEFCE 02/14, March 2002, http://www.hefce.ac.uk/Pubs/hefce/2002/02_14.htm#exec.

Summary of issues

Scientists and engineers make vital contributions to many sectors of the economy, not just through working in R&D. Their increasing attractiveness to a wide range of employers means that those seeking to employ the best scientists and engineers to work in R&D must compete more fiercely for their talents.

However, many R&D employers' packages are not competitive with what the best scientists and engineers can earn elsewhere. There are a number of areas in which action is needed if R&D employers are to attract the best scientists and engineers, including:

- **Salaries** – initial starting salaries and salary progression for scientists and engineers working in R&D are often worse than elsewhere. For example, the best scientists and engineers in industrial R&D earn less than two-thirds what their counterparts in the financial services sector earn.
- **Career structure and job design** – it is essential that scientists and engineers have both attractive initial posts and suitable career progression within the organisation.
- **Continuing Professional Development** – many scientists and engineers choose to work in research primarily due to their interest in the scientific or technical discipline, yet many R&D employers do not provide the time or resources needed to help them to stay abreast of the latest developments in their field.

The Review found that outdated employment practices were often representative of employer attitudes to R&D more generally, which is seen by too many as a short-term drain on profits and 'optional', in a way that other areas of the business are not.

The Review concludes that there is a significant challenge facing the community of employers which seeks scientists and engineers to work on R&D, but one that must be taken up if the supply of high-level SET skills to these businesses and organisations is to be improved.

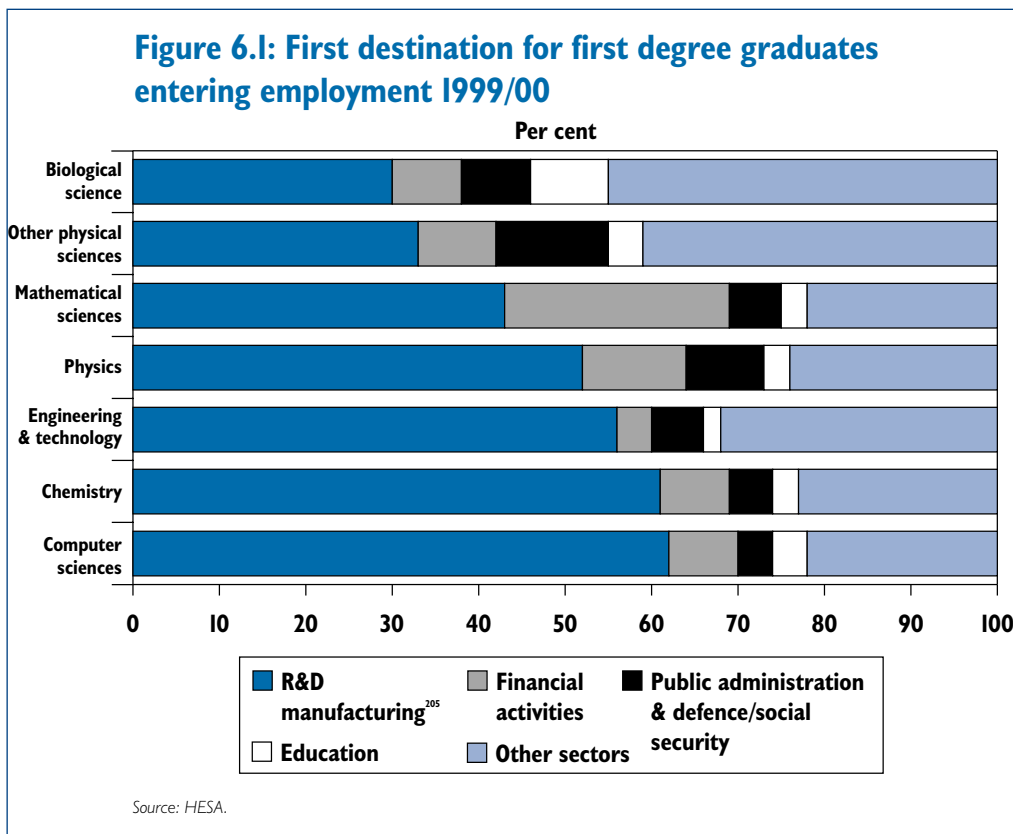
The Review also identifies ways in which the supply of suitably skilled scientists and engineers could be improved through better skills planning by employers, and more coherent dialogue and collaboration in training and research between employers and universities.

This chapter concludes by considering the issue of international mobility of scientists and engineers, and investigates (in particular) the arguments around whether the UK is suffering from a 'brain drain' in SET skills. Some evidence for this is found, although its extent is often overstated (indeed, more scientists and engineers locate to the UK than move abroad). Finally, the review recommends action aimed at improving the capacity of UK businesses to draw upon scientific expertise and talent from other countries in driving forward their R&D activities.

Employment of scientists and engineers

6.1 The demand for scientists and engineers in fields beyond their traditional employment in industry and higher education is rising. Employers in a wide range of sectors are attracted to scientists and engineers primarily for their numerical and analytical skills but also for their problem-solving abilities, computer literacy and ability to deal with large quantities of information. These skills are particularly useful in fields such as finance, accounting, consulting and IT. This increasing demand is set to continue and is welcome, since the contribution that scientists and engineers make in these fields is vital to the growth and success of these sectors. The importance of scientists and engineers to productivity growth is underlined by recent research²⁰⁴ by Haskel. This finds a broadly positive relationship between the proportion of firms employees who are qualified scientists and engineers (irrespective of their present functions) and firms' productivity growth.

6.2 The demand for scientists and engineers across a range of sectors is illustrated in Figure 6.1, which shows that over half of all physics, chemistry, engineering and computer science graduates work in what is loosely described as 'R&D manufacturing'. It also shows, however, that financial services are an important employer for graduates in the mathematical sciences and physics, due to the high-level numerical skills they will have picked up during their course. The education sector and public sector organisations such as the NHS, Public Sector Research Establishments and Government departments are also significant employers of scientists and engineers.

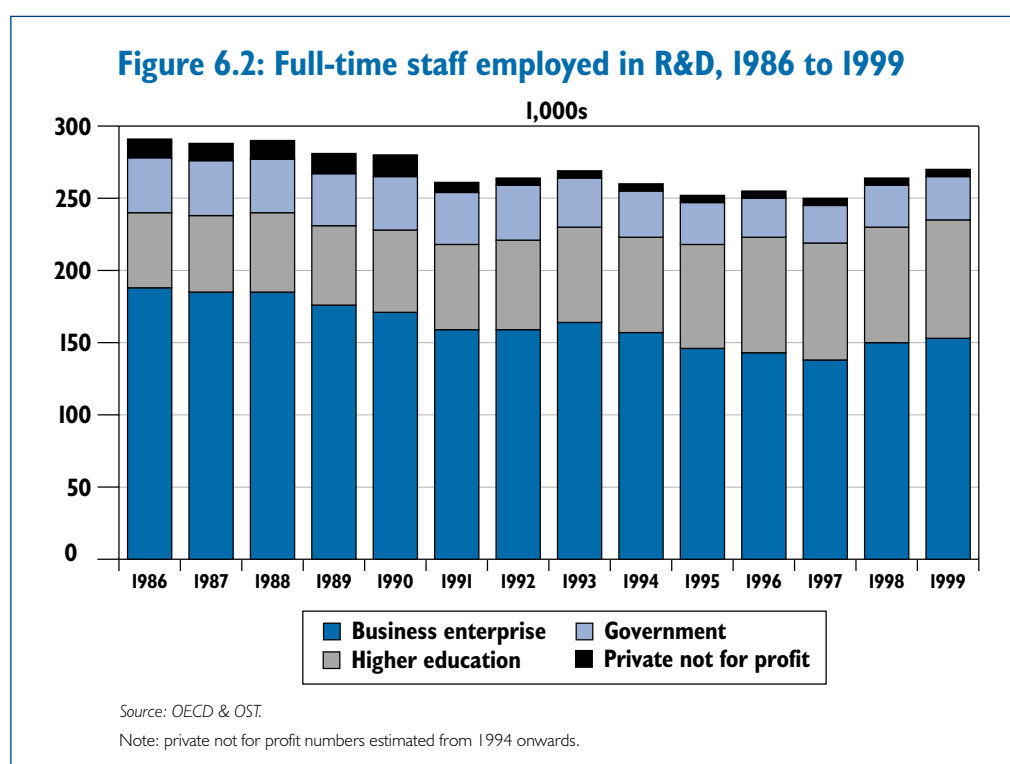


²⁰⁴ UK Manufacturing Productivity in the 1980s and 1990s, Haskel, 2002.

