

CHAPTER 5

THE SCIENCE & ENGINEERING RESEARCH BASE

One of the most important parts of the scientific health of the nation is its science and engineering research base. Defined as publicly-funded research in universities and Research Council institutes, the science base is the lynchpin of all the rest of the country's scientific and engineering activity.

The next generation of scientists is trained in the universities, as are the science teachers of the future. Industry draws on the science base for novel ideas on which to build technological advances, just as the science base draws on industrial research and private sector ideas. It is from the science base that both the people and the research is drawn to inform government policy-making. Moreover, research in universities (both in the sciences and in the arts and humanities) is part of the country's civilisation, saying a great deal about our view of ourselves, and of the world and universe in which we live.

5.1 Public funding for the science base

There is no right figure for the amount of taxpayers' money that should be invested in the science base. The decision must be a pragmatic one, balancing the views of the Minister for Science, who believes that "the more you put in [to the science base], it would be better"¹ and the views of those who believe that the endless immediate demands of healthcare, the relief of poverty, defence or primary education will

"Many outstanding new facilities have been created thanks to the partnership between the charitable sector, government and higher education institutions. Universities have been able not only to create world-class facilities but also to rethink how they are put together - creating central resources that many teams can use, or mixing up researchers from different disciplines to promote innovative multi-disciplinary research."

Dr Mark Walport, Director, The Wellcome Trust

always outweigh other priorities.

Figure 5.1 shows how investment in the science base has changed in the past two decades.

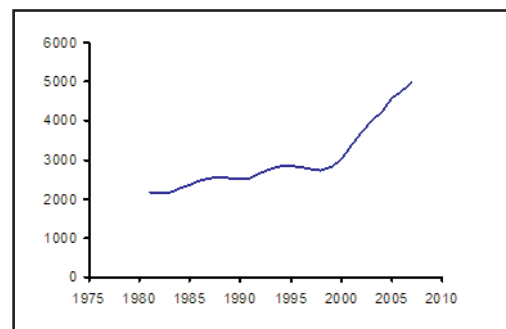


Figure 5.1. Overall government investment in research and development in the science base over the past two decades, with future projections until 2007 (£million, in real terms at 2004 prices) [Source: *Forward Look 2003: Government funded science, engineering and technology*, DTI, 2003, previous editions of this and its predecessors, and *Science & innovation investment framework 2004-2014*, H M Treasury/DTI/DfES, 2004].

International comparisons give one indication of whether or not the level of the investment in the science base is appropriate. In a speech to the Royal Institution, a former science minister pointed out that while a company is not bound to invest at the same rate as its competitors, a Chief Executive who chooses not to do so must be confident that his firm can maintain its position even with a lower rate of innovation². The same surely applies to nations - the UK should invest at least the same proportion of its national wealth in science and technology as other leading economies unless there is a good reason why we can presume to manage with less.

Figure 5.2 makes comparisons across industrialised countries, using a measure of Government investment in scientific research and development in the university sector, and the overall total investment, per head of the population.

Thus, while Figure 5.1 shows that the UK's investment in the science base is historically high, and Figure 5.2b shows that the UK's overall public investment is higher than many comparable countries, Figure 5.2a shows that the UK is in the bottom half of the table in terms of relative investment in the science base.

To maintain a competitive science base in the coming years, the government should aim to invest in sci-

ence and engineering research at a rate above the average of comparable industrialised countries. To achieve this, it will need to continue to increase funding at approximately the same rate as happened between 1998 and 2005.

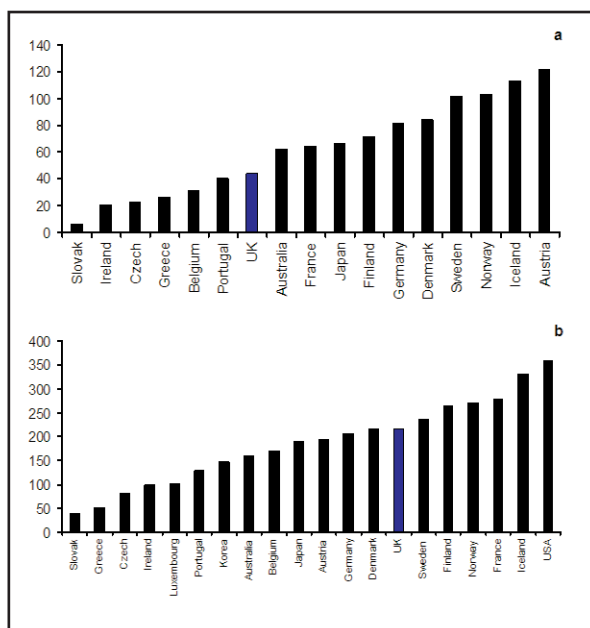


Figure 5.2. Annual government investment in research and development (a) via General University Funds (the OECD's nearest measure of the science base) and (b) through total budgetary appropriations and outlays (both in US\$ per head of the population), including in each case all countries for which data for 2002 are available [Source: *Main Science & Technology Indicators*, OECD, Version 2004/1].

The principles of public funding for research The funding of research in the science base has traditionally been channelled through the 'dual support' system. The basic principle is supposedly that the Research Councils fund specific projects on the basis of prospective applications, while the Funding Councils provide underpinning funds, based on the track record of achievement within institutions.

However, the specific responsibilities placed on the second of these legs have never been properly defined, and this has led to an astonishing degree of confusion³. When the dual support system was reformed in 1993, the white paper described 'general funds ...available for use at the institutions' discretion' in contrast to "specific funds...tied to specific projects"⁴.

