

Campaign for
Science &
Engineering
in the UK



The views of members and supporters of CaSE

April 2007

Science and Engineering Policies for the Next Scottish Parliament

Agenda 2007-2011



www.sciencecampaign.org.uk

Introduction

For centuries, scientists and engineers have contributed to the social, economic, environmental and cultural life of Scotland. Their potential contribution to the well-being of the nation is huge, and if that potential is to be fulfilled, Scottish scientists, educators, technologists and businesspeople will need to operate in a supportive and positive framework of policies.

Recent months have seen an increased interest in science policies in Scotland, with the appointment of the first Chief Scientific Adviser for Scotland and with the Executive conducting a fundamental review of its science policies for the future.

This document, *Science and Engineering Policies for the Next Scottish Parliament: Agenda 2007-2011*, sets out a shortlist of science policy priorities for Scotland, together with some of the facts and analysis that supports them. As a campaigning organisation, CaSE believes that this list represents a challenging but realistic programme for the Scottish Parliament that will sit between 2007 and 2011.

Science and engineering policies for the next Scottish Parliament

- The Scottish science and engineering base cannot be complacent about its strengths, and policy-makers must be vigilant to ensure that fundamental research retains its traditionally strong place in Scotland's universities and research institutions.
- Scotland should no longer aspire merely to have the best funded science base in the UK, but can afford to judge its investments against the best in the world.
- Like the rest of the UK, there is a shortage of well-qualified science teachers in Scotland. Urgent action is needed to increase the recruitment and retention of science teachers, including salary premiums for those in shortage subjects.
- Scottish science teachers are concerned about aspects of the curriculum and its assessment, especially the importance of practical experimental work. Science and engineering are inherently practical subjects and every effort should be made to enhance the practical element of school science, including at primary level.
- While Scotland's universities have a long record of high quality teaching in the sciences and engineering, changes to the funding regime in England could put Scottish university departments at a disadvantage, and the Scottish Executive must be quick to address any potential funding gap that might open up.
- Scotland's companies do not do enough research and development, and the sector of small, high-technology companies is poor by comparison with other parts of the UK. Scotland needs to do more within the powers it has under devolution to make the country an attractive place for research, development and innovation.
- Scotland's universities have an admirable track record of generating income from their research and should be careful not to follow the more restrictive routes to commercialisation that are stifling such activities elsewhere.
- To obtain the highest quality scientific advice to inform policies on a wide range of relevant subjects, the Scottish Executive should invest more in policy-driven scientific research.
- Scottish Parliamentarians do not take as great an interest in science and engineering policies as they might, and the Scottish research community needs to do more to encourage more political engagement with scientific issues.

The science & engineering research base in Scotland

The science and engineering research base in Scotland is the foundation on which all other scientific aspects of national life depend. It is the bedrock of the knowledge economy.

The outputs of the research base

Figure 1 shows the output of scientific research papers published by researchers in England, Wales and Scotland over the past two decades. Over that period, Scottish research output has grown faster than in England, but slower than in Wales.

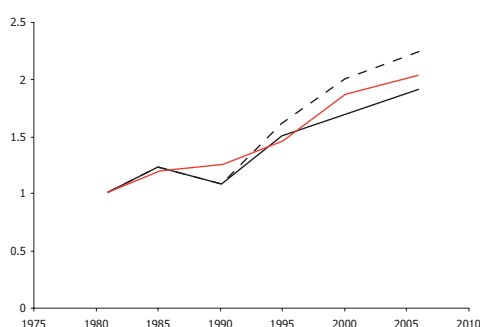


Figure 1. Number of scientific papers published each year where at least one of the authors had an address in Scotland (red line) England (solid black line) or Wales (broken black line), scaled so that in each case, 1981=1 [Ref. 1].

At the same time, the overall quality of Scottish scientific research has shown a sustained improvement. Figure 2 shows how the number of times that Scottish researchers' articles are cited by others in the scientific community has risen relative to English research. In the 1980s, the impact of Scottish science and engineering was only about two thirds as great as that produced by English researchers. It is clear that measured in this way, it is now at least as great, if not greater than the output of English research.