²⁰⁵ R&D manufacturing is the combination of SIC group D (manufacturing) and SIC group K (property development, rental and R&D) - in this case primarily R&D.

6.3 Figure 1.1 in Chapter 1 demonstrated that the UK's R&D performance in the 1980s and early 1990s was poor, with the UK spending less on R&D as a proportion of GDP in 1999 than it did in 1981. Together with the increasing 'capital-intensity' of R&D (the need for more sophisticated and expensive equipment per worker), this poor performance in overall R&D has led to a declining number of staff employed in R&D.

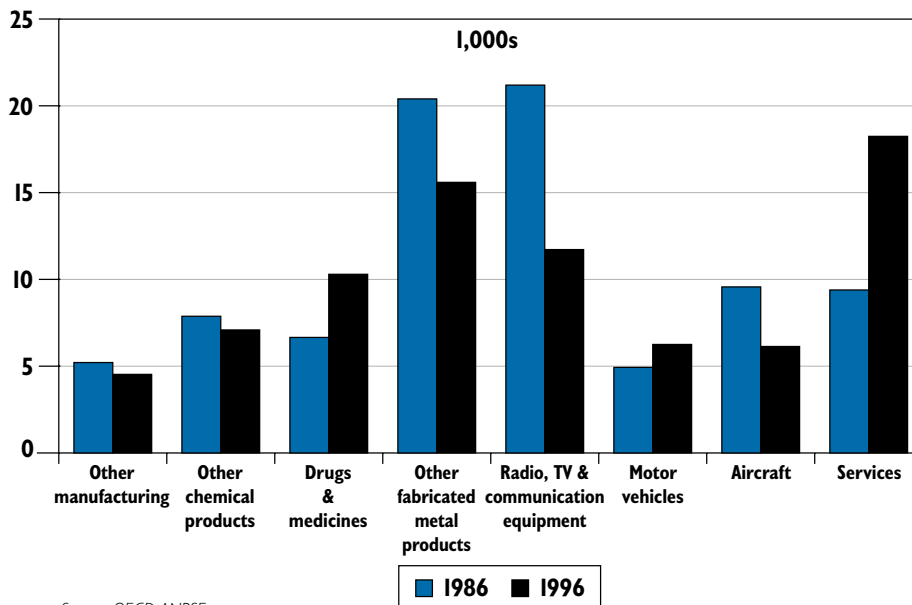
6.4 Figure 6.2 shows that the number of full-time R&D staff fell by over 10 per cent between 1986 and 1997, from nearly 300,000 to around 260,000. The main cause of this fall was a reduction in the number of R&D staff in business (and, to a lesser extent, the public sector), which is offset somewhat by a rise in the number of research staff in higher education. The increase in the number of researchers in 1998 and 1999 suggests an upturn in the level of business R&D activity in recent years²⁰⁶.



6.5 Within the overall fall in employment in R&D between the mid 1980s and mid 1990s, there have been some substantial differences in the trends in individual sectors. Figure 6.3 presents some of the changes in the key sectors. It should be noted that the main driver in these changes is the overall strength and health of the sector and the economy, and the changes do not necessarily represent an increase or decrease in the sector's commitment to R&D.

²⁰⁶ Although, as with the spend on R&D, this positive trend appears not to have continued into 2000.

Figure 6.3: Employment of professional scientists and engineers in business enterprise research sectors, 1986 and 1996



6.6 The chart shows that although the number of scientists and engineers has fallen in many sectors (consistent with the overall trend), the numbers employed in the pharmaceuticals and service sectors have increased significantly. This underlines the growing importance of ‘new’ sectors as well as ‘traditional’ industrial R&D as employers of scientists and engineers.

SET and the City: Employment of scientists and engineers in the financial services sector

Financial services businesses in the City of London are important employers of highly-skilled science and engineering graduates and PhD holders. Nearly 10 per cent of all SET students’ first jobs are in the financial services sector, and this figure rises to a quarter when considering mathematical sciences graduates. Graduates in mathematics and physics in particular are attractive to the City because they often have good problem-solving and very strong numerical skills, which are important in dealing with financial data. City firms acknowledge a preference for SET graduates (and financial and economics graduates) over other disciplines, although this is not the only criteria against which applicants are judged.

In highly mathematical areas such as risk analysis, options pricing and computer modelling there is a growing demand for exceptionally numerate and skilled graduates and, in particular, PhD holders. Demand from financial companies for these skills has grown since the deregulation of the UK financial system began in the 1970s. The subsequent growth in complex and ‘exotic’ financial products such as options and derivatives led to a demand for people who were familiar with solving partial differential equations used in pricing options as well as other highly quantitative modelling techniques involved in risk analysis. In many cases, only mathematics graduates and postgraduates (and other science, engineering, finance and economics graduates and postgraduates who have specialised in strongly mathematical-related areas) are able to deal with the complexities in the analysis of such financial instruments.

The attractiveness of work in R&D

- 6.7 Given the increasing demand for highly-skilled scientists and engineers from a range of sectors, employers wishing to recruit and retain the best scientists and engineers to work in R&D will have to offer ‘packages’ that compete with the best offers available elsewhere.
- 6.8 However, discussion with students, employers and university academic staff, and responses to the Review’s consultation, revealed that highly-skilled scientists and engineers are increasingly viewing the packages offered by many R&D employers as uncompetitive. This contributes to the recruitment difficulties experienced by R&D employers discussed in Chapter 1²⁰⁷.