By early 2000, there was a simple distinction between 'infrastructure money' and 'project grants'⁵, but later the same year, the former had been more widely defined as giving 'universities the capability to undertake research, and in particular the flexibility to pursue 'blue skies' research and develop new areas of excellence'⁶. Less than a year later, a more sophisticated view was published, stating that the funds from the Funding Council leg of the dual support should 'fund the general infrastructure and long-term research strategies of the higher education

institution; support basic research (curiosity-driven research carried out at institutions' discretion) and certain costs of Research Council-supported projects...and contribute to the cost of training researchers'⁷.

By 2002, the definition had mutated, and this part of the system provided 'the freedom to pursue a certain amount of blue skies research, the base from which...academics can make credible proposals [to Research Councils and elsewhere], [and] the costs of training new researchers'⁸. Within weeks, a fourth element had been added, namely 'the resources to build research capabilities'⁹. In 2004, a more specific definition was published, consisting of elements of many of the previous ones, together with the details that investment from the Funding Councils was for 'the salary costs of permanent academic researchers, support staff, equipment and libraries' and 'the flexibility to react quickly to emerging priorities'¹⁰.

5.2 Adventurous research

Funding Council support is clearly important for a wide range of areas, but one essential element is that it is supposed to provide flexible funding for research that is unlikely to receive a grant, but which is in line with priorities of local researchers, even if it is not in line with those of the Research Councils. Examples include ideas put forward by younger researchers who do not have the reputation necessary to win a competitive grant, or entirely novel ideas that challenge the paradigms espoused by the experienced members of grant-awarding committees. If they worked in modern British universities, Darwin, Mendel, Einstein and Newton would probably rely on Funding Council support; their revolutionary ideas would be unlikely to impress conservative committees¹¹.

Nor are these historical examples uninformative about the modern work of research. Risky pioneering research still has the power to deliver impressive and important results. In the 1980s, British Petroleum set up a system that was 'deliberately looking for those scientists funding agencies usually reject outright' but who needed the 'freedom to launch radical challenges to conventional thinking...or start something entirely new'¹². Many of the researchers they funded went on to have outstanding success. Among them were the first people to realise the significance of the three-dimensional environment in the behaviour of genes, a team whose efficient method of producing pure molecules was the basis of a company with an initial value of £200 million, researchers who discovered the potential of doing chemistry in ionic environments (with huge possibilities for environmentally-friendly industrial processes) and mathematicians whose work on quantum theory turned out to have unexpected rele-

vance in the engineering of stable bridges.

Whatever the precise definition of the dual support system, the Funding Council leg of investment is the only potential source of public funds for research of this nature. It is encapsulated in the phrases "the flexibility to pursue 'blue skies' research and develop new areas of excellence" and "curiosity-driven research carried out at institutions' discretion" in the definitions given above.

Figure 5.3 shows how the ratio of investment between the Research Councils and Funding Councils has fallen dramatically in the last two decades.

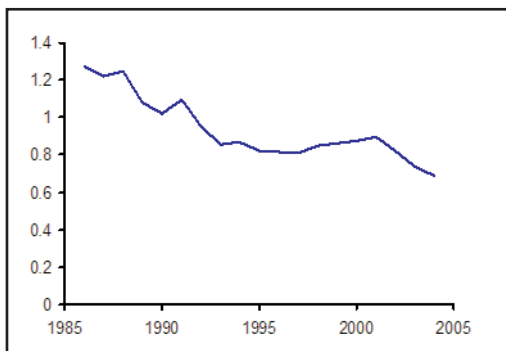


Figure 5.3. Ratio of Funding Council investment in research to Research Council investment between 1986 and 2004. As Research Council budgets have risen faster than Funding Council budgets, the ratio has fallen dramatically [Source: *Forward Look 2003: Government funded science, engineering and technology*, DTI, 2003].

In the mid 1980s, for every £1 that was awarded in targeted Research Council investment on the basis of known projects, the universities received £1.27 for researchers' salaries, training costs, infrastructure and novel, risky research. Now they receive 69p. The consequence is that the Funding Council investment does not cover the full costs of infrastructure, salaries and training, and there is now technically less than nothing remaining for adventurous research with the potential to make serious breakthroughs.

The overall deficit on publicly-funded research in the science base is estimated to be in the region of £1175 million per year, or 35% of the total cost of the research being performed¹³. Box 5.1 examines the particular problem of European funding for research.

One aspect of the remedy, currently being implemented, is for the Research Councils to move towards paying the full costs of the research they support, potentially easing the burden on the Funding Council's resources. In principle, this policy is admirable, although it appears it may be the best part of a decade before it is achieved¹⁴.

There is a danger that, as the Research Councils begin to fund work they support more fully, the

other leg of dual support will not be perceived as important, and may not be maintained or enhanced. This would create a situation in which excellent research was funded as long as it was safe, but in which it was impossible to conduct risky, adventurous work with the potential to make substantial breakthroughs.

The dual support system is by no means the only method of providing funding for adventurous research, but it is a system that the UK has operated successfully in the past, and if a new system were to be developed, it would need to ensure that adventurous projects were funded, and that it was possible to fund high-quality work that for whatever reason was not eligible for Research Council funding.

As Research Councils move towards paying the full economic costs of research projects, either (a) the other leg of dual support funding for research must be maintained and enhanced in some form to regenerate the capacity of university researchers to carry out the most adventurous research, or (b) some other robust mechanism must be invented to ensure adequate funding for pilot projects, preparatory work and high-risk research.

