Department for
Innovation,
Universities &
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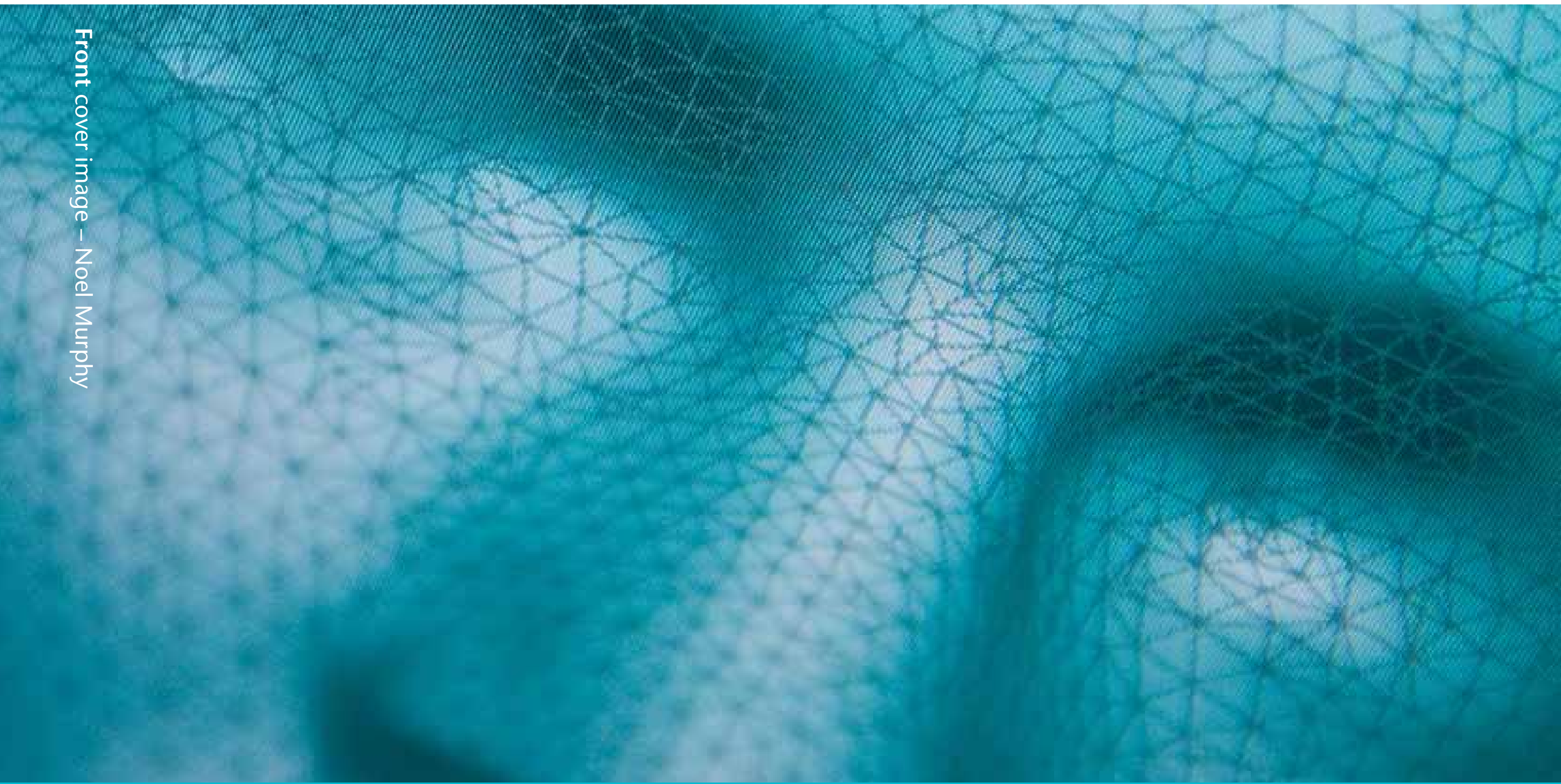

Front cover image – Noel Murphy

Science and Innovation Investment Framework 2004–2014

Economic Impacts of Investment in Research & Innovation

December 2008

Executive summary

This is the second annual report published by the Department for Innovation, Universities and Skills on the Economic Impacts of Investment in Research and Innovation. It updates the first report published in 2007 alongside the Annual Report on the ten year Science and Innovation Investment Framework. The report includes performance indicators and evidence used to assess the overall health of the science and innovation system, and how it delivers economic benefits. International comparisons, where possible, are included.

Indicators and evidence are structured around an economic impact reporting framework, which portrays the generation of economic impacts at the aggregate economy level. The reporting framework includes the categories and influence factors listed below.

Categories:

1. Overall economic impacts
2. Innovation outcomes and outputs
3. Knowledge generation
4. Investment in the research base and innovation

Influence Factors:

A. Framework conditions

B. Knowledge exchange efficiency

C. Demand for innovation

Each Research Council publishes their own report based on the Economic Impact Reporting Framework, containing annual data on the categories and influence factors of the Reporting Framework. This report includes highlights from their reporting frameworks.

Key findings in this report include:

Overall economic impacts

- There is a consensus in the literature that R&D spending has a positive effect on productivity growth, a key driver of long-term economic growth. UK productivity performance has been strong in recent years, with the UK's productivity gap with the US narrowing from 24 percentage points in 1996 to 19 in 2006, the gap with France narrowing from 25 percentage points in 1996 to 17 in 2006, and the gap with Germany narrowing from 30 percentage points to 17 from 1996 to 2006.

- Key examples demonstrate how research contributes to increased economic and social welfare through a diverse range of outcomes, including health, environmental, and social cohesion outcomes.

Innovation outcomes and outputs

- In the UK, 64 per cent of firms were innovation active over the 2004-6 period, up from 57 per cent in 2002-2004[1].
- The UK's number of US patents granted per head of population is similar to that of France, with both countries around 5th equal in the G7. However, the UK's performance is much stronger on registered community trademarks than patents, and is very similar to Germany which leads the G7. On the number of registered community designs the UK is similar to France, though both countries lag behind Germany and Italy.

Investment in the research base and innovation

- In 2006 GERD, or total R&D performed in the UK as a proportion of GDP, was 1.75% an increase on the previous revised ratio of 1.74% in 2005. £23.2bn was spent on GERD, a 4% increase in real terms from 2005 and a 7% increase in cash terms.
- The proportion of R&D performed in the UK in the business enterprise sector (BERD) as a proportion of GDP in 2006 was 1.1%, in line with recent years. In 2005 £14.3bn was spent on total R&D performed in UK businesses, a 5% increase on 2005 in real terms and a 7% increase in cash terms.
- Around 45% of R&D performed in the UK is funded by UK businesses. This proportion is somewhat lower than other G7 countries and the OECD average. However, the UK has a relatively high share of R&D funded from abroad, at around 17%. Around 33% is funded by government sources and 5% funded by private non-profit sources.
- In addition to R&D, expenditure on innovation includes expenditure on, for example, acquiring external knowledge, and acquiring equipment and machinery ITCs and design. In the UK, expenditure on R&D (both within the firm and contracted out) accounts for around one third of total innovation expenditure.

[1] Note in the 10 Year Framework Annual report, there is a reference to the share of innovation active businesses in the UK reaching 68% in 2004-6, up from 49% in 1998-2000. This figures here are calculated on a different basis to reflect the different time periods covered.

Knowledge generation

- The UK is second to the US in terms of number of scientific publications, with around 9% of the world total. China now shares the same proportion of world output with the UK.
- The UK is also second to the US with around 12% of world citations, and with 13% of the most highly cited papers. The UK's citation performance is sustained across disciplines, with the UK in the top three in seven of nine fields (and top three in eight of ten fields including the humanities field, though data for this field is less robust).
- The total number of A level entries for mathematics, chemistry, physics, biological sciences and other science in 2007/8 rose by over 8,000, with each subject experiencing increases.
- The number of graduates from Science, Technology, Engineering and Mathematics (STEM) subjects has increased by 11% over the period 2002/03 to 2006/07.
- The UK is ranked 2nd to Germany in the G7 on the number of PhD awards per head of population. The total number of PhDs in STEM subjects has increased by 18% over the period 2002/03 to 2006/07.
- On the number of researchers in the workforce, the UK performs less strongly, and is sixth in the G7. There has been little change in the UK's performance over the last decade.

Framework conditions

- The UK is an attractive place for foreign owned firms to perform R&D, with a relatively high share of total R&D funded from abroad of around 17%, significantly above those of other G7 countries. Around 27% of R&D performed in the UK's business sector is funded from abroad.
- A national survey of public attitudes to science shows that interest in science has increased since 2000, with 82% agreeing they are 'amazed by the achievements of science,' up from 75% in 2000.
- The financial sustainability of the UK university system is assessed biennially by the Funding Councils. The latest assessment (July 2008) concluded that in 2006/07 only a small proportion (1.7%) of research is undertaken at Higher Education Institutions (HEIs) over which there are concerns about their long-term sustainability.

- A third annual monitoring exercise has been completed on the financial sustainability of Public Research Establishments (PSREs). The third survey indicates that overall, the major improvements made between round 1 and round 2 have been sustained and the PSREs continue to report progress on sustainability. However, the progress since round 2 has been more gradual, reflecting the fact that there are less difficult issues to address, and some of these represent long term problems.

Knowledge exchange efficiency

- In the UK, around a quarter of innovative enterprises source information from universities or other higher education institutions, and a quarter source information from government or public research institutes.
- The latest survey of knowledge transfer activities reported by higher education institutions show a range of positive trends. Income from business for UK HEIs has risen to over a billion pounds in 2006-07. The number of licenses and licensing income from business has exceeded that in the US over the last few years.

Demand for innovation

- One third of UK enterprises rate their clients or customers as a 'highly' important source of information. There has been a decrease in the proportion of firms who regard uncertain demand as being an important factor constraining innovation.
- Around 22% of UK firms regard the lack of qualified personnel as a factor of medium to high importance in constraining innovation. Knowledge-intensive services show the greatest proportion of employment with graduate level qualifications in science and engineering.

Contents

Introduction

The Government set out its long-term vision for UK science and innovation in the Science and Innovation Investment Framework 2004-2014, published in July 2004 (The ten year framework). The ten year framework is underpinned by targets for achievement to track progress, informed by a range of indicators. This report gives an assessment of these indicators and the overall health of the science and innovation system, and how it delivers economic benefits. It also provides an update to last year's report which was published alongside the Annual Report on the ten year framework[2].

How do science and innovation result in economic impacts?

A policy action has an *economic impact* when it affects the welfare of consumers, the profits of firms or the revenue of government. Economic impacts range from those that are readily quantifiable, in terms of greater wealth, cheaper prices and more revenue, to those less easily quantifiable, such as effects on the environment, public health and quality of life[3].