This is consistent with the results of the last Research Assessment Exercise. Scottish universities had departments that were active in research in 28 science and engineering subjects. Of these, the average score in Scotland was higher for 11 subjects than it was

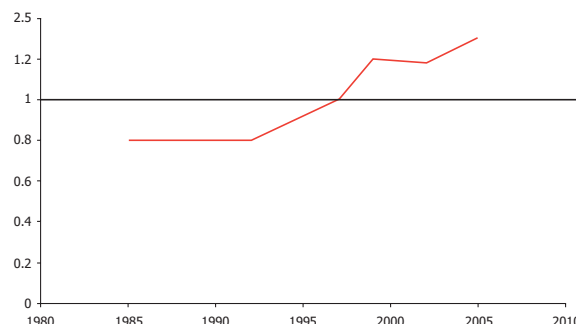


Figure 2. Average number of citations per paper for research papers published from Scottish addresses, relative to the number for English papers, scaled so that the English average=1 for all years [Ref. 3].

in the rest of the UK [Ref. 2].

Funding for Scottish research

Fortunately, the achievements and potential of the Scottish science base have been backed by relatively high levels of investment, compared to the rest of the UK.

For example, Figure 3 shows how much more research funding the UK-wide Research Councils invest in science in Scotland than they do in Northern Ireland, Wales or England.

In part, these differences are due to historical factors relating to the location of the Research Councils own institutes, of which there are a

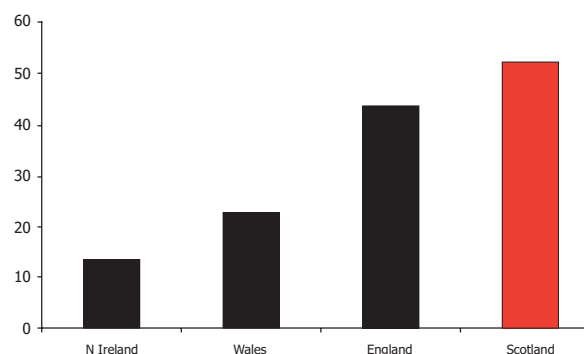


Figure 3. Investment by the Research Councils in the different countries of the UK in the financial year 2005-06 in £ per head of the population [Ref 4].

1. *ISI Web of Science* database.
2. *2001 Research Assessment Exercise The Outcome*, HEFCE.
3. *ISI Web of Science* database, using random samples of 200 research papers (excluding book reviews, letters etc.) with English and Welsh addresses for each year.
4. *Hansard*, House of Commons, 7 March 2007, Column 1996W.

number in Scotland. In Scotland, 28% of total expenditure is used in this way. This compares with 27% in England and 17% in Wales and 14% in Northern Ireland.

But that does not explain the whole picture, because even with Institute expenditure removed, Research Council investment per head is 47% higher in Scotland than in England - and 136% higher than it is in Wales [Ref. 5].

Research Council income is obtained through a competitive process of bidding for grants. Since the Research Councils are not devolved, this funding does not have any impact on the Scottish Parliament's budget.

However, success in obtaining Research Council grants depends in part on the strength of the base from which university researchers apply. In the 'dual support' system of funding that operates in UK universities, the basic infrastructure of laboratories is funded by the Higher Education Funding Councils. These budgets are devolved in both Scotland and Wales.

As Figure 4 shows, researchers in Scotland do well in this element of funding. Per head of the population, their funding from this source is 32% greater than in England and 68% greater than in Wales.

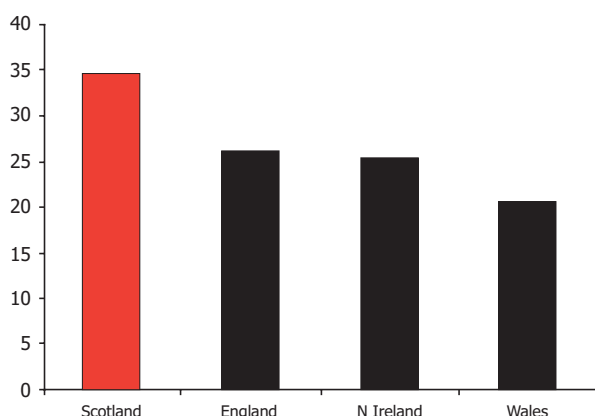


Figure 4. Annual Quality-Related funding for research by the Higher Education Funding Councils, in £ per head of the population [Ref. 6].