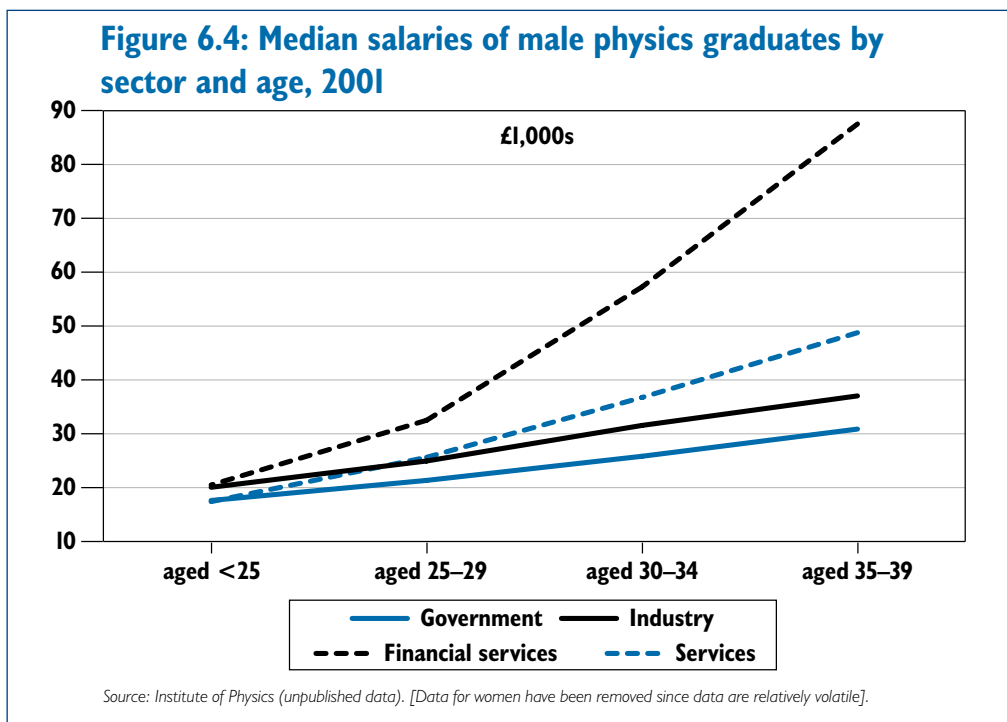
Salaries for scientists and engineers

- 6.9 An attractive starting salary and salary progression are widely acknowledged to be increasingly important factors in graduates’ career choices. This is partly due to the increasing levels of debt that students incur during their time in higher education. In addition, students are being taught – at the request of employers – more about enterprise and commercial awareness during their education, and therefore often apply these principles when choosing employment themselves.
- 6.10 However, the salaries paid to scientists and engineers working in R&D are increasingly uncompetitive with what their counterparts in other sectors are earning. Data from the Labour Force Survey suggests that science and engineering graduates working in a ‘professional’ capacity earn around 10 per cent less than qualified scientists and engineers working in other areas.
- 6.11 This is backed up by a survey carried out for the Mason report²⁰⁸, which found that technical graduates working in the financial services and computer services sectors earned more than their counterparts in the electronics, machinery, pharmaceuticals and R&D services sectors.
- 6.12 Interestingly, the salary differences were greater at the top end of the income spectrum. Although there was little difference in the median starting salaries between these sectors, those around the top quartile in the financial services sector earned around 5-10 per cent more than their counterparts in the electronics, machinery, pharmaceuticals and R&D services sectors. This gap grew to around 20 per cent for those around the top decile, which suggests that financial services companies are targeting their rewards to attract the best people more so than companies in other sectors.

²⁰⁷ Econometric evidence presented in the paper *Technology, Wages and Skill Shortages: Evidence from UK Micro Data*, Jonathan Haskel (Queen Mary and Westfield College), Christopher Martin (Brunel University), November 1998, found that, as theory would suggest, recruitment difficulties are inversely related to the relative wage.

²⁰⁸ *The labour market for engineering, science and IT graduates: are there mismatches between supply and demand?* G Mason, National Institute of Economic and Social Research, March 1999.

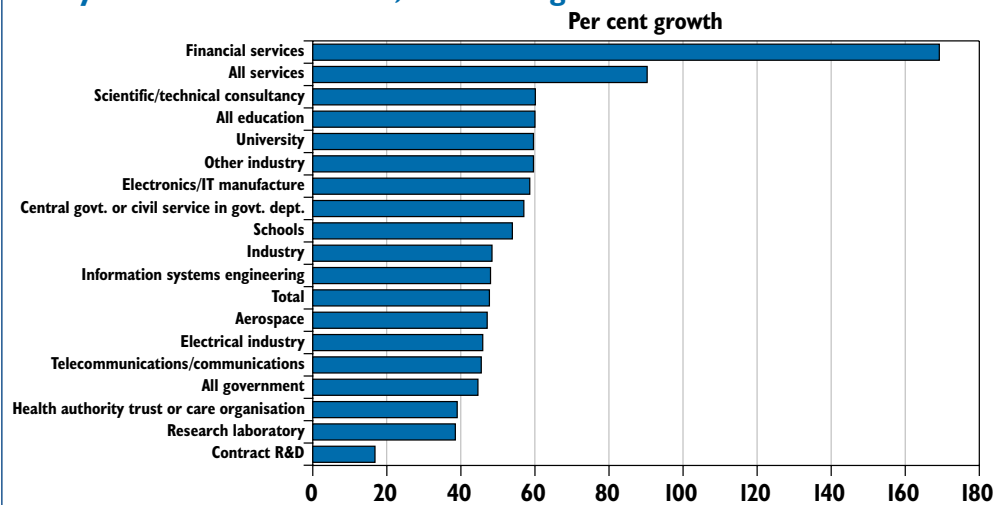
- 6.13 The gaps in salaries between these sectors were also shown to grow substantially with experience. After five years' experience, the median salary of those in the financial services sector was around 5-10 per cent higher than for those in industrial R&D, with the gaps between the upper quartile salaries being around 25 per cent and the gaps between the top decile salaries being around 50 per cent.
- 6.14 This suggests that although businesses in the financial services and similar sectors may not give a substantially higher starting salary to the average graduate, they will pay considerably more for a highly-skilled graduate than R&D businesses. Furthermore, the salary progression is far more rapid in the financial services sector than in industrial R&D.
- 6.15 The findings from this survey are supported by data provided by the Institute of Physics, which show that although there is relatively little discrepancy in the starting salaries of their members working in industry, services and the financial services sector, substantial differences soon emerge. This is illustrated in Figure 6.4.



- 6.16 Figure 6.5 shows that male physics graduates²⁰⁹ employed in financial services and in the service sector generally received significantly larger salary increases between their late 20s and their late 30s than did their counterparts in industry.

²⁰⁹ Members of the Institute of Physics typically possess a physics degree.

Figure 6.5: Growth in median salaries of male members of the Institute of Physics in various careers, between ages of 25-29 and 35-39



Source: Institute of Physics (unpublished data). [Data for women have been removed since data are relatively volatile].

Salary competition for scientists and engineers

Discussions with businesses and others as part of the Review's consultation revealed a number of reasons why R&D businesses often do not compete more vigorously on salaries for the best scientists and engineers.

Attitudes to R&D – Regrettably, some businesses tend to view R&D more as an optional extra than as a core part of their business plan. As a result, if they cannot recruit a scientist or engineer at a particular salary to work on an R&D project, they will often choose not to undertake the project rather than increase the salary offered.

Salary rigidities – Some R&D businesses choose not to compete on salaries for fear of disturbing the salary structures that already exist in a company (for example, to stop a new recruit earning as much as, if not more than, an existing employee).

Alternatives to raising salaries – In response to a recruitment difficulty some businesses choose to retrain their existing staff or improve their advertising strategy. They may also use 'hidden' financial rewards (*e.g.* subsidised mortgages) that will not show up in salary data. In some cases, larger companies may take short-term action by recruiting contract staff, although this can be very expensive and is probably a last-resort measure. In the survey of firms carried out for the Mason report, most firms appeared to prefer these methods of dealing with recruitment problems rather than competing on salaries.

Uncertainty – Business can be discouraged from increasing their starting salaries through uncertainty as to how well the new recruit will perform in R&D. In particular, businesses can find it difficult to assess before appointing someone whether an individual has an 'innovative spark'.

'Choosing the competition' – Many R&D businesses choose not to compete with service sector companies on pay, but instead seek to compete for those scientists and engineers for whom the wish to work in research outweighs salary considerations. In particular,

some businesses look to the public and higher education sectors (the largest employers of scientists and engineers working in research) who tend to pay lower rates than the private sector generally. Public and university pay scales are often inflexible and relatively immune to market pressures in the short to medium term and are therefore poorly correlated with demand for scientists and engineers. Some R&D businesses see university research salaries as a benchmark against which they need only offer slightly higher salaries to attract researchers. However, as referred to previously, this approach is likely to lead to R&D businesses being unable to recruit graduates and postgraduates with entrepreneurial and commercial awareness, who are more likely to choose better paid careers in other sectors.

Economic conditions – There are also arguments that because R&D businesses are primarily in the manufacturing sector they face stronger cost pressures than their counterparts in the service sector, and that their ability to pay scientists and engineers more has been limited by conditions in manufacturing more generally.