Science in this context refers to funding of the research base[4] and the activities involved in knowledge generation by the research base. The terms 'science' and 'research' will be used interchangeably in this report[5]. *Innovation* – the successful exploitation of ideas – reflects the ability of firms, government and the research base to bring together knowledge, ideas, skills and market awareness into new products or processes that better meet consumer and societal needs, and so result in economic impacts.

The economic impacts of science and innovation include the resulting contributions to long-term, sustainable economic growth[6] and increased overall welfare. Both basic and applied research results in significant economic impacts, though the effects of applied research may be easier to practically track through the Framework. The Government has an important role to play in the funding of basic research, which may have the greater potential for spillover benefits and economic impacts.

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[2] Available at: http://www.berr.gov.uk/files/file40398.doc

[3] As defined in the Research Council Economic Impact Group report, "Increasing the economic impact of research councils," July 2006, page 10.

[4] The research base refers to the UK's Higher Education Institutions and large public research institutions.

[5] Apart from instances where 'science' is specifically referring to studies or research in a particular subject area, in which case this is made clear.

[6] Seminal papers by Romer (1990, 1986) model the process of technological change, which is underpinned by science and innovation, and the resulting impacts on economic growth.

Measuring economic impacts

To measure the economic impacts of investment in research and innovation and the health of the system used to deliver economic impacts, information is required on the following components of the system and influence factors:

Categories:

1. Overall economic impacts
2. Innovation outcomes and outputs
3. Knowledge generation
4. Investment in the research base and innovation

Influence Factors:

A. Framework conditions

B. Knowledge exchange efficiency

C. Demand for innovation

These categories and influence factors comprise the **UK Economic Impact Reporting Framework** (Reporting Framework). A diagram of these categories and influence factors is given on page 9.

Information reported on each category and influence factor of the Reporting Framework takes the form of

- *Performance indicators*, where regular monitoring data is collected, and
- *Evidence*, which is based on less frequent studies and academic research, and case studies.

Further development of the Economic Impact Reporting Framework

The measurement approach and the Reporting Framework's categories and influence factors were developed in 2007 by the former Office of Science and Innovation in the Department of Trade and Industry, in consultation with the former Department for Education and Skills and the Research Councils. Input was received from key stakeholders working in the field of evaluating outcomes of innovation and research. More information on development of the framework is available at: http://www.berr.gov.uk/dius/science/science-funding/framework/page9306.html

DIUS is continuing to consult with key stakeholders on the ability of the Reporting Framework to measure the performance of the research and innovation system and its delivery of economic impacts. In light of recent feedback from stakeholders, DIUS plans to expand the coverage of the Reporting Framework in the following areas as information sources develop:

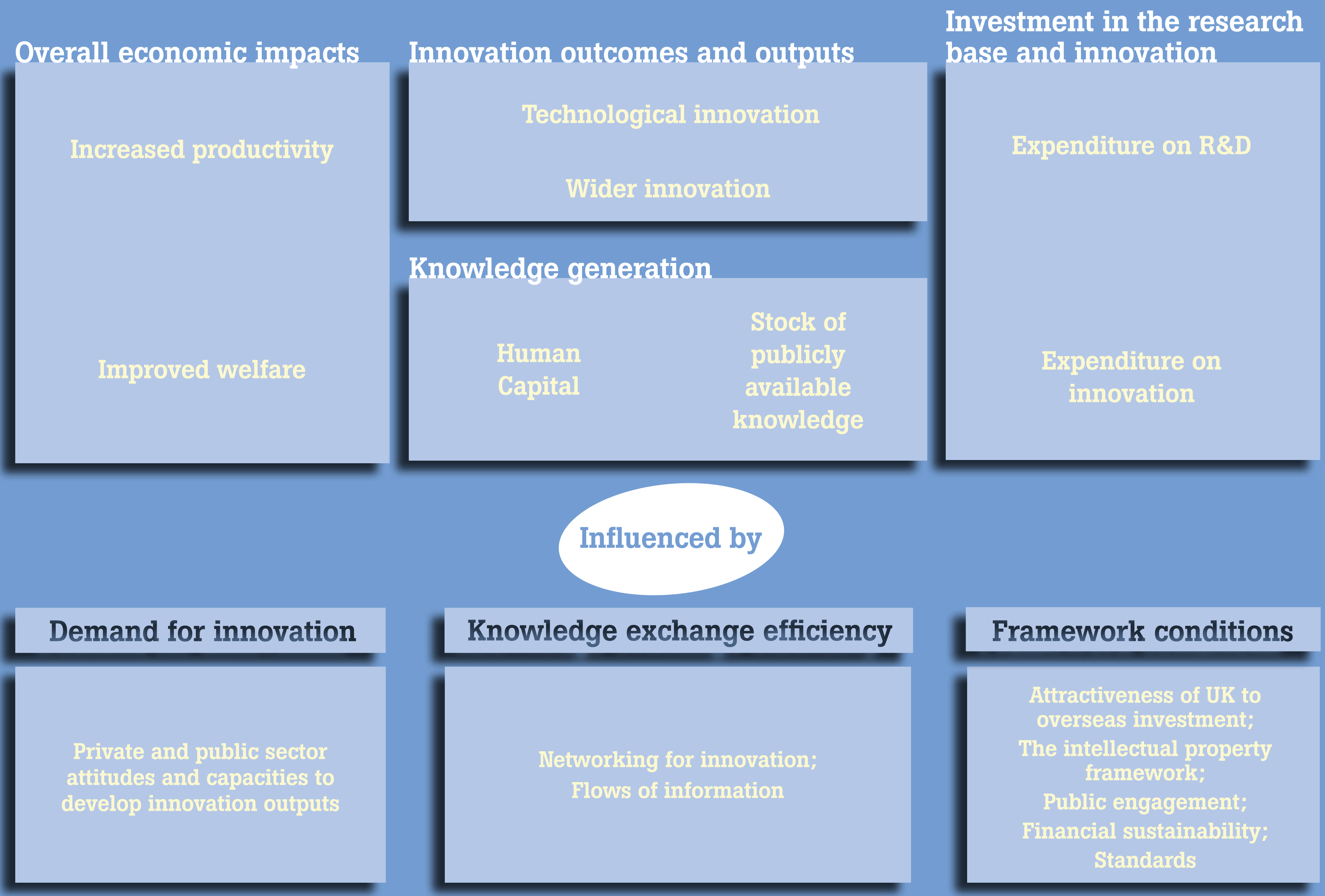
Sectoral coverage: the current Reporting Framework reports indicators that are aggregate in nature, and only limited information is available on a sectoral basis. In particular, the current Reporting Framework reports indicators on innovation outcomes and outputs that are predominantly related to private firms. The Reporting Framework will be modified to take into account domestic and international developments on metrics covering public sector innovation outcomes, and in particular how public procurement promotes innovation. In addition, innovation and research capacity relating to the services sector will be expanded.

Evidence demonstrating linkages between the categories and influence factors of the system: the current Reporting Framework is mainly driven by performance indicators, though evidence on linkages between parts of the system is included where available. DIUS plans to strengthen the evidence base on the linkages as part of its ongoing research and analysis programme. New sources of evidence will be reported as part of next year's report.

DIUS welcomes additional feedback from interested stakeholders on the development of the Reporting Framework and plans for expansion of its coverage. Comments may be sent to:

Science and Innovation Analysis, Department for Innovation, Universities and Skills, Bay 366, Kingsgate House, 66-74 Victoria Street, London, SW1E 6SW

UK Economic Impact Reporting Framework



Links with other reporting frameworks

Public Service Agreement Reporting

In 2007 new public service agreements were set out, identifying the key priority outcomes the Government seeks to achieve in the next spending period (2008-11). Promoting world class science and innovation in the UK is part of the suite of "Sustainable Growth and Prosperity" public service agreements (PSA). To measure performance on this PSA, six indicators have been selected[7]. These indicators are included in this report at the following locations:

1. The UK percentage share of citations in the leading scientific journals *(Section D1)*
2. Amount of income generated by UK Higher Education Institutions (HEIs) and Public Sector Research Establishments (PSREs) through research, consultancy and licensing of intellectual property *(Section F2)*
3. The percentage of UK business with 10 or more employees that are "innovation active" *(Section B1)*
4. The annual number of UK PhD completers in Science, Technology, Engineering and Mathematics (STEM) subjects *(Section D2)*
5. The number of young people in England taking "A" Levels in mathematics, physics, chemistry and biological sciences *(Section D2)*
6. Business research and development (R&D) expenditure – the average UK R&D intensity in the six most R&D intensive industries, relative to the US, Japan, France and Germany *(Section C1)*.

[7] As set out in HM Treasury (2007b) "PSA Deliver Agreement 4: Promote world class science and innovation in the UK."

Research Councils

Each Research Council publishes their own report based on the Economic Impact Reporting Framework, containing annual data on the categories and influence factors of the Reporting Framework, and identifying key outputs and outcomes. This year marks the third year that data has been published. This report identifies highlights from the 2008 data[8] for all Research Councils, and should be read in conjunction with each Council's report, available at: http://www.rcuk.ac.uk

AHRC: Arts and Humanities Research Council

BBSRC: Biotechnology and Biological Sciences Research Council

ESRC: Economic and Social Research Council

EPSRC: Engineering and Physical Sciences Research Council

MRC: Medical Research Council

NERC: Natural Environment Research Council

STFC: Science and Technology Facilities Council

Research Councils are also required to set baselines for their economic impact, against which further economic impacts can be assessed and reported on an annual basis. Councils prepared an initial baseline as part of their Delivery plans published in December 2007. These baselines draw on data published in their Reporting Frameworks, as well as further commissioned evidence.

[8] Commentaries on past submissions of Research Council data have been published by the Office of Science and Innovation and Department for Innovation Universities and Skills, and are available at: http://www.berr.gov.uk/dius/science/research-councils/index.html

A. Overall economic impacts

This section includes evidence on how the science and innovation system delivers economic benefits at the aggregate economy level, by way of increased productivity and improved welfare. Reporting covers two main areas:

- monitoring of GDP and productivity data supplemented with evidence from the economic literature on the attribution of effects to investment in science and innovation; and
- evidence of improved welfare, including material on health, environmental, social and national security outcomes.

The substantial time lags from initial investment to overall economic impacts should be kept in mind in interpreting the evidence in this section, and that impacts will grow over time.

A.1. Increased productivity

There is a substantial body of economic theory underpinning the relationship between research, innovation and economic growth. Innovation, by stimulating new value added goods and services, and ways of doing things, contributes to increased output per head and productivity. Most of the empirical literature concentrates on the productivity effect of R&D, because this is more readily measured.