This commitment to investing in research is probably the single most important factor in the success of the Scottish science base. Core funding from the Scottish Funding Council creates a stronger platform from which Scottish researchers can apply for external grants from the Research Councils and elsewhere.

Of more concern is the potential for politicians to press too hard for research to be of obvious economic benefit, as is clearly the case in the latest consultation on a science policy for Scotland [Ref. 7]. Everybody wishes to maximise the economic impact of the research base, but it only remains healthy if there is a strong balance between work that has immediate uses and longer-term fundamental research.

Overall assessment

The science and engineering base in Scotland is of high quality, partly because it is better funded than other parts of the UK, but it must not lose its traditional strength of focus in fundamental 'blue-skies' research.

5. Hansard, House of Commons, 4 December 2006, Column 15W.

6. Websites of HEFCW, SFC, DELNI and HEFCE.

7. *Science and innovation strategy for Scotland: Consultation paper*, Scottish Executive, 2006.

Science & engineering education in Scotland

Primary school level

Since the sciences do not appear as individual elements of the primary school curriculum, there is almost no robust evidence about the state of science at primary level. However, most primary school teachers are not trained scientists (for example, across the UK as a whole, 47% have no physics qualification of any kind).

Partly as a consequence, primary school teachers lack confidence in their own abilities to engage children with scientific topics. Only about half of primary school teachers say they have 'a lot of confidence' in teaching science, appreciably lower than the two thirds who are self-assured in teaching English [Ref 1].

A recent survey shows that about 50% of primary school teachers in Scotland believe they have 'good resources' for teaching science, the same as in England, but higher than in Wales (42%) or Northern Ireland (20%). At just 6%, Scotland had the lowest proportion of primary teachers who believed their science resources to be 'poor' [Ref 2].

Secondary level

Of the teaching vacancies in secondary schools in Scotland in 2006, 9% were in mathematics and 14% in the sciences. Although this represents an improvement since 2002 in mathematics (when 15% of vacancies were in the subject), the shortage of science teachers has grown substantially, both in percentage terms and in real terms. There were almost twice as many science teaching vacancies in Scotland in 2006 as there were four years earlier [Ref 3]. Moreover, the number of people entering initial teacher training in mathematics in Scotland has been falling since the mid 1990s [Ref 4].

Figure 5 shows that Scotland's teenagers perform well in science compared with some similar countries, but by no means as well as the best in the industrialised world. In mathematics, Scottish

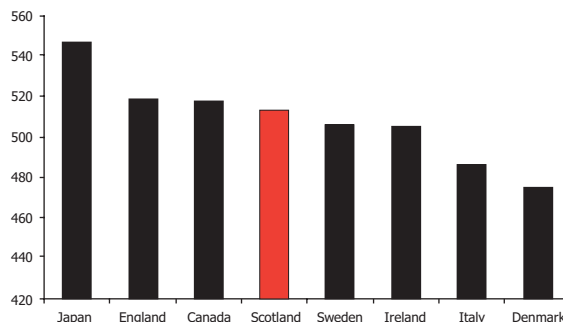


Figure 5. Average score of 15-year old pupils in test of performance in science (arbitrary scale, higher score=stronger performance) in 2003 [Ref. 5].

children performed very well, but were still appreciably behind their counterparts in some other countries, including both Japan and Canada.

A survey in 2004 found that 73% of Scottish teachers found the funds available for larger items of scientific equipment inadequate. About half of Scottish schools were cancelling practical lessons because of a lack of equipment, but an even greater number were doing so because of concerns about the behaviour of disruptive pupils.

Almost 90% of science teachers expressed unease about the way the curriculum is assessed and a large proportion were concerned that mathematics lessons were not preparing young people adequately for their science lessons [Ref 6].

Further education & training

Because of the big differences between the educational systems in Scotland and other parts of the UK, comparisons are difficult, but the most recent figures show that about 7.5% of those enrolling on Further Education courses in Scotland are studying subjects classified as 'engineering or technology' while only 4.5% of those in England are engaged in courses relating to 'engineering or manufacturing' [Refs 4 and 7].

1. *A study into the professional views and needs of science teachers in primary schools*, Council for Science & Technology, 2000.
2. *Primary Horizons: Starting out in science*, The Wellcome Trust, 2005.
3. *Teacher vacancies and probationer allocations 2006*, Scottish Executive, 2006.
4. *Standard tables on higher education and further education in Scotland*, Scottish Executive 2003.
5. *PISA country profiles*, OECD.
6. *Survey of Scottish Secondary School Science*, CaSE, 2004.
7. *Further education, work-based learning and adult community learning - learner numbers in England*, Office of National Statistics, 2006.