Non-salary factors in recruiting and retaining scientists and engineers

6.17 Through discussion with scientists and engineers, the Review identified a range of factors other than salary as important in providing an attractive package, including:

- an attractive career structure, with sufficient responsibilities and challenges; and
- good prospects for training and development, and intellectual rewards.

6.18 Career structure is important to many science and engineering graduates. The Review found that in too many cases R&D businesses were not doing enough to provide an attractive and rewarding job and career in R&D. A number of practices that reduce the attractiveness of careers in R&D were identified:

- **Poor job design**, with many highly-qualified researchers feeling that their skills were being under-utilised. One reason for this is that the majority of graduate recruiters²¹⁰ do not have a separate recruitment process for postgraduates. Postgraduates therefore enter the same jobs as first-degree entrants, which they find unchallenging and unrewarding. A further example of this under-utilisation of skills comes from the Mason report,²¹¹ which found that just over one in four recruiters had filled previously non-graduate jobs with graduates in the previous three years. Better job design could also allow more flexible working, which would encourage more qualified women into (and back into) R&D.

²¹⁰ Evidence from a survey of 80 employers published in November 2000 in *Survey of Employer Attitudes to Postgraduates and Contract Researchers*, S Wright, AGCAS, November 2000.

²¹¹ *The labour market for engineering science and IT graduates: are there mismatches between supply and demand?*, G Mason, National Institute of Economic and Social Research, March 1999.

- A new study for the DTI on the biotechnology sector found that **companies, particularly SMEs, needed to structure and pre-plan the induction of new employees better**, in order to integrate new staff into the firm's work patterns and processes – and hence make them productive – more quickly.
- R&D businesses seem in many cases reluctant to give as much **responsibility** to new graduates as do businesses in the services sector – for example, meeting clients or customers.
- **Poor job security**: some businesses appoint scientists and engineers on successive short-term contracts, coinciding with the duration of R&D projects. This makes career planning very difficult; as a result, short-term contracts can be a significant factor in discouraging women, in particular, from entering scientific careers. The Fixed Term Work Directive, due to be implemented in the UK later this year, should help to reduce unfair use of successive short-term contracts.

6.19 **Training and continuing professional development** (CPD) are vital to staff in fast-moving scientific disciplines, and act as an important retention mechanism. However, science and engineering graduates are offered less job-related training than those from other disciplines.²¹²

- The non-monetary rewards of developing and contributing to scientific understanding are important to many scientists and engineers. Some scientists are willing to forgo improved earnings in order to work in an environment where they can publish and continue to contribute to the broader body of knowledge.²¹³ CPD can likewise help motivate and retain such staff.
- Trade associations and professional bodies should advise companies on effective induction and training processes, and can help engage HEIs and other providers to deliver high-quality, high-level CPD to businesses. The DTI study of the biotechnology sector indicates that, given the timescales that can be involved in changing undergraduate and postgraduate courses in HE, companies needed to make much greater use of CPD in tackling their skills needs.

6.20 R&D businesses must also employ sophisticated **recruitment techniques** to be able to compete for science and engineering graduates with other sectors. The financial services industry, for example, uses a wide range of media and events to attract students, from poster advertising to targeting of key HEIs and courses. This involves marketing of the sector and the firm as well as advertising particular jobs. The DTI study of the biotechnology sector reveals that normally more than one recruitment method is used in a successful recruitment exercise. Taking sandwich year or vacation students is also a valuable tool for recruitment.

²¹² Evidence from the Institute of Employment Studies in *The Graduate Review 2001* by Sarah Perryman and Richard Pearson, showed that science and engineering graduates were less likely to have participated in training at work compared to other graduates.

²¹³ *Do scientists pay to be scientists?*, Stern, NBER Working Paper 7410, October 1999.

Recommendation 6.1: Attractiveness of careers in R&D

Responding to the challenge of improving the attractiveness of jobs in R&D to match or surpass all other opportunities open to the best science and engineering graduates and postgraduates is crucial to individual businesses' future success – since their R&D underpins their future products, services and, ultimately, their future sales and profits.

Through consultation with businesses and scientists and engineers themselves, the Review has identified a number of issues related to work in R&D that employers must address in order to be able to attract the best science and engineering graduates and postgraduates.

- **Initial pay.** Starting salaries are an increasingly important factor in students' career choices, in part due to the effect of student debt and students' increasing commercial awareness. The starting salaries and bonuses paid to scientists and engineers working in R&D are often not as high as they could receive in other sectors or occupations. While it may not be necessary to match the highest salaries paid elsewhere, the Review is clear that businesses will ultimately need to raise the salaries and other financial rewards they offer if they are to compete for the best scientists and engineers (particularly those with an entrepreneurial spark or good commercial awareness). This goes hand-in-hand with the need for businesses to look at R&D not as a cost, but as an investment in their future survival and growth.
- **Salary progression.** Similarly, retention in an increasingly mobile workforce relies upon salary progression that compares well with the other opportunities available. Evidence suggests that the salary progression for scientists and engineers in R&D does not compare favourably with that for their counterparts in other sectors.
- **Career structure.** Science and engineering graduates and postgraduates can be put off entering R&D due to unattractive career structures – with short-term contracts, low levels of responsibility, few chances for progression within R&D and poor job design (*e.g.* jobs that do not use their skills to the full). It is clear from the Review's consultation that many employers can do more to improve the career structures of scientists and engineers, through addressing these and other influential factors.
- **Training and professional development.** Scientists and engineers working in research do so partly because of their interest in the subject, and it is therefore key that they can stay in touch with the latest developments in their field. Employers should do all they can to provide time and resources to allow them to do this, and partake in CPD activities, which will also bring benefits in terms of recruitment and retention. There is a role for the Government and for trades unions in helping to make sure that smaller businesses are able to provide sufficient training and CPD to research employees.

- **Recruitment mechanisms.** The Review believes that many R&D businesses must improve their recruitment mechanisms to compete better with other employers. For most R&D businesses, especially the smaller ones, increasing marketing efforts and taking opportunities to widen the number of students they make contact with should improve their ability to recruit the scientists and engineers they need. R&D businesses must also take responsibility for improving the perception of jobs in R&D.

The Review is clear that the response of R&D employers to these challenges is crucial in providing an adequate supply of scientists and engineers for R&D. Without improved and more attractive opportunities to work in R&D, the UK's best scientists and engineers will doubtless be tempted elsewhere, since the demand for their skills – and the rewards offered – will only grow over time.

Recommendation 6.2: The challenge to employers

The Review recommends that the Government should establish a group of R&D employers to support and monitor employers' responses to the challenge of improving the pay, career structures and working experiences for scientists and engineers in R&D. The group should include representatives from businesses (large, medium and small) and others that employ scientists and engineers in an R&D capacity.

The Review believes the group must act as a driving force in taking the recommendations in this report forward and should publish a report, before the next public spending review, setting out the response of employers to the challenges identified by this Review. The group might also play a key role in considering cross-regional and national R&D skills needs, referred to in Recommendation 6.4.

Communication and collaboration in research and training

6.21 The need for effective communication between businesses, the education sector and students has been highlighted throughout the report. The key messages have been that:

- the profusion of independent schemes aimed at enthusing and educating pupils in science and engineering is inhibiting the collective effect of these schemes, and the Government should establish SETNET as the single channel through which schools and colleges access these schemes (recommendation 2.12);
- R&D businesses must communicate better with HEIs to influence the skills that SET graduates and postgraduates develop;
- R&D businesses benefit from relationships with individual students in HEIs, who may be potential recruits; and
- research collaboration between R&D businesses and HEIs often aids recruitment.