Since at least the time of the Industrial Revolution, the members of every generation have looked back on their parents' and grandparents' lives and been amazed at the speed of technological advance. Children of the 21st century can barely believe that home computers did not exist when their parents were at school. Anyone born in the first part of the twentieth century can remember the days before antibiotics, before man-made satellites of any kind, and before the existence of television.

The importance of potential as well as current achievement

All of these things evolved from science that could not have been predicted a few decades ago. When the structure of DNA was uncovered, nobody could possibly have envisaged that within the lifetimes of the researchers who were responsible, the human genome would have been sequenced, and drugs would be made possible through an understanding of genetics.

Because of the unpredictable nature of scientific discovery, and the technological advances that are based on that discovery, it is important for a healthy science base to support researchers and groups that have the potential to be important, as well as groups that have established reputations.

In recent years, funding mechanisms have increasingly focused on existing excellence, and analogies have been made with the world of international soccer; the Chief Scientific Adviser described a scheme

to attract good researchers by paying them higher salaries as a hunt for "the David Beckhams of science"¹⁵. Leaving aside the fact that Beckham is paid more for each 90-minute football match than a university researcher earns in a year, the analogy had some merit.

Beckham had his first professional games in 1994, with Preston North End Football Club, then in the third division of the Football League. Similarly, Les Ferdinand, who played for Queen's Park Rangers, then Newcastle, then Tottenham Hotspurs, began his career with the non-league team Hayes. These lower-ranking clubs did not have the wealth of the richer clubs, but they did have the basic resources to allow the future stars to practice their profession.

Just as the Premier League in football depends on the lower divisions for new talent, so the research league depends not only on the departments that have already proved themselves to be internationally excellent, but also on those that have the basic resources to allow people to develop, and which may have the potential to be promoted into the research premier league.

For this reason, mechanisms for allocating public resources for research need to be allocated selectively, but the degree of selectivity needs to allow for groups with potential as well as groups that are already excellent.

At the moment, some four universities share more than a quarter of all research funding from the Higher Education Funding Council, and just ten share more than one half of the funding¹⁶. Figure 5.4 shows how the most generously funded ten institutions receive more than twice as much money as the next ten. A third of all institutions that are potentially eligible receive no research money at all.

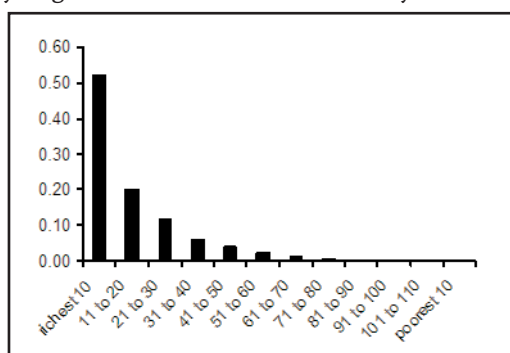


Figure 5.4. Proportion of research funding allocated by the Higher Education Funding Council for England to groups of ten universities, ranked from the best-funded to the least well funded [Source: *Recurrent grants for 2005-05: Final allocations*, HEFCE, 2004].

In part, this pattern has come about because of the way in the Research Assessment Exercise is used to allocate funding. Universities in England now receive little or no funding for most departments that

gained a grade of 4 in the exercise, which is defined as "quality that equates to attainable levels of national excellence in virtually all of the research activity submitted, showing some evidence of international excellence". This excellence is judged by a panel of outstanding experts, based on written submissions that include details of the publications, grant income and strategies of the departments¹⁷.

This outcome was brought about partly because funding has not increased as rapidly as the improvements in performance that the assessment has revealed. Nevertheless, it is clear that to remove funding from departments rated as being at least "nationally excellent" is not healthy for the long-term strength of the science base. More and more of these nationally-excellent departments are closing, a loss we can ill afford.

In the short term, adequate levels of funding should be restored at least to departments rated 4 in the last Research Assessment Exercise.

In the medium term, funding decisions should be based not only on the preservation of what is already excellent but with due regard to the need to invest in

"Research funding is already more selective in this country than in the USA, and there is no evidence that concentrating it even further would deliver what the Government wants."

Professor Ian Haines, Chairman of the UK Deans of Science
potential excellence.

5.3 Central interference and direction

A central tenet of government science policy throughout most of the twentieth century was the Haldane Principle¹⁸. This preserves a measure of independence for the universities, and prevents them from becoming merely active agents of the state, providing military research and industrial technology. Even those who believe that public funding for research should not be a priority nevertheless can accept that government interference should be kept to a minimum¹⁹.

To maintain independence, each of the Research Councils has a separate Royal Charter and is governed by a Council of academics, industrialists and others experienced and distinguished in the fields of science, engineering, and technology. In this way, they are able to ensure that scarce financial resources are targeted on projects of the highest scientific quality, irrespective of the specific topics that are funded.

But no government can abdicate its responsibility to use taxpayers' money wisely, so the Haldane Principle has always been slightly fuzzy around the edges. Thus, although the Research Councils have traditionally taken their own decisions about which individual research projects to fund, the members of their governing Councils are appointed by the government. Moreover, the relative division of funds among the Councils (and hence among scientific and engineering disciplines) has always been the role of ministers who are accountable to Parliament and to the electorate. That is no doubt why medical research receives 40% more funding than science concerned with the natural environment²⁰.