Higher education

Between 2002 and 2004, the number of British students studying physical sciences in the UK as a whole rose by almost 10%, but in Scotland, the number graduating in these subjects rose by a slightly smaller amount, 8%. Similar patterns occurred in mathematics, where there was an increase of 19% across the UK but Scotland saw a rise of only 12%, and in biological sciences, where the figures were 18% for the UK and 14% for Scotland. Engineering and technology was the only scientific discipline to buck the trend, with a modest increase in graduations in Scotland (of 3%) compared to a small fall (of 4%) in the number of students throughout the UK [Refs 8 and 9].

Funding per student is marginally higher in Scotland than in England and significantly higher than in Wales. Exact comparisons are difficult and are always slightly out of date, but Figure 6 shows that grant aid per science student in Scotland was about £1,000 higher in 2003 than it was in Wales [Ref. 14].

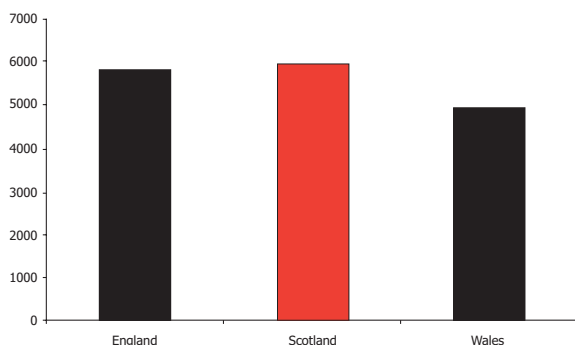


Figure 6. Public funding for science students at university (2003) in £ per student per year [data explained in Ref 10].

However, Scotland will need to ensure that it does not slip relative to England. The impact of student fees in England could potentially be important. Moreover, the average figure for England will be raised following the recent announcement of the English Funding Council of an additional £75 million for students of chemistry, physics, materials and science and some parts of engineering [Ref. 11].

Overall assessment

Scottish science education is good, but there is no room for complacency. The future is threatened by a shortage of well-trained specialist school teachers and the need to keep pace with the rest of the world in funding the universities.

8. *Higher education graduates and graduate destinations 2004/05*, Scottish Executive.

9. *All HE students by level of study, mode of study, subject of study, domicile and gender 2004/05 and 2002/03*, Higher Education Statistics Agency.

10. The best description of the problem with an explanation of data is in *Agenda*, Spring 2006.

11. HEFCE to provide an additional £75 million to support very high cost and vulnerable science subjects, HEFCE press release, November 2006.

The contribution of science & engineering to the economy of Scotland

Private sector investment in research

Science and engineering are major drivers of the economies of advanced industrialised nations, and it is crucial to Scotland's future success that companies in Scotland perform vibrant research and development, and that they have in place strong mechanisms to utilise both their own research findings and those of the universities.

As Figure 7 shows, overall private sector investment in research and development has grown substantially in Scotland in recent years, but not as fast as some other regions in Europe. Moreover, Scotland started from a relatively poor base, so industrial investment in research and development remains stubbornly low in Scotland relative to many other parts of Europe.

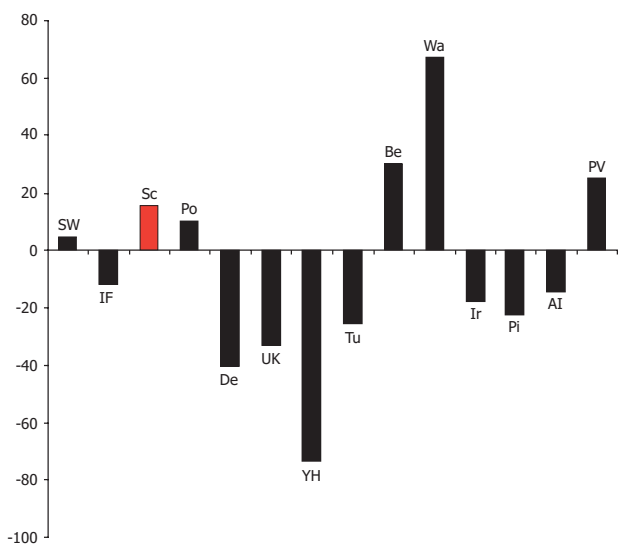


Figure 7. Percentage change in private sector R&D as a proportion of GDP between 1996 and 2003 in the South West of England, the Ile de France, Scotland, Poland, Denmark, the UK, Yorkshire and Humberside, Tuscany, Belgium, Wales, Ireland, Piemonte, Alsace and Pais Vasco [Ref. 1].