Productivity growth can be assessed using Average Labour Productivity (ALP), the most common productivity measure. GDP per capita can be decomposed into a combination of labour productivity, measured by GDP per hour worked, and labour utilisation, measured by hours worked per capita. Table 1 shows the decomposition for the UK and other countries.

Table 1: Growth in GDP per capita 1995-2006

	GDP per capita		GDP per hour worked		Labour Utilisation[1]	
	1995-2000	2001-2006	1995-2000	2001-2006	1995-2000	2001-2006
United Kingdom	2.9	2.1	2.3	2.2	0.6	-0.1
Canada	3.2	1.7	2.3	1.0	0.8	0.7
United States	2.9	1.7	2.2	2.2	0.7	-0.4
Japan	0.8	1.6	2.1	2.2	-1.3	-0.5
OECD19[2]	2.6	1.7	2.2	1.8	0.4	-0.1
EU15	2.6	1.2	1.8	1.3	0.8	-0.1
France	2.4	1.0	2.1	1.5	0.2	-0.5
Germany	1.9	0.9	2.0	1.4	-0.1	-0.5
Italy	1.9	0.1	0.9	0.0	1.0	0.0

Source: OECD, 2008

[1] Labour utilisation is measured as hours worked per capita.

[2] OECD 19 includes Japan, EU15 and NAFTA countries.

The Government has identified five key drivers of labour productivity through which improvements occur, and science and innovation is one of them. The other drivers are investment, skills, enterprise, and competition. These five drivers are interlinked: the level of access to capital, skills and the regulatory environment will impact on a firm's ability to innovate.[9] More information on these linkages is contained in sections E and G in this report.

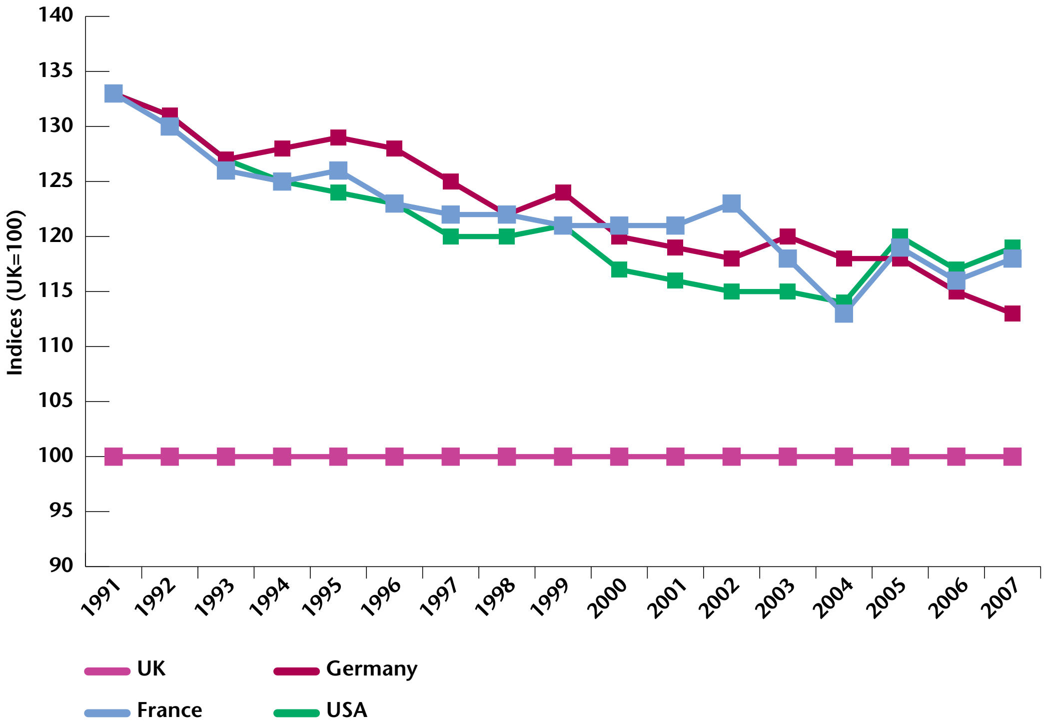
The Department for Business, Enterprise and Regulatory Reform (BERR) monitor the UK's progress on improving labour productivity through the benchmarking of the UK's performance on the five drivers relative to similar countries.

UK productivity performance has been strong in recent years with signs of progress compared to other countries, such as France and Germany. Also, the UK productivity gap with the US has not widened, while both France and Germany have seen a fall back in productivity levels relative to the US.

[9] As noted in HM Treasury and BERR, November 2007, Productivity in the UK 7: securing long-term prosperity, Available at: http://www.hm-treasury.gov.uk/d/productivityintheuk7141207.pdf

While the level of UK output per hour worked remained lower than comparable levels in Germany, France and the US in 2007, the gap on this measure has narrowed with France and Germany since 1997. The UK productivity gap with Germany narrowed from 25 percentage points in 1997 to 13 in 2007 whilst the gap with France has narrowed from 22 to 18 percentage points over the same period. However the gap with the US on an output per hour worked basis has remained relatively constant, narrowing marginally from 20 percentage points to 19 between 1997 and 2007.

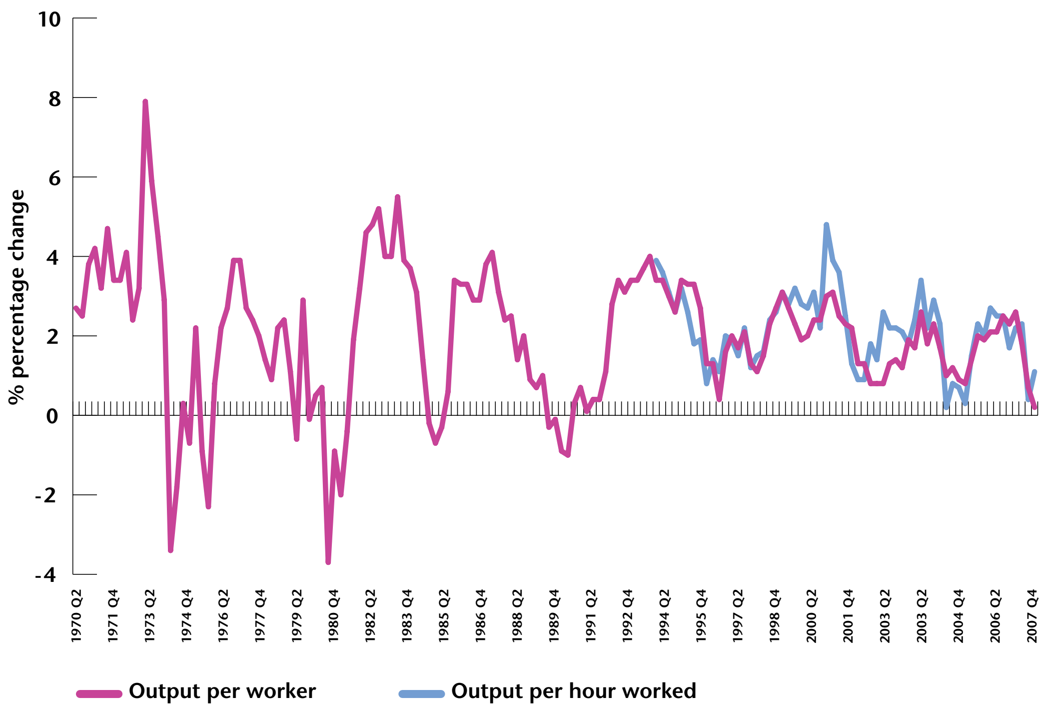
Figure 1: International comparisons of productivity (GDP per hour worked, Purchasing Power Parities)



Source: ONS

Source: ONS

Figure 2: Annualised UK labour productivity growth, percentage change on period one year ago



Source: ONS

There are also signs that the UK is making progress towards improving its productivity performance over the economic cycle. In the 2008 Pre-Budget Report, it was reported that in the economic cycle that ran from 1997H1 and on current evidence ended in 2006H2, trend productivity growth had averaged 2.5% a year, compared with 1.9% in the previous two economic cycles.

Productivity growth varies over the economic cycle, as can be seen in Figure 1. The Government continues to monitor progress under each of the five drivers of productivity through the Productivity & Competitiveness Indicators[10].

The Congressional Budget Office[11] report that there is a consensus in the empirical literature that R&D spending has a positive effect on productivity growth, a key driver of long-term economic growth. A similar result was found by Higón in 2007[12].

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[10] http://www.berr.gov.uk/publications/economicsstatistics/economics-directorate/page21913.html

[11] Congressional Budget Office (2005)

[12] Higón (2007)

Multi-Factor Productivity

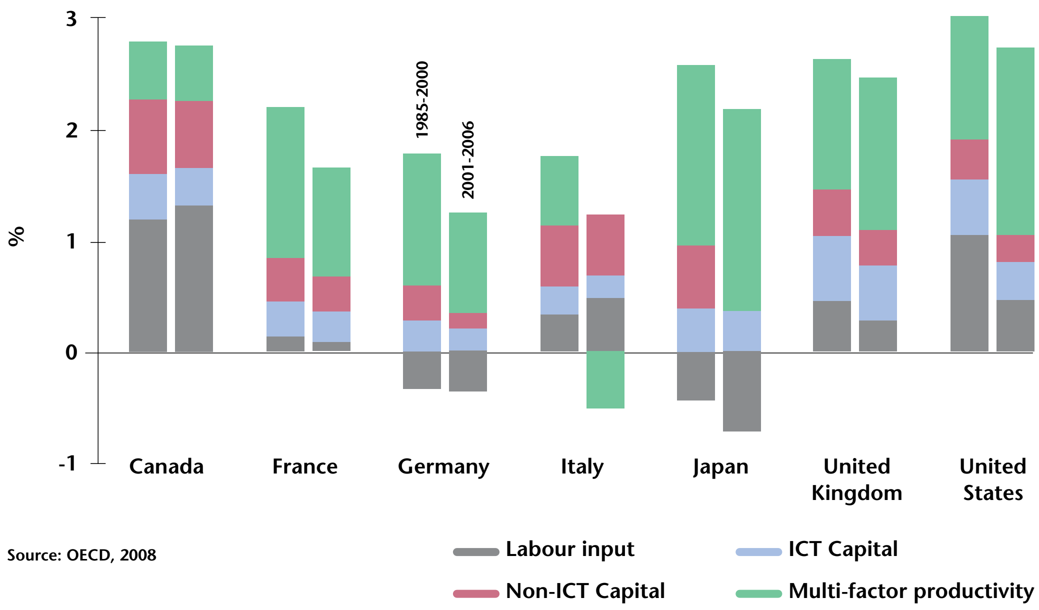
Quantifying the effects of research and innovation on economic growth involves breaking down the growth of GDP into its sources from labour and capital input. The remaining component of economic growth can be attributed to the efficacy of using those inputs; this is known as multi-factor productivity (MFP). Innovation can play a key role in determining a country's economic growth via its effect on MFP, by increasing the amount of goods or services that can be produced from a given amount of labour and capital, for instance through new technology or methods of organisation. Figure 3 shows the significant contribution of multi-factor productivity to the UK's overall economic growth.