6.22 Interactions between business, schools and Further Education colleges have been covered in Chapter 2. This chapter deals with the need for businesses to communicate better with the HE sector. Both businesses and HEIs have responsibilities for this and must be partners in improving the connections between science and engineering in higher education and the flow of SET graduates into R&D businesses. The Review is concerned that:

- businesses do not assess their future skills needs effectively;
- businesses do not (and often cannot) communicate their skills needs effectively to HEIs, and so do not readily develop effective partnerships; and
- more research collaboration between businesses and HEIs is needed.

Business assessment of skills needs

6.23 Although companies carrying out R&D often plan their research years in advance, skills needs are rarely assessed on the same timescale. The Review's discussions with firms in a variety of sectors indicate that while skills planning by large companies can be for 3-5 years ahead (often the length of the business planning cycle), SMEs and those companies in fast-moving industries such as ICT generally plan on a very short horizon (less than one year) if at all, preferring to recruit skilled labour from other businesses in the same field when need arises.

6.24 A recent study of the biotechnology sector by Angle Technology for the DTI²¹⁴ found that company business planning was typically on a 3-year cycle, but HR planning timescales were much shorter and in most cases planning for staff needs was sketchy. The HR brief was often held by a senior manager rather than a HR specialist, particularly in smaller companies.

6.25 Large companies tend to devote more resources to recruitment and skills planning than do SMEs; partly as a result, SMEs tend to face more recruitment difficulties. SMEs need to be supported and advised on their skills planning by trade associations, Sector Skills Councils, the Small Business Service or wherever else SMEs go to for help in their business planning. In some cases, regional or local business networks associated with clusters of SMEs²¹⁵ can allow collaboration on defining and planning for skill needs.

²¹⁴ to be published April 2002.

²¹⁵ The south of England has a number of successful R&D clusters including the biotechnology industry in and around Oxford and Cambridge whereas regions such as the Midlands and Yorkshire have large manufacturing clusters.

Recommendation 6.3: Skills planning

It is clear that although many businesses may plan their R&D projects a number of years in advance, they often do not plan their skills needs for this research more than a year ahead. Although there are difficulties in detailed skills planning, the Review believes that R&D businesses must do more to establish what science and engineering skills they will need for future research projects in order for them to be able to recruit the skilled scientists and engineers they need with less difficulty.

HE-business collaboration in training and skills supply

- 6.26 The relationship between businesses and HEIs in meeting companies' skills needs must be a partnership. In too many cases, businesses have an inadequate grasp of their own skills requirements, and believe that HEIs should alter courses to meet their needs without reference to the other fields graduates might work in. Equally, as discussed in Chapter 3, universities and other HEIs often do not listen effectively to businesses, and have in many cases been insufficiently innovative in course design. One constraint on course design and adaptation has been the professional standards set by bodies like the Engineering and Technology Board which – in practice – largely determine the content of some courses and make them burdensome to alter. More flexibility from accreditation bodies is needed.
- 6.27 Partnerships between HE and business need to be rooted in the strengths of the two partners: businesses are best able to assess their current and near-future skills needs, while universities are expert educators and can – through their work at the forefront of new knowledge – teach students about areas which will grow to prominence in the future. They also must take account of the needs and relative weaknesses of the two: constraints of finance, the time lag between agreeing to develop course materials and offering the course, and so on.
- 6.28 HEIs have in the past responded to business skill needs by redesigning existing or designing new degree courses or modules, but this can be time-consuming and expensive. The Royal Academy of Engineering's Visiting Professorship Programmes aims to develop university teaching materials based on real-life business case studies and have been effective in fostering links between industry and academia. Communication between business and HE is currently too ad-hoc and varies widely in effectiveness. Large R&D businesses currently communicate with HEIs through Industrial Advisory Boards, careers services, or through sponsoring Chairs²¹⁶, but are not often actively involved in degree course design. SMEs are generally less proactive in communicating with HEIs, but clusters of SMEs and local or regional business networks tend to have better links with HEIs. More coherent skills messages are needed in order for HEIs to respond effectively. At the regional and sub-regional level, RDAs are vital to understanding labour markets and making HEIs aware of skills needs; this understanding must also be aggregated up to a national level, drawing on the work of trade associations, the Council for Science and Technology, Foresight and the new Sector Skills Councils.

²¹⁶ *i.e.* paying for a Professor in a particular field, almost always one relevant to the business.

6.29 Work placements and collaborative projects can be a good way of bringing HEIs and R&D businesses together, providing recruitment opportunities and reducing the search costs of recruitment for companies and potentially allowing staff to engage in CPD or to gain further qualifications. Existing schemes and mechanisms include:

- the **STEP**²¹⁷ (Shell Technology Enterprise Programme) scheme, which encourages SMEs to consider employing graduates (rather than non-graduates) and each year provides around 1,000 undergraduates with experience of working in a SME and encourages them to consider a career in a small company;
- **TCS** (formerly the Teaching Company Scheme), which aims to facilitate the transfer of technology between businesses and HEIs through providing business based training (for at least two years) for 'high quality' first SET degree graduates (at the beginning of 2002 there were more than 900 programmes in operation, predominantly in SMEs);
- the **CASE**²¹⁸ (Co-operative Awards in Science and Engineering) scheme, which aims to encourage communication and build links between universities, students and business employers in science and engineering (CASE allows research students to work on projects of one to three years in duration which are of direct relevance to a particular industry, jointly supervised by an academic supervisor and the company where the research student might be based); and
- HEI-run **sandwich courses** that enable students to gain valuable industrial and commercial experience during their programme of study. In the academic year 1999/2000 approximately 12,000 SET students graduated from sandwich courses²¹⁹. The benefits of sandwich courses have been widely recognised; the Dearing Review in 1997 recommended that where possible every student should do a work placement. However, a survey of SET employers in the Mason report²²⁰ found that only 38 per cent of all recruiting enterprises had recently been involved in providing placements for sandwich students, despite their widespread wish to recruit graduates with industrial experience; SMEs had particular difficulty in offering placements.
- The **Industrial Secondment Scheme** supported by the Royal Academy of Engineering provides engineering academics with the opportunity to learn of the latest developments in industry.

²¹⁷ STEP (Shell Technology Enterprise Programme) is managed under contract to Shell International and is an undergraduate work experience scheme that is also funded by SBS and DTI.

²¹⁸ CASE projects are jointly devised and supervised by academic departments and co-operating bodies (industrial and commercial organisations in the public or private sectors, and local authorities and research council institutions and laboratories). The CASE award scheme has been successful in part because it has developed incentives for all parties (student, HEI and business) to be involved.

²¹⁹ *Students in Higher Education Institutions*, HESA.

²²⁰ *The labour market for engineering science and IT graduates: are there mismatches between supply and demand?*, G Mason, National Institute of Economic and Social Research, March 1999.

Recommendation 6.4: Skills dialogue

The Review believes that the supply of skills to R&D businesses can be improved through more coherent skills dialogue between these businesses and universities. The Regional Development Agencies (RDAs) should take a leading role in the coordination of regional dialogue between businesses and HEIs through the new FRESAs (Frameworks for Regional Employment and Skills Action) to ensure that demand for higher level skills at a regional level can be met.

Furthermore, the Review recommends that the sector skills councils (which, the Review believes, should be represented in FRESAs) work with the Learning and Skills Council, trade associations and other business groups to identify – based on the regional skills discussions – evolving cross-regional and national R&D-related skills needs.

Recommendation 6.5: Business involvement in higher education

Although universities need to be proactive in ensuring that courses are as relevant to business as possible, the Review believes that businesses must become more actively involved in university course design. In particular, the Review recommends that employers' bodies – for example, the CBI and trade associations – and the Government work to encourage more R&D businesses to participate in providing work placements for SET graduates and postgraduates (for example, in sandwich year courses).