Figure 8 shows how, despite the overall growth in recent years, private sector investment remains lower than in other small industrialised countries like Denmark and Belgium, lower than the UK average and less than half that of the South West of England.

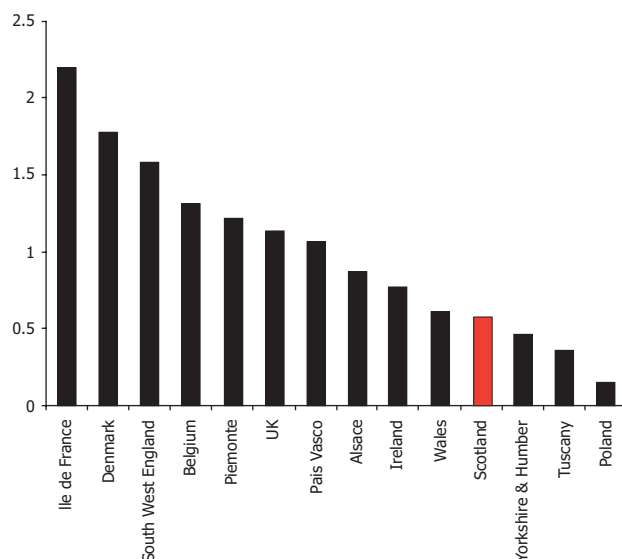


Figure 8. Percentage of GDP invested in business R&D in different countries and regions of Europe (2003) [Ref. 1].

Companies in Scotland

Although Scotland has a very high number of companies listed on the stock exchange (37 companies per million of the population compared with 14.0 in the English Midlands, 25.5 in the South West of England, 32.9 in East Anglia and just 7.4 in Wales) it performs relatively badly in the science-based business sector.

As Figures 9 and 10 demonstrate, a very small proportion of the listed companies based in Scotland are research-intensive, and among those

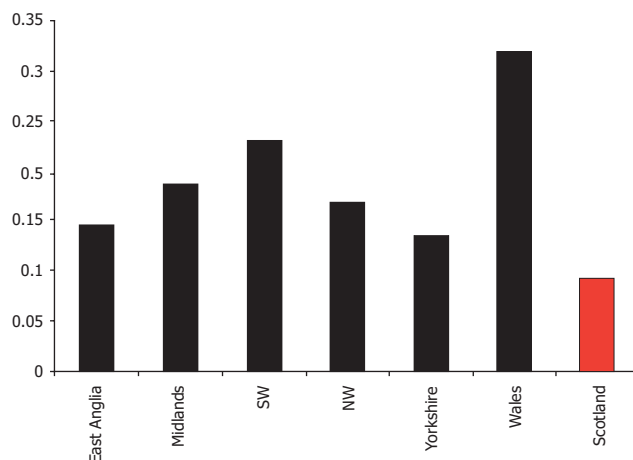


Figure 9. Proportion of listed companies that performed enough R&D in 2005 to be included in the R&D Scoreboard 2006 [Refs. 2 and 3].

1. Total intramural R&D expenditure (GERD) by sectors of performance and region, Eurostat.
 2. www.londonstockexchange.com (accessed in February 2007).
 3. R&D Scoreboard 2006, DTI, 2006.

science-based companies, there is a low percentage of smaller enterprises.