How important are research and innovation to increasing multi-factor productivity? A 2004 OECD study[13] of a group of 16 countries from 1980-1998, including the UK, found:

- A 1% increase in business R&D increases multi-factor productivity by 0.13%;
- A 1% increase in public R&D increases multi-factor productivity by 0.17%.

While the measured effect seems small at first, the problems of measuring the capital inputs in growth accounting should be kept in mind, and also the effects of other drivers of multi-factor productivity.[14]

Figure 3: Contributions to growth of GDP, G7 countries, 1985-2000 and 2001-2006



Source: OECD, 2008

[13] OECD (2004)

[14] See Chapter 12: International comparisons of productivity, ONS Productivity Handbook, 2007.

A.2. Increased welfare

Total GDP figures can be used as a broad indicator of an economy's overall welfare or well-being. However, aspects of improved quality of life including health, environmental, and social cohesion outcomes are not directly captured in the current system of national accounts, though may be captured indirectly to the extent improved outcomes result from improvements in productivity.

There have been many attempts in the literature to identify and measure these wider impacts. Godin & Doré[15] identify eleven key socio-economic areas in an attempt to clarify the scope of impact from research and innovation. These areas with examples of type of impact are given below.

- Science (Knowledge, Activities)
- Technology (Products, Services)
- Economy (Production, Investment)
- Culture (Attitudes, Values)
- Society (Welfare, Activities)
- Policy (Public programmes, Security)
- Organisation (Planning, Work organisation)
- Health (Public health, Health system)
- Environment (Resource management, Climate)
- Symbolic (Credibility, Visibility)
- Training (Graduates, Use of knowledge)

However as Ekboir[16] explains, many factors influence the relationship between research and innovation and socio-economic impacts. Since impacts result from the actions of the whole system, there will be difficulty in attributing effects to research causes. The problem of attribution is compounded because impacts often appear after many years. Hence evidence on impacts is likely to be long-term in nature.

[15] Godin & Doré (2005)

[16] Ekboir (2003)

Table 2 gives a number of examples of how research contributes to a wide range of impacts on welfare and the quality of life. More details and additional examples are included in individual Research Council's Economic Impact Reporting Frameworks.

Table 2: Welfare impacts of publicly funded research

Aspect of welfare/ well-being	Case study example
Health	Research at the Institute for Animal Health, funded by the Biotechnology and Biological Sciences Research Council, contributed to the eradication of Rinderpest in Africa, with a net economic benefit of over $1 billion annually. Advances in DNA technology (including DNA microarrays and DNA fingerprinting) have been underpinned by key research contributions funded by the Medical Research Council. The MRC has also co-sponsored a study of the economic benefits arising from UK medical research with the Wellcome Trust and the Academy of Medical Sciences, to be published in 2008/9. Drugs effective against MRSA have been discovered using cost and time-saving techniques developed through the Engineering and Physical Sciences Research Council's e-science programme.
Environment	The Natural Environment Research Council's British Geological Survey provides vital information on subsidence and ground instability throughout the UK. It is estimated that fast access to relevant information for the public, mortgage companies, insurers, developers and planning authorities has saved the UK economy between £70 million and £270 million over 25 years."*
Social Cohesion	The Centre for the Analysis of Social Exclusion, funded by the Economic and Social Research Council, was found to have made a significant contribution to better and faster policy making in the area of social exclusion, and to be a key producer of evidence to inform the development of the Government's Sure Start programme. The Design Against Crime Research Centre, University of the Arts London, generates greater understanding of how to tackle crime. Four research grants funded by the Arts and Humanities Research Council, focusing on the problems of theft, are estimated to have saved £4.7 million in avoided costs and emotional stress.

Source: Research Council Economic Impact Reporting Frameworks
*Calculation applies a discount rate over 25 years of 3.5% and conforms with HM Treasury appraisal standards.

The UK hosts a number of large-scale science facilities, including Diamond Light Source based at Harwell in Oxfordshire and ISIS based at the Rutherford Appleton laboratory, adjacent to Diamond. A review of the economic impact of the UK's large-scale science facilities[17] concludes that the major economic impacts arising from location of a large scale science facility are from employment of relatively high paid staff that are recruited from the local area, and the awarding of contracts to UK-based suppliers. UK suppliers are relatively successful in winning 'low technology' contracts, related to construction and installation phases, but are less successful in winning 'high technology' contracts, where the market for specialised equipment and services is global.

Limited evidence was found that facilities were transferring knowledge and technologies to their suppliers on a substantial scale, given the volume of contracts involved. There was also limited evidence to suggest that the facilities could on their own seed the development of clusters, as the clusters in their local areas predate the establishment of the facilities and the facilities are small in relation to the total volume of scientific investment.

[17] Review of economic impacts relating to the location of large-scale science facilities in the UK, SQW Consulting (2008)

B. Innovation outcomes and outputs

Innovation – the successful exploitation of ideas – reflects the ability of firms, government and the research base to use ideas, skills and knowledge to create new products or processes that result in economic impacts. Innovation includes both technological innovation and wider innovation. This section covers indicators on:

- New or improved products, processes, services;
- New businesses;
- Generation of intellectual property;
- Strategic innovation.

B.1. New or improved products, processes, services

Surveys of innovation are carried out regularly in the UK, in parallel with broadly common surveys in other European countries. The UK Innovation Survey[18] classifies a business as innovation active if it is engaged in any of the following:

- Introduction of a new or significantly improved product (good or service) or process for making or supplying them;
- Innovation projects not yet complete, or abandoned;
- Expenditure in areas such as internal research and development, training, acquisition of external knowledge or machinery and equipment linked to innovation activities.

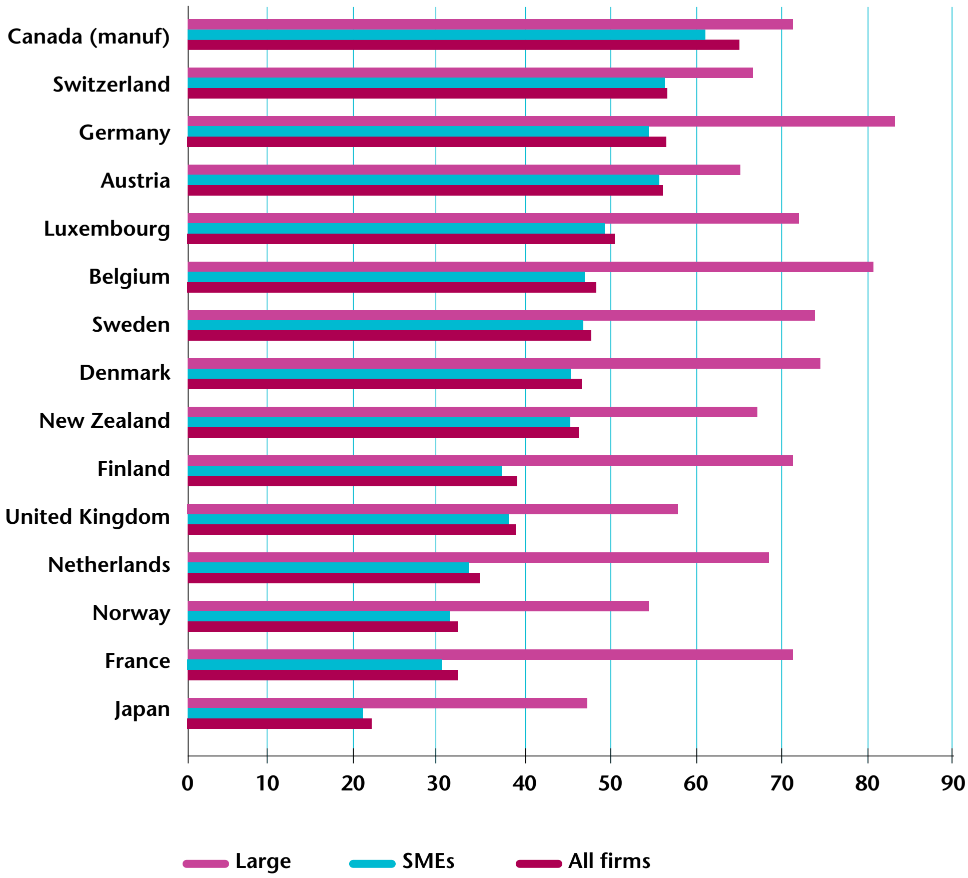
The 2007 UK Innovation Survey showed that 64% of enterprises were innovation-active over the 2004-6 period, an increase on the 57% in the 2002-2004 period[19]. The 2007 survey also showed that 23% of enterprises brought new products to market, down from 25% in the 2005 survey, and 12% of enterprises introduced new processes, down from 16 per cent in the 2005 survey.

[18] Data is taken from the 2007 and 2005 UK Innovation Survey. The 2007 survey covered the period 2004-2006 whilst the 2005 survey covered 2002-2004.

[19] Note in the 10 Year Framework Annual report, there is a reference to the share of innovation active businesses in the UK reaching 68% in 2004-6, up from 49% in 1998-2000. This comparison is calculated on a different basis as the time period for comparison differs.

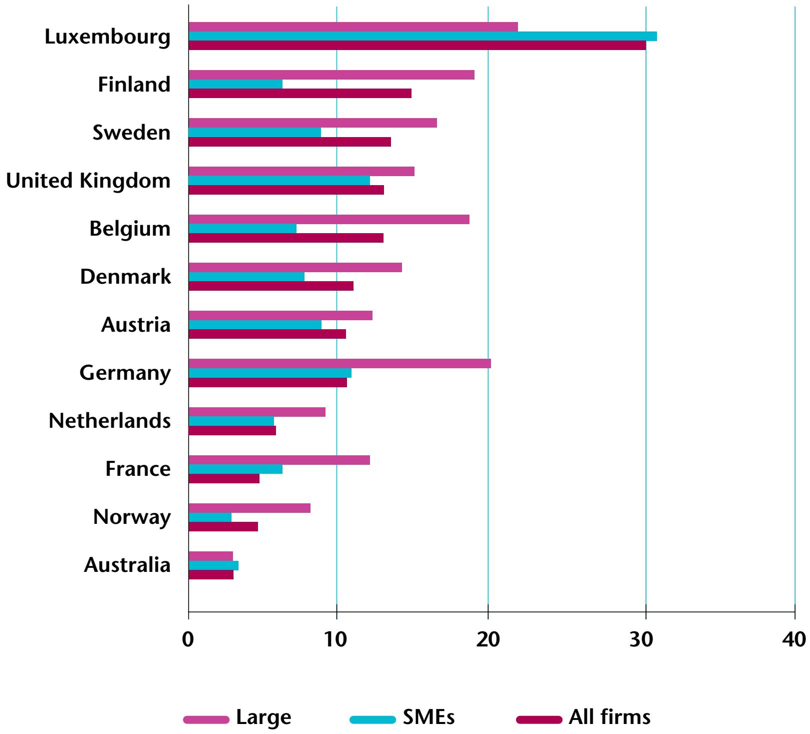
International comparisons on innovation performance are available through the Community Innovation Survey, the collective name for the UK and other European innovation surveys. Other countries including Canada, Japan and Switzerland also undertake broadly comparable surveys. The numbers for the UK differ when making international comparisons, due to differences in core sector coverage in other countries. While the UK performs less strongly than other countries as measured by the proportion of firms introducing a product or process innovation, the UK's innovation intensity (as measured by the share of turnover from product innovations) is relatively high.