Recent years have seen Haldane's boundary shifted substantially. At the simplest level, the Office of Science and Technology has started to allocate large tranches of the science budget centrally rather than through the Research Councils. Figure 5.5 shows how rapidly this change has taken place, with some half a billion pounds now allocated in this way. Much of this money may be invested in desirable projects (much of it is used for university infrastructure), but it nevertheless remains under more central control than any such investment did in the past.

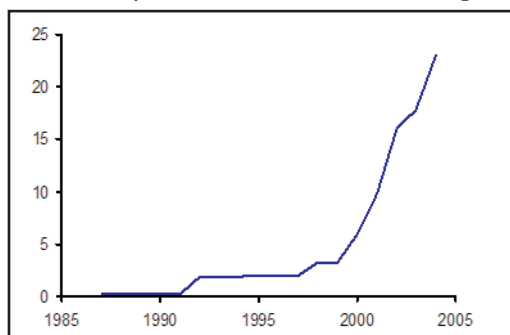


Figure 5.5. Percentage of the science budget allocated centrally rather than by the Research Councils over the last twenty years [Source: *Forward Look 2003: Government funded science, engineering and technology*, DTI, 2003].

The inevitable consequence of this increase has been that new money for the Research Councils has not kept pace with the headline figures for investment in the science base. While the science budget has increased by 68% since 1997, and the Office of Science and Technology's central budget has risen by 1600%, the funds available to the Engineering and Physical Sciences Research Council have risen by only 6%.

As a result, the number of grant applications being funded is actually falling in some disciplines. Figure 5.6 shows the figures for physics. The House of Commons Science and Technology Committee believes that in a number of subjects the pattern revealed in Figure 5.6 has become a serious problem. In medicine, for example, the success rate for responsive-mode applications have fallen to levels that are

Box 5.1

Full economic costs and the European Union's funding for research

The UK's contribution to the EU research budget is substantial, estimated at £400 million per year over the past few years, approximately 5% of the total public investment in research and development. This has risen from 2% since 1986.

The bulk of this money is distributed via the Framework programmes, which have been the subject of intense scrutiny in recent years.

Accepting European grants causes universities to lose money, because they do not cover anything like the full costs of the work they support. The standard rate paid for indirect costs is just 20% of the direct costs of a grant, when the real cost is probably nearer 100%. In most other European countries, specific provision is made for the national government to fund the difference, but in the UK, universities are expected to find the balance from their own resources.

One estimate is that there would be a shortfall of £31,000 on a grant of £120,000, of which approximately half is accounted for salary costs, and in which £24,000 is the element allocated to indirect costs, with the balance made up of specified direct costs.

It is likely that, on existing trends, the UK will win grants totalling perhaps €2.5 billion over the course of the Framework 6 Programme. Using conservative ratios of the level funding received to the full costs of the work done, the research work will actually cost €3.14 billion to perform. This represents a shortfall of €160 million per year, equivalent to £100 million. For a university, the only realistic source of funds from which this subsidy can come is the relevant Funding Council, the budgets of which are already stretched.

If British researchers are more successful in winning grants, this subsidy will need to be larger. If they are less successful, there will be less pressure on the budget. Under current circumstances, the universities and Funding Councils therefore have no way of preparing and budgeting for this problem. By far the most sensible way of solving the problem would be for European grants to pay for the full costs of the work they are meant to be funding. The UK government has expressed support for this position.

The British Government should make the payment of full costs by European grants a priority in the negotiations for future EU funding of science.

"unacceptable"²¹ and in economic and social science, the Research Council should "increase significantly the proportion of responsive mode funding"²².

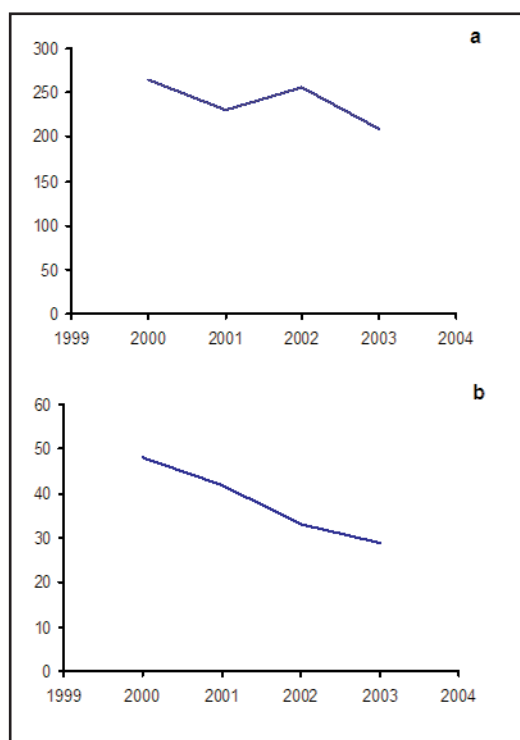


Figure 5.6. Success-rates for grant applications to the physics programme of the Engineering & Physical Science Research Council in the past few years. (a) Number of grants awarded; (b) Percentage of applications funded [Source: *Physics World*, November 2004].

A central objective of policy for the science base should be to sustain high success rates for high-quality responsive-mode grant applications. Under the current system, it should not fall below 40%.

In addition to ministers and civil servants retaining more control over direct scientific investment in this way, they have also begun to attach strings and conditions to a great deal of research funding that have eroded academic freedom.

The attitude of ministers was clear when the Secretary of State for Education mistakenly referred to his 'letter of direction' to the Higher Education Funding Council. When the Council's chief executive pointed out that (in keeping with Haldane's ideas) the letter was, in fact, officially called a 'letter of guidance,' the minister was unrepentant²³.