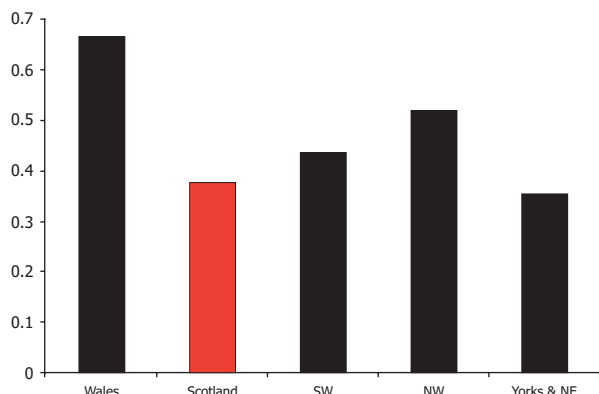


Figure 10. Proportion of companies in the R&D Scoreboard that have a market capitalization of less than £50 million [Refs. 1 and 2].

Knowledge transfer from the universities

In terms of generating economic activity from the science base, the universities in Scotland are very efficient at generating profits from their discoveries. This is partly because the Scottish universities are generating a significant income from their intellectual property, but because their costs in doing so appear to be relatively low (23% of the income generated compared with 94% in Ulster, 62% in Yorkshire and the North East and 84% in the South West of England), so their efforts are financially very efficient.

As Figure 11 shows, this means that the income generated for the Scottish economy from such activities is currently high by the standards of

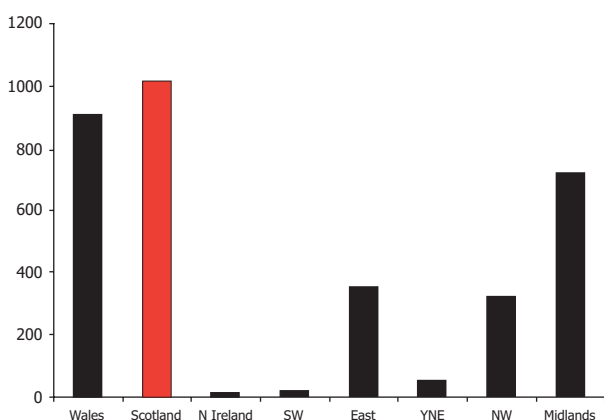


Figure 11. Net income per 1000 head of the population from universities' intellectual property in different parts of the UK [Ref. 3].

other parts of the UK.

In general, UK universities have been putting more and more resources into protecting their intellectual property, but have generated less and less income from doing so [Ref. 3]. Scotland must preserve its relatively *laissez faire* efficiency in this field and not go down the route experienced in England.

Overall assessment

Scotland needs more incentives and encouragement for private sector research, development and innovation, and is not matching other parts of the UK in producing small, high-technology companies.

1. www.londonstockexchange.com (accessed in February 2007).
 2. R&D Scoreboard 2006, DTI, 2006.
 3. Higher education-business and community interaction survey, HEFCE 2006.

The importance of science and engineering to society and government

Science to inform government policy

The amount of money invested in science for policy making in Scotland has risen at a faster relative rate than in England or Northern Ireland, but not Wales, since devolution (see Figure 12).

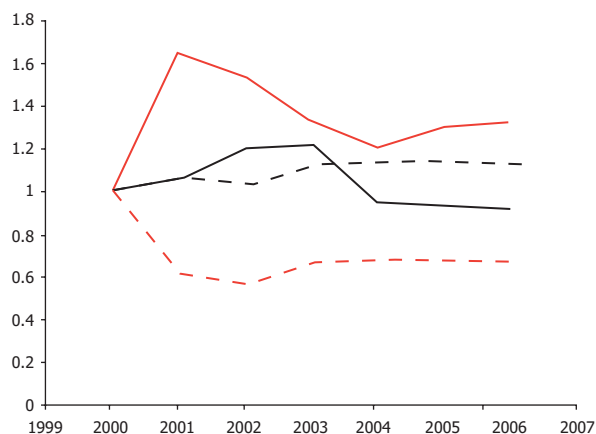


Figure 12. Investment in research via civil ministries in real terms in Wales (solid red line), Scotland (broken black line), England (solid black line) and Northern Ireland (broken red line) scaled so that the year figure for the year 2000=1 in each case [Ref 1].

However, as Figure 13 demonstrates, in absolute terms such investment remains low by the standards of the rest of the UK and other parts of Europe.