Figure 4: Firms having introduced a product or process innovation 2004-06 (as a % of all firms)



Source: Fourth Community Innovation Survey, and country surveys, 2004-06

Figure 5: Share of turnover from product innovations 2004-06 (as a % of total turnover)



Source: Fourth Community Innovation Survey, and country surveys, 2004-06

The Community Innovation Survey quantifies innovation outputs and outcomes for the private sector, but does not cover the public sector. Innovation in the public sector delivers a number of benefits, including improved value for money, more effective service delivery, and building stronger community engagement and representation. These benefits can be generated through new or improved services, process innovations, new policy instruments, or innovations relating to the establishment of new organisations and new patterns of cooperation and interaction.

While innovation in the public sector is increasingly studied, the measurement and reporting of innovation in a systematic sense is in its infancy, both domestically and internationally.[20] Future editions of this report will take into account developments on metrics covering public sector innovation as they develop.

[20] See, for example, a paper on public sector innovation in Innovation Index Working Paper, NESTA (2008)

B.2. New businesses

The creation of new firms is a key channel by which economic benefits of research and innovation are achieved. A study from Warwick University[21] describes UK university spin-out performance as "excellent, both in terms of quantity and quality". The same paper suggests UK universities also perform favourably in comparison to their US counterparts; taking into account the median age of UK technology transfer operations is 8 years younger on average than US operations.

Data reported from Higher Education Institutions show that the total number of UK spin-outs has risen since 2004, with a similar growth rate in the US. The decline in 2003/4 and 2004/5 may be attributed to the impact of schedule 22 of the 2003 Finance Act.

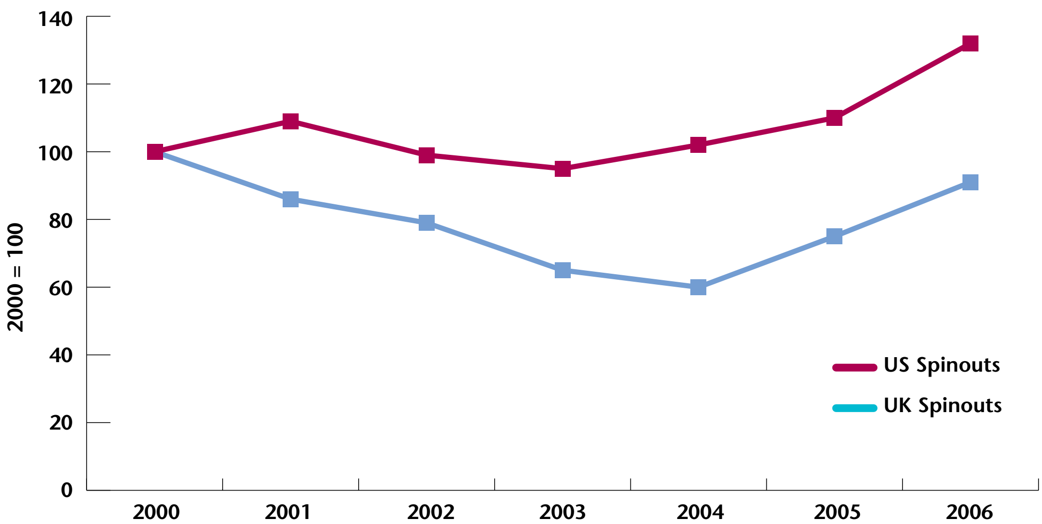
The fourth annual survey of public sector research establishments (PSREs) indicates an increase in the number of spin-outs from last year; with an overall increase from 2003/4, as shown in Table 3.

Table 3: Number of UK spin-outs formed

Indicator	2000/1	2001/2	2002/3	2003/4	2004/5	2005/6	2006/7
Higher Education Institutions	248	213	197	161	148	187	226
Public Sector Research Establishments				69	84	74	101

Source: Higher Education Business-Community Interaction Survey & Annual Survey of knowledge transfer activities in the public sector research establishments

Figure 6: Relative changes in UK and US spin-outs from HEIs



Source: Higher Education Business-Community Interaction Survey (2000-01 to 2006-07)

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21 Williams (2005)

B.3. Generation of intellectual property (IP)

Measures of intellectual property are often used as proxy indicators for outputs of innovation. Frequently examined indicators relating to the number of US patents granted, registered community trademarks and registered community designs are set out in this section. In some sectors, e.g. music or film, intellectual property is protected through copyright. However, because there is no administrative process involved in granting copyright, there are no similar statistics on the use of copyright.

Figure 7: US patents granted per head of population (thousand)

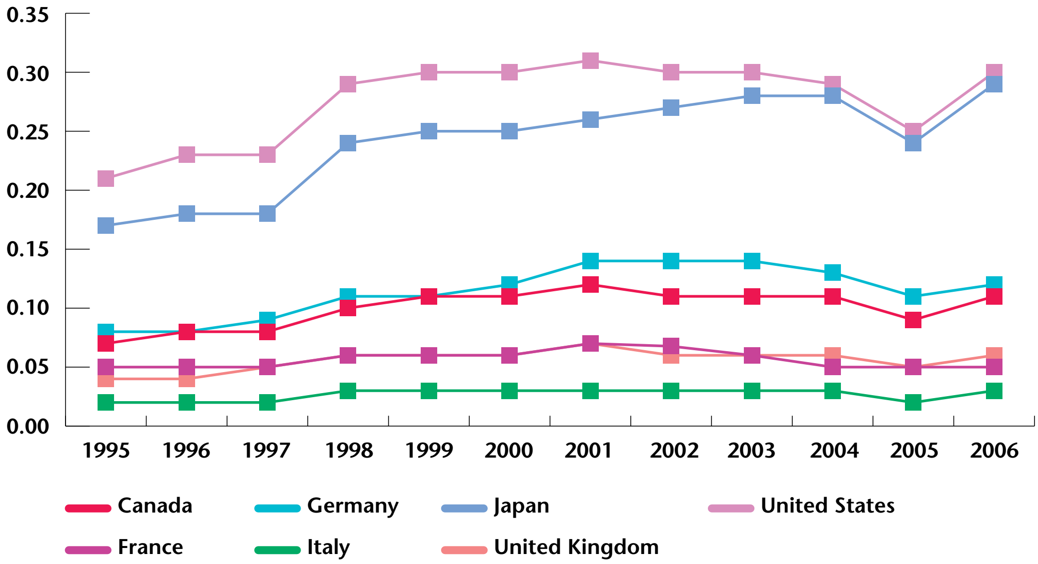


Figure 8: Registered community trademarks per head of population (thousand)

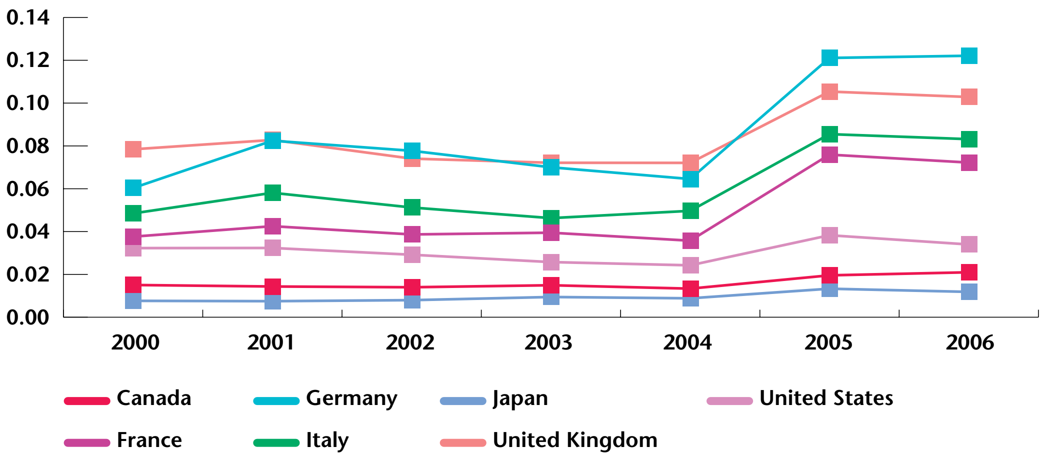
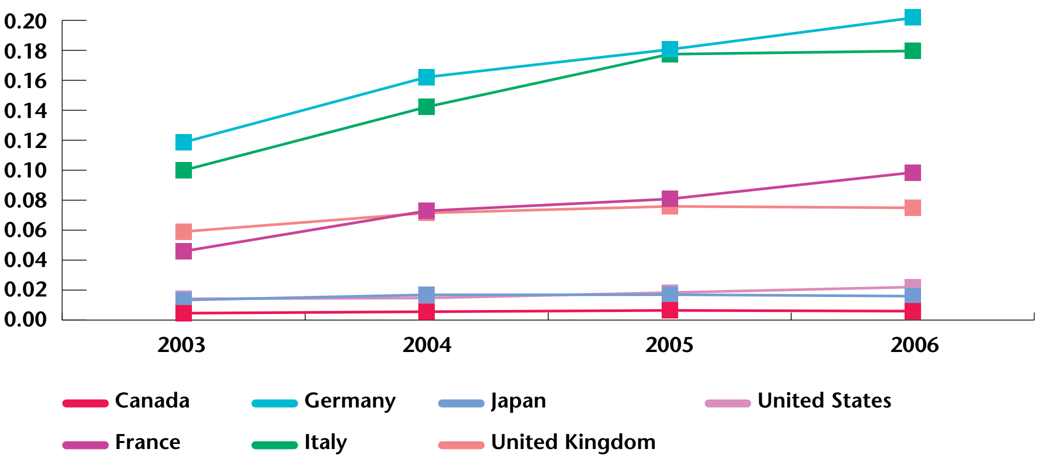


Figure 9: Registered community designs per head of population (thousand)



Source: OECD; Office for Harmonization in the Internal Market

The number of patents granted by the US Patent and Trademark Office per head is a widely used indicator which, although likely to overstate the patenting performance of the US due to 'home country bias,' allows a broad comparison of the patenting performance of EU countries. The UK's number of US patents granted per head is similar to that of France, with both countries around 5th equal in the G7. Broadly similar results are obtained when triadic patents are used (patents taken at the US Patent and Trademark Office, Japanese Patent Office and European Patent Office). The relatively lower level of patenting in the UK may be due to cross-country differences in the levels of business R&D.