In 2002, for the first time ever, the allocation of the science budget included ring-fenced pots of money, which the Research Councils were required to invest in specific areas of research, such as "the rural economy"²⁴. Although the rural economy is important, if the country needs research in the field, it is the job of the relevant government department (the Department of Environment Food and Rural Affairs) to perform it. It is not appropriate to force the

Research Councils to fund work in the area irrespective of the relative quality of applications they receive.

More recently, with the creation of Research Councils UK (RCUK), a body supposedly designed to assist the Research Councils in their job, it appears that the funding bodies are being ever more tightly controlled from the centre. RCUK has dictated a list of a score of questions that researchers "will be working to solve in the next few years"²⁵. They range from the broadest questions that have puzzled the human mind for millennia to the politically-fashionable trivia.

One of the questions is 'What is gravitation?' an issue that surpassed the limits of understanding of geniuses like Einstein and Newton. It is risible for a central bureaucracy to define that such a question will be solved within a few years. At the other end of the spectrum of absurdity is the question 'What does it mean to be a citizen of the expanding European Community?' As with the ring-fenced funding for issues concerning the rural economy, this is a question that may be interesting, but which is the properly the business of the relevant ministry of state. In this instance, that would presumably be the Foreign and Commonwealth Office, but since it has no research budget at all, it cannot fulfil this role²⁶.

The costs of Government interference of this kind are twofold. First, the restriction of freedom makes university careers seem less attractive to exceptional researchers. Max Perutz was one of the greatest scientists of the 20th century; the laboratory that he ran produced an exceptional number of Nobel Prizewinners. He attributed its success to the freedom he gave to the exceptional scientists. 'Had I tried to direct people's work,' he wrote, 'the mediocrities would have stayed and the talented ones would have left'²⁷.

Second, and perhaps even more seriously, governments make very poor judges of what is the most exciting and profitable research for the science base to pursue. They are not uniquely bad, but they are much worse than those actively involved in a community of scholarly research, who have the combination of experience and understanding to judge which avenues have the potential to succeed.

Neither governments nor indeed scientists could have predicted the importance of the research that uncovered the structure of DNA, the esoteric theoretical work of Einstein, the plant breeding experiments of Mendel or the botanical and zoological collecting of Darwin.

To prevent serious damage to the long-term potential

of the science base, the government should remove the strings, conditions and additional direction that has come in recent years.

5.4 Trusted, independent funding

One of the major changes that has happened in the funding of the science base in recent years has been the growing tendency for public sources of funding to require matching funds before they can be released.

For example, the Science Research Investment Fund, which is funded by Government to the level of £500 million per year, nevertheless requires universities to raise a further £50 million from elsewhere²⁸, with private industry the only likely source of such huge sums of money.

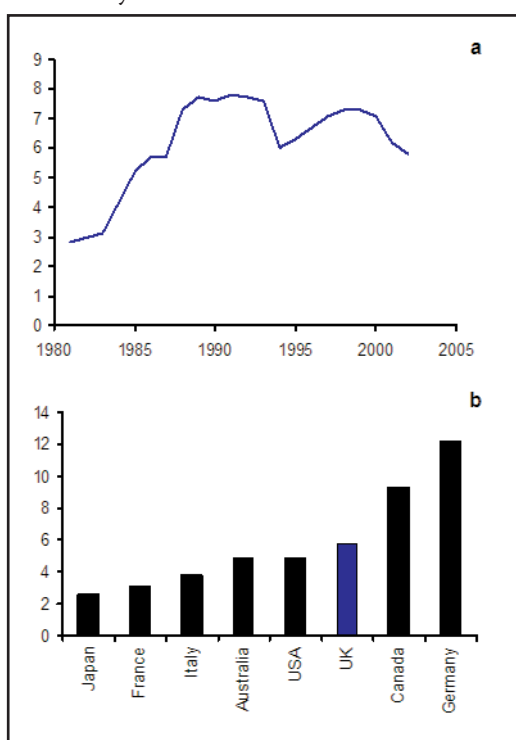


Figure 5.7. Industrial funding for university research. (a) Percentage of Higher Education research and development funded by industry in the UK over the past two decades; (b) Percentage of Higher Education research and development funded by industry in the G7 countries and Australia (most recent year for which data are available in each case, mostly 2002) [Source: *Main Science & Technology Indicators*, OECD, Version 2004/1].

Figure 5.7 shows that industrial funding of research may be gradually falling from an historical high, and that British universities obtain a higher proportion of their research funding from industry than their counterparts in most other countries. American university researchers would need to raise an extra US\$500 million per year to match the success of their British counterparts.

Although the benefits of universities and industry working together are undoubtedly potentially very large, so are the costs of forcing public funding to be unlocked by private funding.

First, it is probable that such schemes do indeed skew the research agenda. If one industry happens to be thriving and wants to invest in UK universities, it will almost certainly guide administrators towards using its funds to build laboratories in its field. Academic researchers in disciplines where private industry is not so strong will not be able to unlock public money so easily, and will not receive investment.

Moreover, as well as the actual distortion of priorities, the perception that industry is having too much influence on public laboratories is a high price to pay. On issues where expert advice is needed for the development of public policy, it is essential to have sources that are seen to be trustworthy to the wider public, which has a healthy scepticism for official pronouncements.

Most public funding for university science should be awarded on the basis of research potential and quality, and should not require the universities to raise large sums of matching funds.