HE-business collaboration in research and development

- 6.30 Despite the clear commercial benefits to many businesses from research collaboration with HEIs²²¹ and the value of training SET undergraduates and postgraduates in a commercial research environment, very few businesses participate in innovation partnerships²²² with HEIs.
- 6.31 The Government already supports a number of industry-academic collaborations and centres, which involve the participation of businesses and universities and serve to encourage research collaboration²²³ and hence communication between the parties involved. Some of these research initiatives also provide training for SET students/graduates and PhDs in an industrially orientated research environment, which helps to develop the skills required for working in business R&D:
- **Faraday Partnerships** have several objectives including improving the two-way flow of technology and skilled people between the science base and industry. Faradays create partnerships between industrially oriented research organizations, such as Research and Technology Organisations (RTOs), government agencies, private sector laboratories

²²¹ Studies suggest that there are significant benefits for companies if their scientists and engineers collaborate with university research teams. Collaborative research projects allow for a greater transfer of tacit knowledge which companies require to be able to commercialise the research and thus offset their commercial development costs. One such study is *Commercialising knowledge: university science, knowledge capture, and firm performance in biotechnology*, J Armstrong, M Darby, L Zucker, NBER Working Paper 8499, October 2001.

²²² The Community Innovation Survey 2001 (DTI) found that only 13 per cent of businesses had innovation partnerships with HEIs on a local level and 19 per cent on a national level.

²²³ However, the Review is concerned that the research conducted in these collaborations is often too dominated by existing academic interests and funding and too little driven by business needs.

and the science and engineering base. The 18 Faraday Partnerships undertake core research to underpin product and process development at the same time as providing industrially relevant postgraduate training. (Three Industrial CASE studentships are allocated to each partnership every year.)

- At the end of 2001 the Engineering and Physical Science Research Council (EPSRC) established twelve **Innovative Manufacturing Research Centres** (IMRCs) at universities across the UK. The IMRCs cover several mainstream areas of manufacturing such as aerospace, defence, automotives and construction. The EPSRC has allocated £60m to the IMRCs over a five year period and expects that at the end of those five years third party funding will add another £45m. The aim of the IMRCs is to develop strong research links with industry and encourage collaborative research between universities and industry.
- There are a range of other '**Centres of Excellence**' in which universities and businesses collaborate to generate and apply knowledge to solve commercial problems, such as the Centre of Excellence in Advanced Telematics at the University of Birmingham and the Virtual Centre of Excellence in Mobile and Personal Communications led by the University of Surrey. The Engineering Design Centre (EDC) in Cambridge, also known as a 'Centre of Excellence', was recently identified as an IMRC by the EPSRC; the National Assembly for Wales recently established 20 Centres of Excellence for Technology and Industrial Collaboration; and the Ministry of Defence has recently launched a series of Defence Technology Centres designed to enhance UK defence capability.

6.32 These joint research organisations have an important role in preparing SET graduates with the appropriate skills needed for working in commercial R&D, and this should be given higher priority than at present. However, they need to do more to stimulate business investment in their research and R&D businesses should take a stronger role in leading their research.

Recommendation 6.6: Research collaboration between business and higher education

There are a number of Government sponsored schemes that act to encourage research collaboration between businesses and HEIs. However, the Review feels that the collective impact of these schemes is not as great as it should be. The Review therefore recommends that the Department of Trade and Industry, as part of its increased focus on innovation and skills, and more effective delivery of business support, should evaluate the success of existing initiatives in this area – in particular, paying attention to whether the training elements of these schemes are sufficiently supported and prioritised and the extent to which they play a strong role in employer-university communication and collaboration.

The need for better innovation partnerships

- 6.33 Business has been critical of the bias towards academic research of some of the existing research organisations in the UK and is often sceptical about the benefits of investing in more applied research itself. This not only leads to under-investment in collaborative research, but also reduces the opportunities for scientists and engineers in academia to gain experience of commercial work, and vice versa.

Overseas research organisations

The experience of a number of other countries in establishing joint-research initiatives between industry and academia can provide some relevant experience for the UK.

The Fraunhofer Institutes in Germany are applied research institutes that undertake contract research on behalf of industry, the service sector and government. Research is both industrially focused applied research as well as 'blue-skies' research. Applied research is directed at providing technical solutions to improve the competitiveness of industry. These Institutes have been able to provide commercial R&D experience for up to 10 per cent of German SET students/graduates. TNO (abbreviation of the Dutch name: *toegepast-natuurwetenschappelijk onderzoek*) in The Netherlands is also an applied research organisation, again connecting fundamental research with practical applications that can be commercially exploited by business. As with the Fraunhofer Institutes, up to 10 per cent of SET graduates and PhD students in The Netherlands undertake research in a TNO.

The Cooperative Research Centres (CRCs) in Australia aim to bring together research in universities, government laboratories and private industry and provide some training relevant for industry. There are currently 65 CRCs in Australia and Government funding for them has been approximately matched by business investment in the centres since their establishment in 1990. Approximately 250 companies are currently involved in the research being done in the CRCs.

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- 6.34 There is therefore a need for the Government to develop and part-fund innovation partnerships between businesses and HE, built on applied research that is directed by industry demand and learning from experience in other countries. The focus of such partnerships should be regional so that strong links can be made between local universities and business clusters in science and engineering.²²⁴ A key aim should be for the partnerships to provide scientists and engineers from business and academia (including students) with skills training relevant to business R&D.

²²⁴ Clusters are usually business-led but are underpinned by the local scientific base, including universities and research institutes, that endeavour to supply a suitably skilled pool of labour for the local companies.

6.35 The foundations for such partnerships are already being laid down in some regions. The North West Science Council, for example, brings together HEIs, the RDA and business to develop a long-term science strategy for the North West of England. One of its aims is to ensure that university research is focused on improving the performance of the region's businesses (such as the chemicals industry), helping to establish new products and processes and set up innovative new companies.

Recommendation 6.7: Innovation Partnerships for collaborative research

The Review recommends that the Government, while retaining successful initiatives, should develop stronger, more coherent and more substantial "Innovation Partnerships" to boost research collaboration between universities and businesses. The Review believes that these should incorporate the following principles:

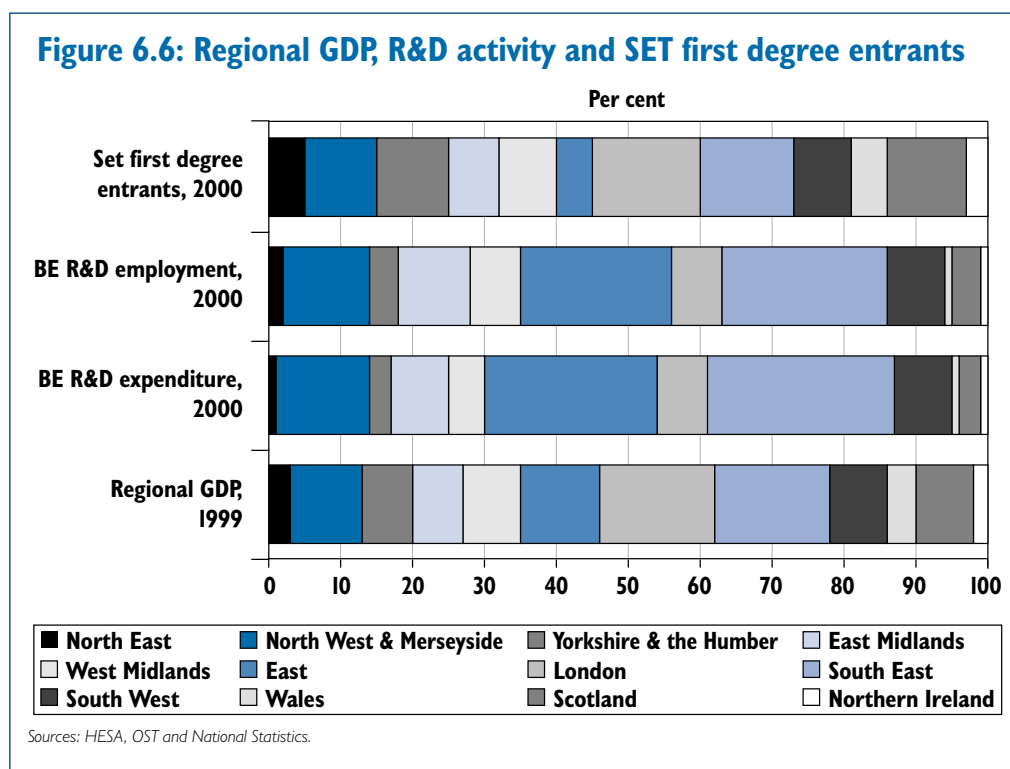
- that the research be business-led and focused on commercially-oriented R&D;
- that the partnerships be based on clusters of businesses with particular research interests, either nationally or regionally;
- that the Government invest in each partnership alongside the prime funders (business, higher education and RDAs);
- that each partnership could be virtual or could have a physical centre, depending on the nature of the research and the participants in the partnership; and
- that each partnership should have an explicit, core aim of prioritising skills training for SET students and graduates, building a critical mass of SET students and graduates with experience in commercial R&D, and encouraging the interchange of people and technology between business and academia.