Patenting behaviour varies according to sector. The former Department of Trade and Industry's 2006 R&D scoreboard shows that patent intensity (US patents granted per £10 million R&D investment) varies strongly between sectors such as electronics, technology hardware and personal goods, which have high patent intensities, and pharmaceuticals and telecoms, which have much lower patent intensities. In sectors of the economy such as financial services, patenting may be less generally appropriate as a means of IP protection. Therefore the UK's industrial mix will affect its overall patenting performance. The UK's continued shift to high-value added services would tend to imply a shift away from patenting, and alternative indicators of protection methods may be more appropriate (see section C.1).

One such indicator is the number of registered community trademarks. Research shows that trademark activity is positively associated with firm productivity[22]. This measure may overstate the performance of European Union members relative to other countries who do not use the community registration system. However, comparisons can be made between countries EU members. The UK scores more highly on trademarks than patents and is broadly comparable to Germany.

A further indicator is the number of registered community designs (this measure may also advantage countries within the European Union). The UK's performance is similar to France, though both countries lag behind Germany and Italy.

B.4. Strategic innovation

Section B1 discussed the product and process innovation aspects of innovation activity. However, wider domains of innovation activity are essential for these traditional modes of innovation to be effective and profitable. Amendments to management practices, business strategies or organisation can be the main modes of innovation where market conditions do not require product or process change.

In the UK, firms participate in a range of innovation activities through organisational and management change. Comparisons with other countries across the EU show that many smaller countries record relatively high shares of businesses involved in organisational and/or marketing innovations. This may reflect a process of catch up with the management practices prevalent in more advanced economies.

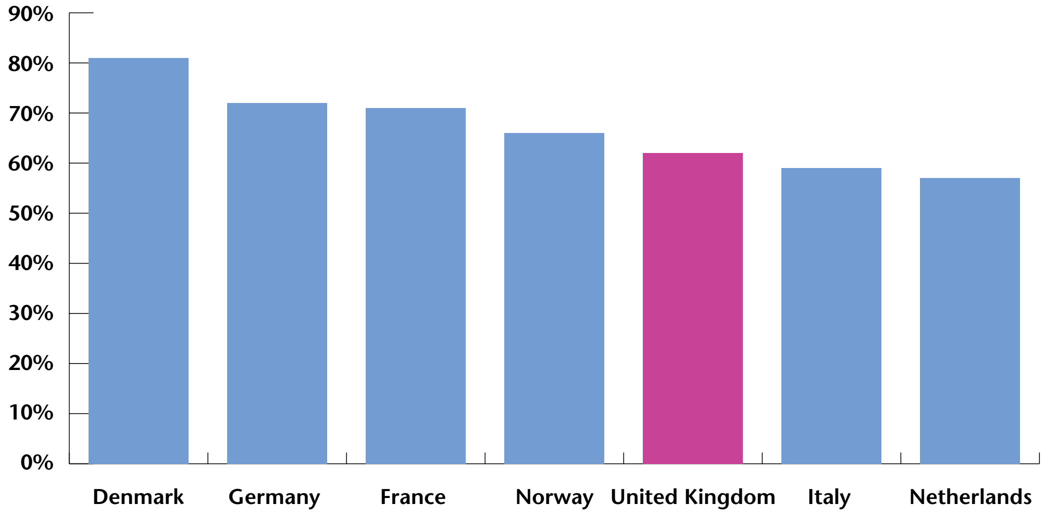
Table 4: Types of strategic innovation, percentage of all enterprises

Type of wider innovation undertaken	2002-04	2004-06
Corporate strategy	16	15
Management	13	12
Organisational structure	16	20
Marketing	19	18

Source: UK Innovation Survey

[22] Greenhalgh and Rogers (2007)

Figure 10: Proportion of innovation active firms who introduced organisational and/or marketing innovations in 2002-2004



Source: Fourth Community Innovation Survey

C. Investment in the research base and innovation

This section sets out trends in funding of the science and innovation system, and includes indicators on:

- Expenditure on R&D, with details of proportions of publicly funded R&D, privately funded R&D, and overseas funded R&D; and
- Other forms of innovation expenditure, as defined by the European wide Community Innovation Survey.

Investment in the research base and innovation will have effects on overall economic impacts, as well as effects on the knowledge generation and innovation outcomes and outputs components of the science and innovation system:

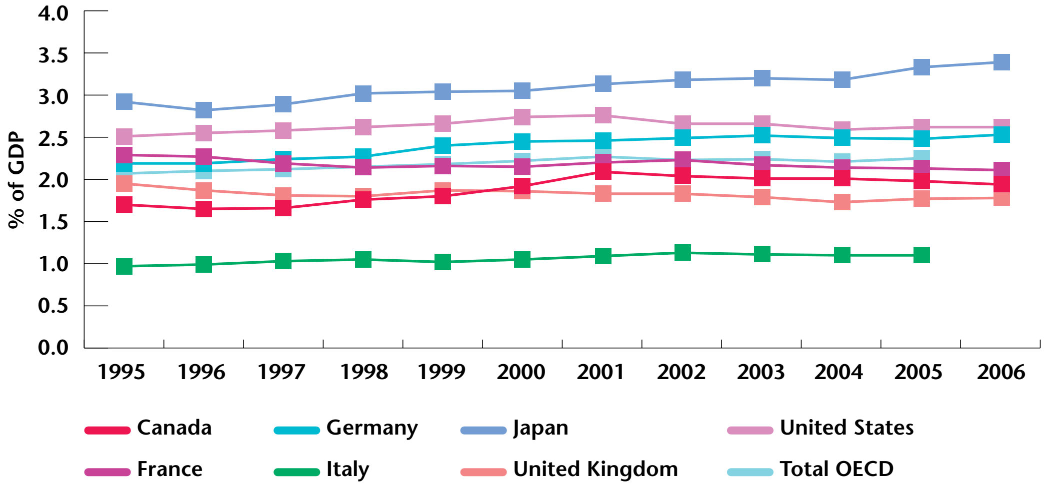
- Increases in R&D have important effects on productivity (see section A), and evidence suggests that both tax incentives and direct government funding of R&D performed by firms have a positive effect on business financed R&D[23].
- Public investment in research leads to additions to the stock of codified knowledge and human capital. It takes around six years for investment to have a full impact on the number of publications and seven years for an impact on citations[24].

C.1. Expenditure on R&D

The ambition set out in the ten year Framework is for the UK to reach a ratio of Gross Expenditure in R&D (GERD) to GDP of 2.5% by 2014. Office for National Statistics (ONS) figures show that in 2006, GERD or total R&D performed in the UK as a proportion of GDP was 1.75%, an increase on the previous ratio of 1.74% in 2005. £23.2bn was spent on GERD, a 4% increase in real terms from 2005 and a 7% increase in cash terms. Total R&D ratios for G7 and the OECD average have been fairly stable for the past decade as Figure 11 shows, with R&D growing in line with GDP.

[23] OECD (2003)
[24] SPRU (2004)

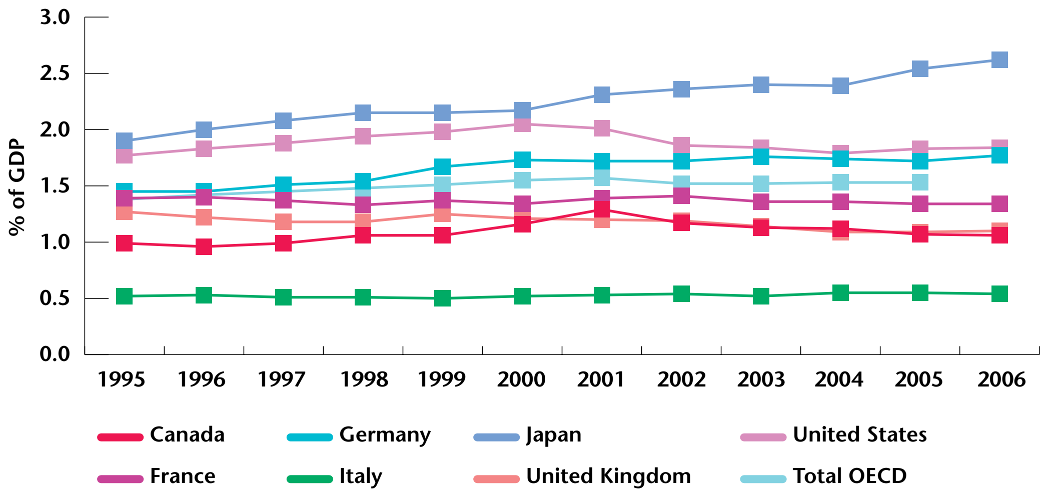
Figure 11: Gross expenditure on R&D as a % of GDP



Source: OECD Main Science and Technology Indicators

The proportion of R&D performed in the UK in the business enterprise sector (BERD) has shown a slight downward trend as a share of GDP for the past decade. ONS figures show that in 2006, BERD as a proportion of GDP was 1.1%, in line with recent years. In 2006 £14.3bn was spent on total R&D performed in UK businesses, a 5% increase on 2005 in real terms and a 7% increase in cash terms. Shares of Business R&D to GDP in other G7 countries have been relatively stable, with the exception of Japan.

Figure 12: Business enterprise R&D as a % of GDP



Source: OECD Main Science and Technology Indicators

The UK's share of national income in R&D investment remains low compared to other leading industrialised nations, and this is largely due to the UK's industrial mix. UK companies generally show similar R&D levels to others in their sectors, but the UK is specialised in less R&D intensive industries. The sector mix issue is analysed in depth in a DIUS analytical paper on Business Innovation Investment in the UK, published with the Innovation Nation White Paper in 2008[25]. This indicates that most of the difference in R&D intensity between the UK and leading competitors can be explained by sector mix.

Therefore, it is more useful to consider a country's business R&D performance by sector, rather than looking at aggregated figures. The Public Service Agreement for Science and Innovation reflects this by including the average UK R&D intensity in the six most R&D intensive industries, relative to other G7 economies. DIUS will be publishing performance on this indicator as part of its reporting of the Science and Innovation PSA.