However, the scientific community must continue to resist the tendency for sections of the media and groups opposed to particular technologies to question the integrity of researchers who are, or have been in the past, funded private industry.

It has become almost normal for those who wish to cast doubt on the opinions or conclusions of particular scientists to imply that they are not trustworthy because of industrial links, even where those links are irrelevant or decades out-of-date. There is no reason to suppose that scientists who have received industrial funding, or whose work is carried out in partnership with business are any less honest than anyone else.

While there might be serious concerns that forcing universities to raise funds from business may affect the kinds of scientific questions that they are able to ask, the presence of industrial funding is no reason to doubt researchers' answers to those questions.

5.5 Recruiting and retaining the best people

Research is carried out by people, not by institutions. Maximising the potential of research requires the recruitment and retention of the best people, and the formation of the best teams.

At the moment, the universities in the UK are routinely experiencing difficulties in recruiting and retaining world-class researchers in science and engineering. The problem does not apply to all subjects in all universities, but there are difficulties in many institutions, and across many disciplines. For exam-

ple, 57% of universities responding to a national survey reported that they had left scientific posts unfilled because none of the candidates were of the appropriate calibre, while 37% admitted that they had been forced to appoint members of staff who, in the past, would not have been considered good enough²⁹.

There is also evidence that an increasingly high proportion of good applicants for research jobs come from outside the British system. Although academia has always been an international enterprise, and has maintained its strength partly through the flow of people among different countries, it will not be sustainable in the long term if filling posts relies unduly heavily on an ability to attract foreign researchers. As economies develop in the countries that have recently joined the European Union and nations in Asia that are rapidly becoming technological giants, there will be less incentive for their best people to leave. One established researcher at a major British institution expressed the situation thus: "We've been running on the pool of talent from eastern Europe, China and India for some time - but now it looks like the needle is hitting empty"³⁰.

The reasons for such difficulties are complex, but it is clear that many attractive career options are available to the kind of first-class scientists who might otherwise become or remain academic researchers. One such option is to work in better-funded universities in other countries, especially the USA. A quantitative study of those people who had been awarded doctoral degrees in scientific and engineering subjects in 1988 found that the best of them are now carrying out research in the science base of the USA³¹.

Other career options include working in scientific industry. As one indication of the attractions of such an option, university scientists in the UK are paid substantially less than their counterparts working in the pharmaceutical industry. The differential varies from about 20% to about 50%³². In the chemical industry, scientists in their thirties earn about 12% more than university scientists of a similar age, while those in their early fifties can earn as much as 30% more³³.

The pool of talent Although there is an urgency about the need to recruit and retain outstanding people into research careers in universities, there is a wider problem. The pool of scientific talent from which universities can draw is diminishing, because young people are turning away from science subjects at school and at university.

This problem is not unique to the UK; it is shared by most of the industrialised nations of the world, and it

is important to undertake a variety of steps to encourage more children and young people to take an interest in science, engineering and technology. Some of these are addressed in Chapter 6.

If employers other than universities - notably scientific industry and government departments - were to offer more attractive career prospects and remuneration packages, it may help to increase the flow of young scientists entering research careers.

Many factors affect a person's choice to follow a scientific career in a British university. For example, some leeway in organising one's own time and the collegiate nature of the enterprise are aspects of the job that are particularly appealing to a large number of researchers. Many of these features of an academic career are less prominent than they were in the past, but they remain important nevertheless.

Traditionally, one of the great attractions of an academic career has been the acceptance that researchers will have some freedom to pursue their own research interests. The degree of such freedom inevitably varies among institutions, subjects and individuals, but a high proportion of university researchers enjoy some measure of liberty. Recent changes in the ways in which research is funded have made inroads into this freedom, including the hypothecating of particular pots of money for areas that are politically expedient³⁴ and the listing of specific scientific questions that the research community must work to solve in 'the next few years'³⁵. These are dealt with in more detail in Section 5.3.

Almost everyone involved in academia in Britain appears to believe that his or her job is becoming substantially more bureaucratic than it used to be. There may well be good reasons for this, but paper-shuffling should be kept to a bare minimum.

Thus, the Funding Councils' proposals to substantially complicate the Research Assessment Exercise by introducing three mechanisms in the place of one³⁶ were a move in the wrong direction.

Good teaching and good research often go together, but neither can thrive in an environment in which funding deliberately favours the other. In recent years, the Research Assessment Exercise has been the only way in which universities can increase their financial rewards they receive for excellent performance. Research has been favoured over teaching.

One of the effects has been that teaching is sometimes seen as a second-class activity, and a large number of individuals have been attracted into the system who have no interest in teaching. Others have been encouraged to believe that an interest in

“It has been obvious for a long time that the salaries being offered to scientists are inadequate to recruit and retain the talented people that are needed.”

Dr Vicki Stone and Mrs Linda Wood, Napier University
teaching will be harmful to their careers.

If we really want to attract the best scientists into the UK's science base, it is ridiculous to give the impression that researchers who are also interested in teaching are unwelcome. Moreover, if we want to encourage more of the best students to consider university science as a career, it is foolish to deny them access to some of the best role models.

A more sensible balance between research and teaching needs to be restored to the university system.

Employing individuals with a commitment to their subjects is an important requirement for a world-class science base. The best research is performed by those people who genuinely care about their subject.

There are undoubtedly a small number of people who cannot imagine pursuing any other career path than academic science. As long as they have enough to get by, their love of science outweighs their needs or desires for money.