Regional supply and demand for scientists and engineers

6.36 The Review considered regional differences in the demand for, and supply of, scientists and engineers. The supply tends, naturally, to be heavily influenced by the number and type of HEIs in the region. However, demand is driven by the need for the skills of scientists and engineers from both businesses and universities in the region, as well as the public sector.

6.37 Figure 6.6 sets out the proportion of SET first degree graduates, business enterprise R&D expenditure, business enterprise R&D employment, and GDP, broken down by regions and countries. It shows that whereas London, the North East and Yorkshire and the Humber tend to generate a higher proportion of science and engineering graduates than the businesses in the region employ in R&D activities, the East and South East regions tend to have a higher proportion of R&D employment than their proportion of 'home-grown' scientists and engineers. This suggests a trend for some science and engineering students to migrate from universities in London, Yorkshire and the Humber and the North East, to jobs in the East and South East. (The level of R&D employment in a region tends to correlate closely with the level of R&D in that region, as might be expected.)

6.38 It is also interesting to note that Scotland's proportion of the UK's science and engineering graduates is higher than its proportion of UK R&D employment (in part because of its high participation rate in higher education). This supports a widely repeated view heard during the Review that the supply of SET skills in Scotland was more buoyant than elsewhere in the UK. To a lesser extent, the same was said in Wales and Northern Ireland.



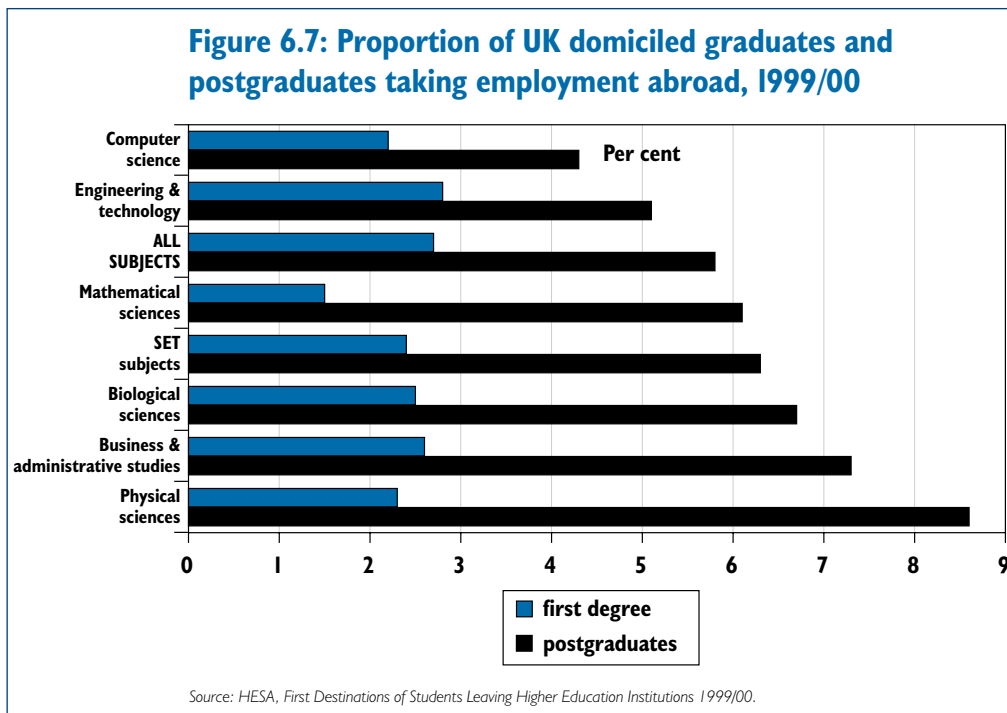
6.39 That these differences occur is only natural, since graduates tend to be relatively mobile compared to non-graduates, and many graduates will study in a region and then choose to return to the area in which they went to school, or, indeed, elsewhere. However, a significant proportion will choose to work (or study further) close to their higher education institute.

6.40 Although graduates are highly mobile, higher education institutions nevertheless significantly influence the type of higher-level science and engineering skills available in a country/region. It is therefore important to the regional economy that the mix of science and engineering skills developed in the region's HEIs is suitable for its R&D base (and other employers). Regional Development Agencies therefore need to work with local employers and HEIs to consider the science and engineering skills needs of their region, to build the innovative capacity of the region. This will require the RDAs in England extending their expertise to match the experience of their counterparts in Wales, Northern Ireland and Scotland.

International mobility of scientists and engineers

A 'brain-drain'?

- 6.41 A number of concerns have been expressed to the Review about a 'brain-drain': a net outflow of scientists and engineers from the UK, who carry out research abroad where financial and non-financial rewards for researchers are seen to be greater. The Review considered these concerns carefully.
- 6.42 There is some evidence supporting the view that increasing numbers of top scientists and engineers are leaving the UK.²²⁵ Such evidence is usually on a micro level (for example, a survey of Royal Society Fellows which found that in 1969 only 16 per cent of Fellows worked outside the UK, 5.5 per cent in the US, while in 1999 26 per cent worked abroad and 12 per cent in the US²²⁶). These results are not unexpected, since the labour mobility generally has increased significantly in the last 30 years.
- 6.43 There is some evidence to suggest that the migration may be greater in science and engineering than in other areas. Figure 6.7 sets out the proportion of graduates taking employment abroad. This shows that SET graduates are more likely to move abroad for employment than graduates in general, which is consistent with the view that R&D employers recruit internationally to obtain the best.



²²⁵ *Science policies for the next Parliament, agenda for the next five years*, February 2001, Save British Science.

²²⁶ *Royal Society News Release*, 27 January 2000.

- 6.44 However, other studies have concluded that this is not happening on a sufficient scale to contribute to a significant shortage in supply itself.²²⁷ Furthermore, the UK attracts a large number of scientists and engineers from abroad – for example, in 2001 there was a net increase in the inflow of almost 5,000 scientists and engineers.²²⁸ This suggests that the UK may actually enjoy a ‘brain-gain’ rather than a ‘brain-drain’.
- 6.45 The Review concludes that there are undoubtedly a number of examples of top UK scientists and engineers being tempted to work abroad by better pay and conditions, particularly UK academics tempted by larger salaries overseas. However, the Review does not believe that there is sufficient evidence to suggest that the UK is suffering from a serious ‘brain-drain’ as such. Indeed, the UK appears to be a net beneficiary of the increasing migration of science and engineering talent.
- 6.46 Nevertheless, the Review acknowledges that both higher education and business must do more to recruit and retain the UK’s best scientists and engineers. This is one of the underlying reasons for the recommendations made earlier in this chapter and in Chapter 5, which aim to improve the salaries and other working conditions of scientists and engineers in business and higher education respectively. In particular, in Chapter 5 the Review recommends that the Government provide additional funding for universities in order to enable them to pay differential amounts to recruit and retain their best academic staff. The Review believes that through such measures, and through businesses and other employers taking up the challenge to improve the attractiveness of jobs in R&D in the UK, it will be possible for the UK better to retain its top scientists and engineers.