While the proportion of R&D performed in the business enterprise sector *as a proportion of GDP* is lower in the UK relative to other countries, 62% of total R&D is performed in the business sector. This proportion is in line with other countries. ONS figures show around 36% of R&D is performed in the government, higher education and research council sectors.

Turning to the sources of funding for R&D in the UK (rather than where the R&D is performed), ONS figures show that, in 2006, 45% of R&D performed in the UK was funded by UK businesses, up from 42% in 2005. This proportion is somewhat lower than other G7 countries and the OECD average. However, the UK has a relatively high share of R&D funded from abroad at 17% in 2006 (down from 19% in 2005). Around 33% is funded by government sources (including higher education funding councils and Research Councils) and 5% is funded by private non-profit sources.

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[25] Available at http://www.dius.gov.uk/publications/innovation_nation_docs/BusinessInnovationUK.pdf

Figure 13: Gross expenditure on R&D by sector of performance, 2005

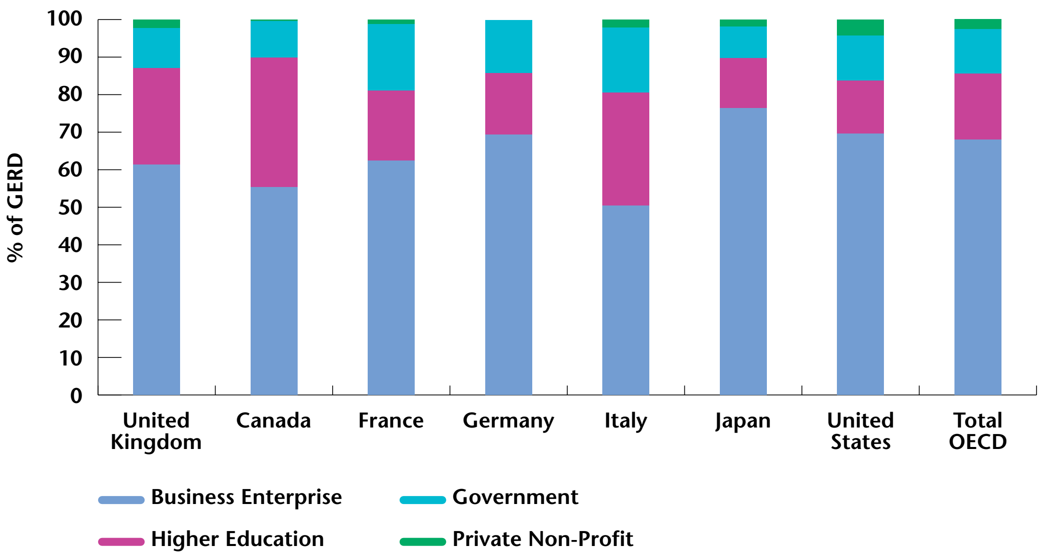
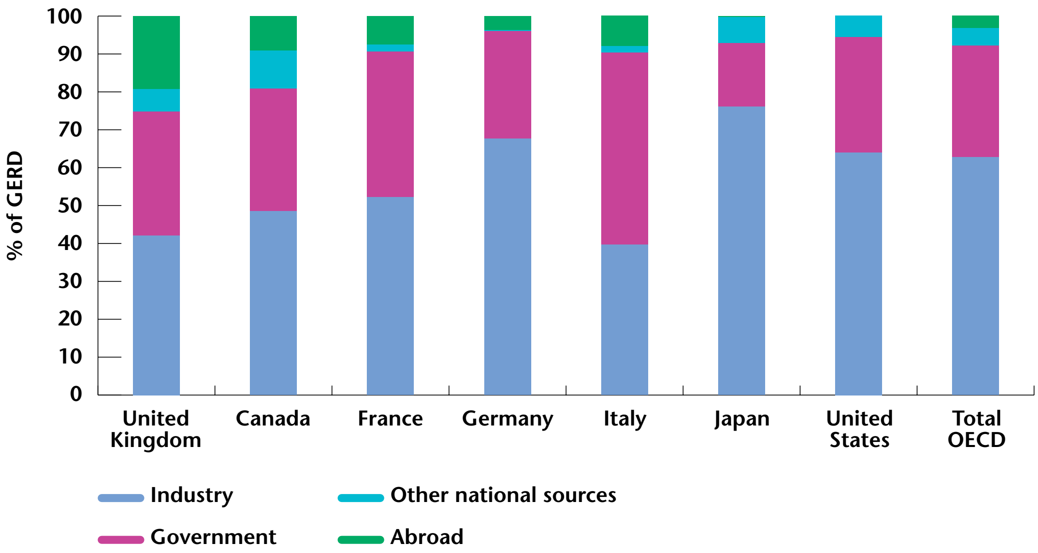


Figure 14: Gross expenditure on R&D by source of funds, 2005



Source: OECD Main Science and Technology Indicators. Note that for the US, the source of funds for GERD from abroad is included in the other totals. The UK numbers in these charts differ slightly to reported figures from the Office for National Statistics, as the OECD make adjustments to data to enable international comparisons and also may not always have the most up to date data.

Research Council Investment

The Research Councils collectively invest in research covering the full spectrum of disciplines from the medical and biological sciences to astronomy, physics, chemistry, engineering, social sciences, and the arts and humanities. Table 5 shows the Comprehensive Spending Review (CSR) allocations of funding until 2010/11.

Table 5: Comprehensive Spending Review 2007 allocations 2007/08 – 2010/11

£'000	2007-08	2008-09	2009-10	2010-11	CSR07 Total	End CSR07 Increase
AHRC	96,792	103,492	104,397	108,827	316,716	12.4%
BBSRC	386,854	427,000	452,563	471,057	1,350,620	21.8%
ESRC	149,881	164,924	170,614	177,574	513,112	18.5%
EPSRC	711,112	795,057	814,528	843,465	2,453,050	18.6%
MRC	543,399	605,538	658,472	707,025	1,971,035	30.1%
NERC	372,398	392,150	408,162	436,000	1,236,312	17.1%
STFC	573,464	623,641	630,337	651,636	1,905,614	13.6%
Total	**2,833,900**	**3,111,802**	**3,239,073**	**3,395,584**	**9,746,459**	**19.8%**

Source: The Allocations of the Science Budget, December 2007. Note that this table shows planned allocations. See each Research Council's Economic Impact Reporting Frameworks for more details on actual allocations.

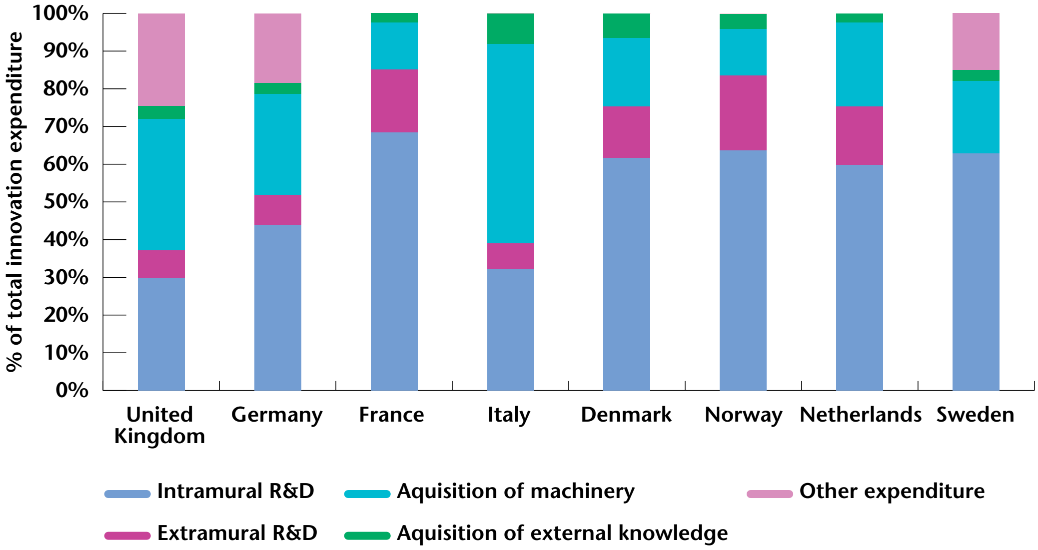
C.2. Other innovation expenditure

R&D, although vital, is not the only significant input to innovation and thus to economic performance. Indicators which reflect inputs into the UK's wider innovation performance, which includes the effects of design and business model innovation, suggest greater investment than R&D statistics alone suggest.

The Community Innovation Survey defines innovation expenditure on the basis of the "Oslo Manual", a joint publication from the OECD and Eurostat which provides international guidelines and definitions. This definition also includes, in addition to R&D, expenditure on acquiring external knowledge and acquiring equipment and machinery (including computers and software).

Figure 15 shows that in the UK, R&D accounts for around a third of total innovation expenditures in the UK. Other types of innovation expenditure are relatively larger in the UK than in many other countries. These include market preparations for new or improved products, design and expenditure for training linked to innovation activities.

Figure 15: International comparison of innovation expenditure, 2005



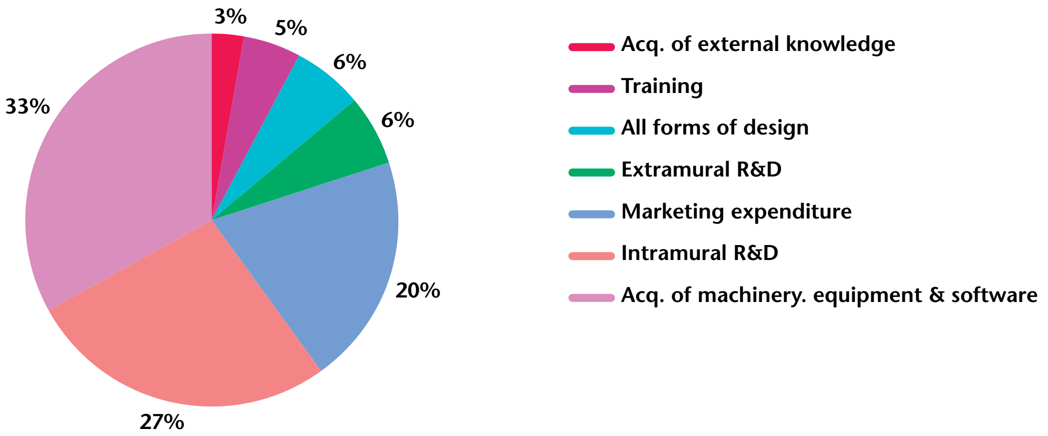
Source: Fourth Community Innovation Survey

A recent HM Treasury Economic Working Paper[26] investigates the consequences for the measurement of productivity of treating spending on intangible assets as investment. It finds that traditional measurement techniques may underestimate the importance of investment in intangibles in driving productivity growth, highlighting the importance to the UK economy of science, innovation and knowledge-based industries. On this basis, investment in intangible assets – such as human and organisational capital, design and software has been at a similar level to physical investment in recent years.