However, almost all such people are young, and few people in their thirties or older can afford this luxury. Housing costs, family obligations, and other commitments increase, and the nation would be foolish to rely on the commitment of its researchers, without taking other factors into account.

The fact that some young people will join the science base without being properly rewarded may marginally affect the average salary of researchers in their twenties. But in the competition to attract and keep the best people, it will have little overall effect.

Of course, different individuals within the science base have different motivations. The traditional contract for an academic job in a university requires individuals to carry out teaching, research and administration, often in unspecified proportions over an unspecified number of hours.

It is entirely possible that some people would be prepared to take on more administration in return for a modest pay rise, while others would make less financial demands if they could be relieved of some research duties in order to focus on their excellent teaching.

To some extent this already happens, in the sense that Deans and Heads of Department are paid more for taking on administrative and management responsibility.

But in seeking to attract and retain the best people, and the best mix of people, into university science, it would help to get the most out of individuals if a more sophisticated system of rewards and benefits was available.

The funding for salaries should be sufficient to allow universities to achieve a more sophisticated system of rewards and benefits for academic staff, rewarding contributions to teaching, administration and research.

There are growing concerns that the remuneration of university researchers is not keeping pace with the market, particularly since other employers offer additional benefits such as share options, health insurance and company cars³⁷. Many academics believe that the problem began when university salaries were decoupled from civil service pay scales.

In defining what would be a more suitable salary trajectory than the present one, it is worth considering that there are a number of career stages at which competition for talent might be particularly strong. Three that are important are (i) the point of entry into the system (for example, as a postdoctoral research assistant), (ii) the point at which a researcher has "proved" himself or herself, and (iii) the point at which academics are beginning to take on leadership roles as heads of important research groups, departmental heads or deans.

The precise ages at which these events occur will vary from person to person, but roughly speaking, a researcher will enter the system in his or her mid twenties, will have proved himself or herself to have potential by his or her early thirties, and may begin to take on additional leadership roles at the approximate age of 40.

Choosing whether or not to enter the research system at all is the first crunch point in a career. Pressures at this stage include the need to pay off student debts, which are now estimated to be almost £20,000 on average, and the desire to start out on a career that will reward one's interests and personal ambitions. In addition, this is point at which people are hoping to buy a house and start a family.

In a highly competitive market for the best talent, universities must recognise that they cannot rely too heavily on the fact that many young people may be

relatively idealistic, and consider academic research despite the drawbacks. Higher education institutions must compete with industry and overseas institutions to ensure that they attract their fair share of the best researchers.

After a doctorate and a few years of postdoctoral research, an outstanding individual researcher will have shown real signs of their talent. For the typical researcher, this will happen at about the age of 30, and for those who have demonstrated their potential, other employers (especially scientific industry) will be keen to attract many of the best.

Thus, to compete for the best, universities need to be able to offer enhanced average salaries for researchers at this stage in their career, and in a free market, most of the best researchers will be able to command substantial pay rises. In the overall trajectory of average salaries, there will therefore be a sharp increase at this stage.

After a few years of independent research, some academics will be promoted to have significant leadership responsibility. They may become Heads of Department, Deans or Pro-Vice Chancellors. Equally importantly, some will be leaders of major research programmes, either by being in charge of a significant research group or by forging an innovative path as an internationally-renowned individual.

Not all academics will have the skills or the inclination to perform these leadership roles, although good universities will offer training and professional development to help equip those with the potential to fulfil these functions.

Industry needs such leaders, and will be keen to poach some of the best. Universities need to be able not only to retain the best of their research managers, but may also want to bring in new talent at this level. Part of the reason for importing such people is to relieve the management burden on those existing research leaders who do not have the aptitude or desire to fulfil these roles, so that they can make the greatest contribution through their research.

To retain or attract such people may require substantial salaries, since industry is understandably keen to hold on to and attract the cream of first-class researchers who are also able leaders, administrators and managers.

Although not everyone will command the highest salaries, attracting and retaining the very best of these mid-career scientists will mean that the average salaries of researchers will rise sharply between the mid thirties and mid forties.

During this stage, some people will leave the system. At present, there are roughly twice as many research-active scientists and engineers in British universities in the second half of their thirties as there are in the second half of their forties (but this may be partly due to temporal variations in appointment, not just people having left the system).

In other words, the system is increasingly competitive, and it is notable that between the stages of lecturer and professor, the differential between academic and industrial scientists increases dramatically³⁸.

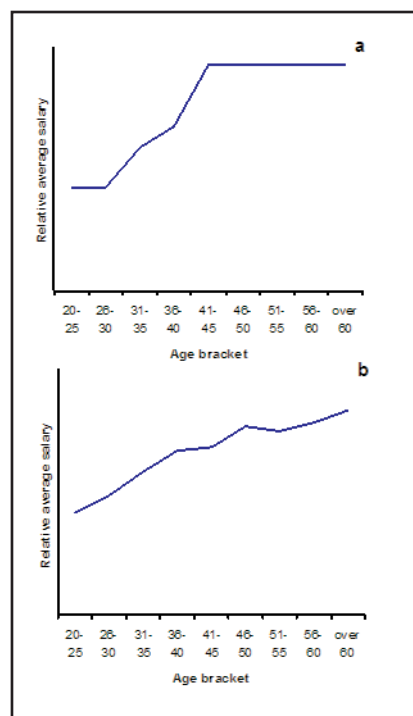


Figure 5.8. (a) Hypothetical shape of the trajectory of average salaries for academic scientists and engineering, based on the need to recruit and retain key people at crunch points (b) Shape of the current trajectory of average salaries for academic scientists [Source: *Attracting the Best: Report of a Save British Science Symposium on Recruiting and Retaining World Class Researchers in the UK's Universities*, SBS, 2004].