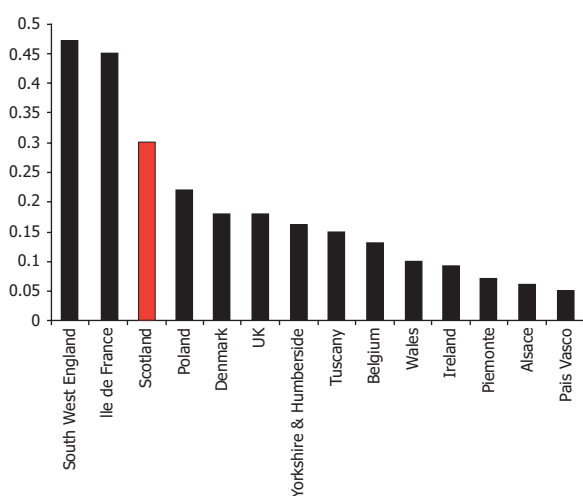


Figure 13. Government-sector research and development as a proportion of GDP in some different countries and regions of Europe [Ref. 2].

Political attitudes to science

The appointment of a Chief Scientific Adviser for Scotland is a clear signal that the Executive considers science to be a crucial element of the nation's success. However, during 2006, members of the Scottish Parliament asked, on average, 0.47 written questions about science policy, almost identical to the figure of 0.45 for members of the Welsh Assembly, while in Westminster, the number was higher at 0.66 written questions per member about science policy [Ref. 3]. These figures have changed since 2002, when Scottish Parliamentarians were showing more interest in science policy than their Westminster counterparts.

The devolution settlement for science

While the Scotland Act 1998 gave primary jurisdiction over some aspects of science to the Scottish Parliament, it reserved other issues to the UK Government.

The result is a complicated picture, with educational issues devolved, but research issues only partly so, and with many economic issues (such as tax breaks for research) being wholly outside the competence of the Parliament.

'Science policy' is not formally devolved, which in practice means that the Research Councils retain a UK-wide remit. But the reserved nature of science policy is limited in practice only to the extent that the Parliament's ambitions or lack of them make it so. There is nothing in the devolution settlement, for example, to stop the Parliament investing more in science.

Overall assessment

To ensure that Scotland gets the maximum benefits from science and engineering under devolution, the political establishment needs constantly to engage with scientific issues.

1. Net Government expenditure on R&D by departments in real terms, SET Statistics, DTI (accessed in February 2007).
 2. Total intramural R&D expenditure (GERD) by sectors of performance and region, Eurostat.
 3. DeHavilland information systems., Infopool; the figures refer to questions about science policy, and do not include all questions that happen to be about scientific issues.

CaSE in Scotland

CaSE is a small organisation with a primary focus on science and engineering policies in Westminster and Whitehall. But we believe that science and engineering policy in the devolved administrations is very important, and we seek to represent the views of our members in Scotland wherever possible. The Executive Committee of CaSE includes Professor Bill Banks of Strathclyde University and Dr Vicki Stone of Napier University, who act as CaSE's principal points of contact for Scottish science policy matters.

Other recent activities in Scotland include the following:

- During campaigns for the election of members of the Scottish Parliament, we publish the responses of party leaders to a series of questions about science policy.
- CaSE has held several dinners with MSPs from all parties to discuss current issues in science policy.
- CaSE's comment regularly appears in the Scottish media, including BBC Radio Scotland, *The Scotsman*, *The Herald*, *The Aberdeen Press and Journal* and others.
- MSPs have tabled Parliamentary Questions based on our publications.
- CaSE gave both written evidence to the Executive's ongoing review of science policy, and its views were quoted extensively in the final report.
- In 2004-05, CaSE undertook a major survey of science teachers in Scottish schools to assess the state of practical experiments in the curriculum, and followed it up with more detailed interviews.
- CaSE is one of the organisations involved in the event called *Science and the Parliament*, held annually in Edinburgh to promote interaction between the scientific community and members of the Parliament.

www.sciencecampaign.org.uk/activities/scotland.htm



CaSE staff Peter Cotgreave and Caroline Holland meet the Chief Scientist for Scotland, Professor Anne Glover in Edinburgh



CaSE's Director and colleagues from other organisations meet former Deputy First Minister, Jim Wallace MSP



CaSE staff and members of the Advisory Council meet Brian Adam MSP, David Davidson MSP, Robin Harper MSP, Elaine Murray MSP and Nora Radcliffe MSP

www.sciencecampaign.org.uk

Campaign for Science & Engineering
29 Tavistock Square
London
WC1H 9QU
020 7679 4995
info@sciencecampaign.org.uk

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