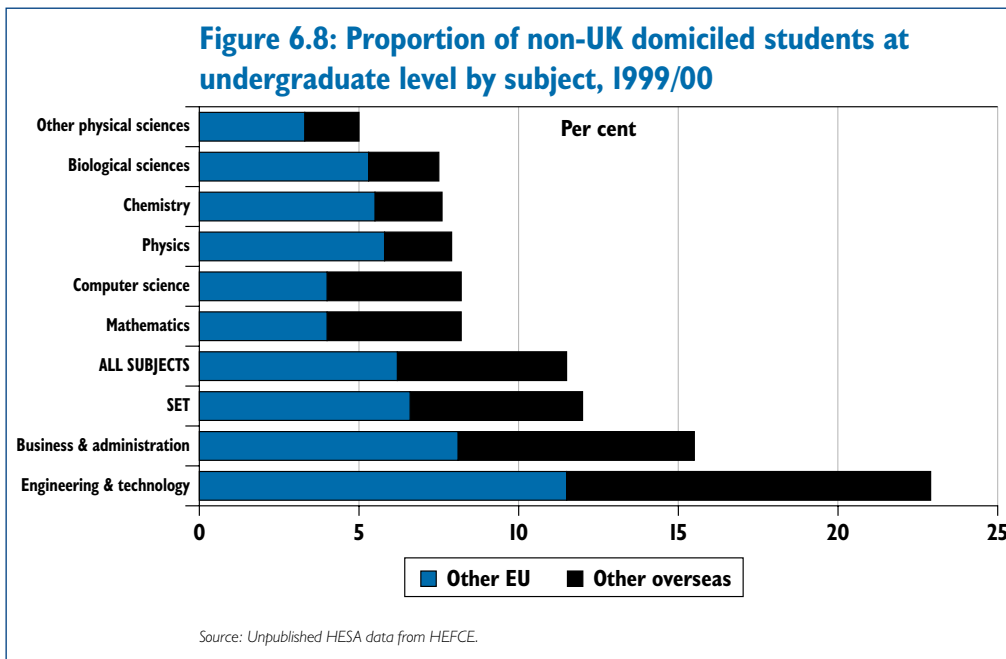
Accessing scientific and technical talent from abroad

- 6.47 As discussed, the UK is at present a beneficiary of international inflows of professional scientists and engineers. The evidence on international flows of scientists and engineers shows that significant numbers of scientists and engineers enter the UK each year from abroad; ten per cent (6,626) of work permits granted in 2000 were for engineers and technologists.²²⁹
- 6.48 The UK is also an attractive place to study for science and engineering first degrees and postgraduate qualifications, and large numbers of overseas students study engineering in UK universities compared to other subjects (see Figure 6.8). This is in part due to the strong reputation of the UK, and in part because UK degrees tend to be shorter (and hence cheaper) than degrees elsewhere.

²²⁷ *Skills Task Force Research Paper 17, Science Skills Issues*, The Institute for Employment Studies, Jane Aston, Nick Jagger, Richard Pearson, December 1999.

²²⁸ According to data on the flows of scientific professionals from *The International Passenger Survey*, Office for National Statistics.

²²⁹ *International migration and the United Kingdom: Recent patterns and trends*, RDS Occasional Paper No. 75, Home Office, Janet Dobson, Khalid Koser, Gail MchLaughlan, John Salt, December 2001.



6.49 The flows of non-UK domiciled science and engineering graduates add to the supply of scientists and engineers available for UK R&D businesses to employ. The OECD considers talent to be disseminated most easily through the physical movement of people, and considers those countries receiving large numbers of foreign students to be best-placed to exploit this and to take advantage of new ideas.²³⁰

6.50 The flow of scientists and engineers from overseas is an elastic source of labour; migrant labour flows are highly sensitive to changes in demand for certain professions. This source of labour therefore can help to alleviate supply problems in the short to medium term – providing the work permit system allows it to work successfully. (For example, the supply of scientists and engineers in the US has benefited from a high level of immigration of overseas scientists and engineers.)

Effectiveness of the work permit system for scientists and engineers

6.51 The work permit system allows employers based in Great Britain to employ people who are not nationals of a European Economic Area²³¹ (EEA) country and are not otherwise entitled to work in this country. The Government recognises that there are certain professions in the UK where vacancies are particularly difficult to fill with EEA nationals (one such area is electronic engineers and physicists of IEng²³² or equivalent level in certain specialist areas).

²³⁰ OECD Science, Technology and Industry Scoreboard 2001: Towards Knowledge-based Economies, OECD, Paris.

²³¹ Countries other than the United Kingdom, that are members of the European Economic Area are Austria, Finland, Greece, Italy, Netherlands, Spain, Belgium, France, Iceland, Liechtenstein, Norway, Sweden, Denmark, Germany, Ireland, Luxembourg and Portugal.

²³² Incorporated Engineering degree.

6.52 Recent changes to the work permit system have smoothed the application procedure and the speed of processing applications significantly. For example, Work Permits UK, now part of the Home Office's Immigration and Nationality Directorate, turns around 90 per cent of applications within one day and employers can make applications on-line. Partners of overseas employees are also allowed to work in the UK, and dependent children (under 18) can travel to the UK with the work permit holder and attend schools in the UK.²³³

Changes to the work permit system

In October 2001, the Government announced the introduction of a new highly skilled migrant's permit. This allows skilled professionals such as scientists and engineers to transfer to the UK to seek work, without having already secured employment, providing they have the means to support themselves and meet a number of specific criteria concerning qualifications and work experience. This new scheme started operation in January 2002.

In addition, the Home Office is in the process of establishing formal procedures to allow certain overseas students (including those studying for degree level qualifications) who graduate in the UK to apply for a work permit without leaving the country. This will be beneficial to the number of overseas SET PhD graduates who wish to stay and work in the UK. Currently students can switch into work permit employment, but only on a discretionary basis.

These changes are part of a wider review of the work permit system which began two years ago, and has contributed to increasing the efficiency of the system and the range of skills which employers can access through this route, including extending the length of work permit available to five years.

6.53 Through the consultation process, a few R&D businesses said that they had recruited scientists and engineers from overseas in situations where the employee had required a work permit. Most of these businesses said that the work permit system now allowed them to recruit from abroad without difficulty, but that there were some additional costs, such as re-location and security clearance. These costs were not significant enough to deter most companies from recruiting from abroad.

6.54 However, the consultation also revealed that many employers – particularly smaller and medium-sized companies – are not aware of the recent changes to the work permit system.

²³³ As well as helping UK employers to recruit scientists and engineers from outside the EEA, the Work Permit system also plays a key role in helping to alleviate difficulties in the teaching profession, as called for in chapter two. In 2000, 4,368 work permits were granted for teaching professionals, although it is not possible to identify which subject areas or levels were covered.

Recommendation 6.8: Migration and work permits

The Review welcomes the Government's campaign to raise HEIs' and overseas students' awareness of the recent improvements to the work permit system. However, given the lack of knowledge of these changes shown by businesses during the course of its consultation, the Review recommends that this campaign be extended to cover the business community, including smaller and medium-sized businesses engaged in R&D. Through this, more UK businesses will be able to draw upon worldwide scientific expertise in driving forward their R&D.

6.55 In addition to allowing overseas students to remain and work in the UK, taking action to encourage more EU nationals to study in the UK is also desirable. The Review's recommendation in Chapter 4 welcoming the possibility of extending maintenance grants to other EU students is therefore relevant.