The overall average salary in later career stages for researchers is unlikely to change substantially. Many will stay, but are unlikely to be able to argue that there is an unusually high demand for their skills. Industry may consider them to be too set in their ways, and the foreign academic market is far more concerned with current achievement and future potential than past performance. Although some will inevitably be able to command salary increases in a market for the best, the effect on the average may be modest, because others may even take real-terms cuts as they wind down towards retirement.

Some of the best researchers may want to move on and find new challenges after thirty or more years in a similar job, and it is unlikely that the universities will be able to tempt them to stay. So at the higher end of the market, pressure for increases in the aver-

age salary will be reduced.

Taken together, these arguments suggest that, in a system designed to attract and retain world-class researchers, the overall shape of the average salary trajectory will look something like Figure 5.8a. It is characterised by a sharp rise relatively early, and a boost in mid career, followed by a levelling off.

The proposed scheme represents a broad outline, and the process of implementing it would no doubt refine it.

However, it is clear that the proposed scheme is somewhat unlike the current situation, which is described in Figure 5.8b. Apart from a modest rise in average salaries in their early forties, the salaries of university researchers currently increase almost linearly with age.

The scheme in Figure 5.8a was quantified by a group representing academia, government, industry, and the charity sector during a symposium in the summer of 2004. Figure 5.9 shows the trajectory they produced, based on assumptions that salaries needed to be competitive in a marketplace, but also needed to be affordable to the taxpayer.

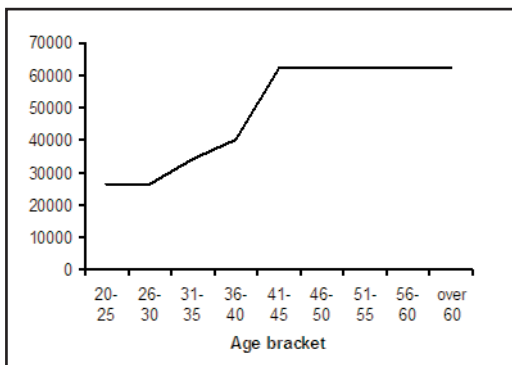


Figure 5.9. Proposed average salary trajectory (in £) for academic scientists and engineers, based on the opinions of academics, public servants, industrialists and others [Source: *Attracting the Best: Report of a Save British Science Symposium on Recruiting and Retaining World Class Researchers in the UK's Universities*, SBS, 2004].

The overall addition to the wages bill of university academics if the scheme in Figure 5.9 were to be implemented would be approximately £250 million per year in England. This represents a little less than 6% of the Government's current annual expenditure on science, engineering and technology research and development in the science base. It is less than 3% of the Government's overall annual expenditure on scientific and engineering research and development³⁹.

It should be stressed that Figure 5.9 describes the average rather than the salary of any one individual, and to emphasise this point, Figure 5.10 shows trajectories for four hypothetical individuals.

The Government should provide an additional £250 million annually through the Higher Education Funding Council, specifically to address the salary element of the problems of recruiting and retaining the best researchers.

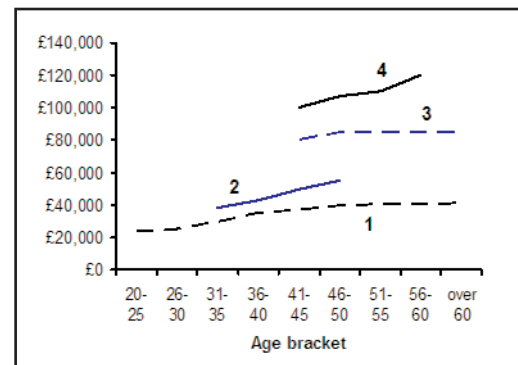


Figure 10. Pay trajectories of four hypothetical individuals in the science base. Line 1: a dedicated researcher who never wants to take on extra responsibility, and who cannot be attracted into industry by any offer of an increased salary. Individual 1 always earns less than the average. Line 2: an individual brought into the university system in their early thirties after a short spell in industry. Individual 2's salary rises steadily but not spectacularly, and, after ten years in academia, the individual leaves to become a consultant. Line 3: someone attracted into academia at a senior level from industry as a dean. He continues in more or less the same job for ten years before retirement. Line 4: a research superstar attracted to the UK from the USA. The individual continues to bring in significant grants and to attract the best graduate students and postdoctoral researchers to work in her team. As a result, her salary continues to rise before she leaves in her 50s to head a research group in the charity sector.

5.6 Provision of scientific information

Because scientific information is specialised, and the results of research require detailed scrutiny, the market for scientific publications is a complex one. In fact, its nature makes some aspects difficult to regulate by normal market forces, and concerns have grown in recent years that a lack of access to scientific publications may hinder the progress of some parts of science and engineering⁴⁰.

Moreover, new vehicles for publishing, particularly the internet, are changing the ways in which the publishing market works, and potentially causing changes to the competitive market in scientific ideas, which is the market that really matters.

It is only through trial and error that changes will be assessed, and new models of publishing tested. Unfortunately, the Government has made it clear that it does not intend to take an active role in helping to balance the needs of the academic and industrial scientific communities, the commercial publishers and, importantly, the taxpayer⁴¹.

The Government should make modest funds available for experimental systems of providing access to scientific publications, such as the institutional repositories proposed by the House of Commons Science & Technology Committee.