The categorisation of expenditure on innovation is not entirely consistent across countries so Figure 17 provides more detail on the pattern of the UK's spend for a more recent year, 2006, including a composition of expenditures in the 'other' category in the Community Innovation Survey. Figure 16 provides a breakdown of innovation expenditure by industrial sector.

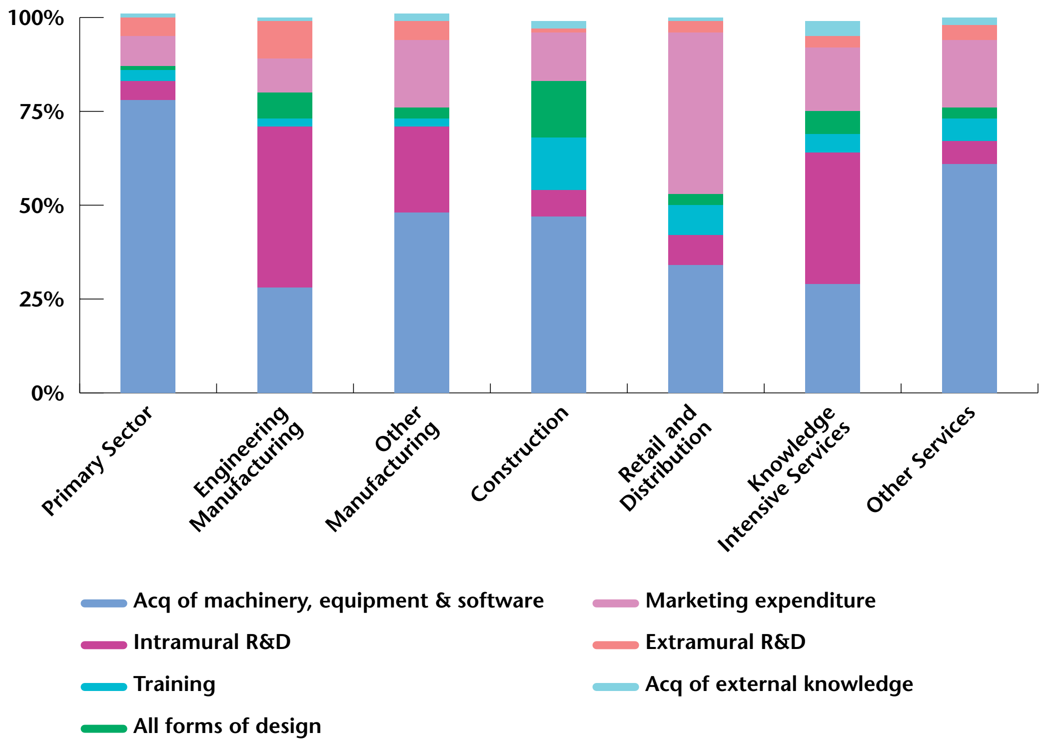
[26] HM Treasury (2007a)

Figure 16: UK expenditure on innovation by type, UK Innovation Survey 2007 (all respondents)



Source: UK Innovation Survey 2007

Figure 17: Shares of innovation expenditure by industrial sector



Source: UK Innovation Survey, 2007

D. Knowledge generation

This section reports indicators of the main outputs of the research base of codified and tacit knowledge. Codified knowledge is captured by performance indicators on contributions to the stock of publicly available knowledge, including publications and citations. The tacit knowledge element is captured by performance indicators on human capital, including the number of skilled graduates and researchers. Indicators which are important to sustaining the stock of skilled people are reported, including the ten year Framework's next steps targets related to Science, Technology, Engineering, and Mathematics (STEM) qualifications.

The knowledge generated by the science and innovation system will have direct effects on innovation outcomes and economic impacts. Findings from the literature include:

- A 1% increase in the stock of publicly funded basic research has been estimated to lead to a 2-2.4% increase in the number of commercially available new compounds in the pharmaceutical industry (Toole 1999).
- 20% of private sector innovations are based to some extent on publicly funded research in universities (Tijssen 2002, based on data for the Netherlands).
- 72% of citations from private research papers are to papers produced by public research organisations. (Tijssen and Leeuwen 2006, based on international data)
- ¾ of scientific papers cited in the US in industrial research are from publicly funded research (McMillan and Hamilton 2003).

The science and innovation system produces highly skilled researchers and graduates, who as employees directly transfer to and use their knowledge in, acquired to firms and the public sector. DIUS is currently leading a programme of analysis on Science, Technology, Engineering and Mathematics Skills in order to gain a better understanding of where graduates and researchers go and the nature of demand for their skills. A report will be published in late 2008.

D.1. Adding to the stock of publicly available knowledge

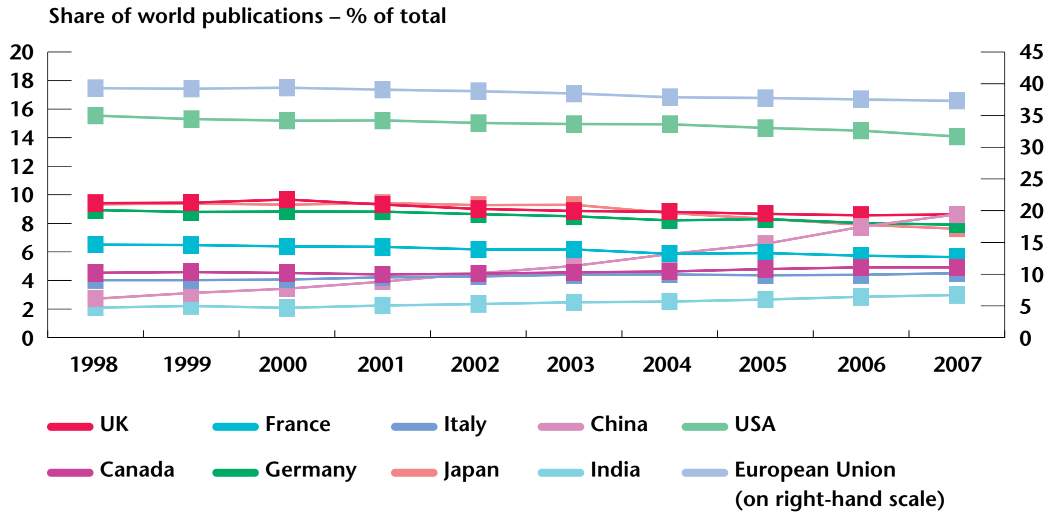
The primary output from the public research base is the volume of research articles published worldwide. The UK is second to the US in terms of number of publications, with around 9% of the world total. China's share of publications has markedly increased in the past decade, and now stands level with the UK.

The number of citations a publication receives is an indicator of its influence and international visibility in the scientific community. The UK is again second to the US with around 12% of world citations, and with 13% of the most highly cited papers. The UK's citation performance is strong across disciplines, with the UK in the top three in seven of nine fields (and top three in eight of ten fields including the humanities, though the data for this field is less robust).

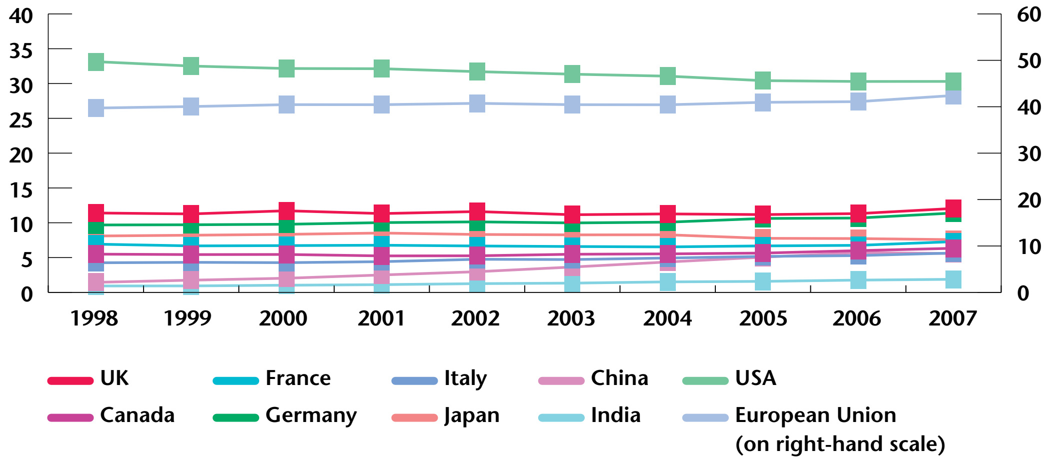
The number of citations per publication is an indicator of the impact of a country's research. The UK has closed the gap with the US on research impact, though Germany's strong recent performance now places it first in the G8.

The number of citations per unit of R&D performed in the public sector is an indicator of a country's research productivity. Most publications will be produced in the public, rather than private, sector. The UK has maintained high levels of productivity over the past decade.

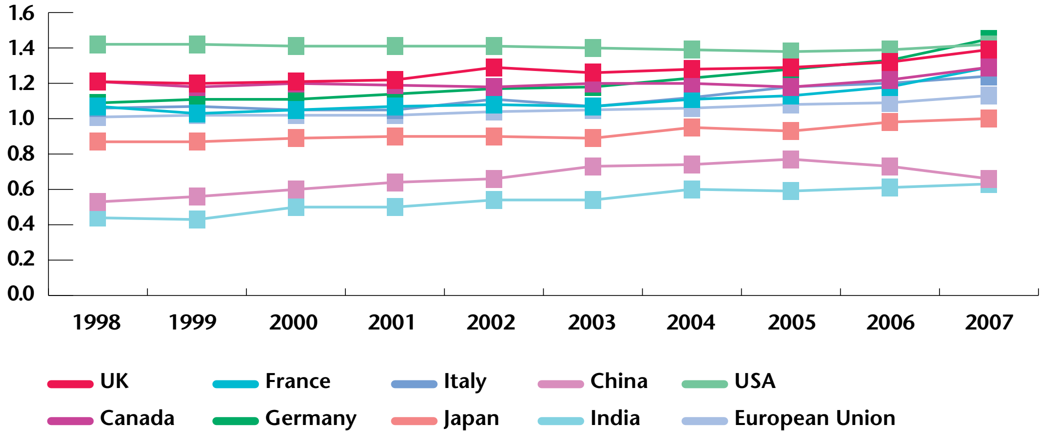
Figure 18: Adding to the stock of publicly available knowledge – international comparisons



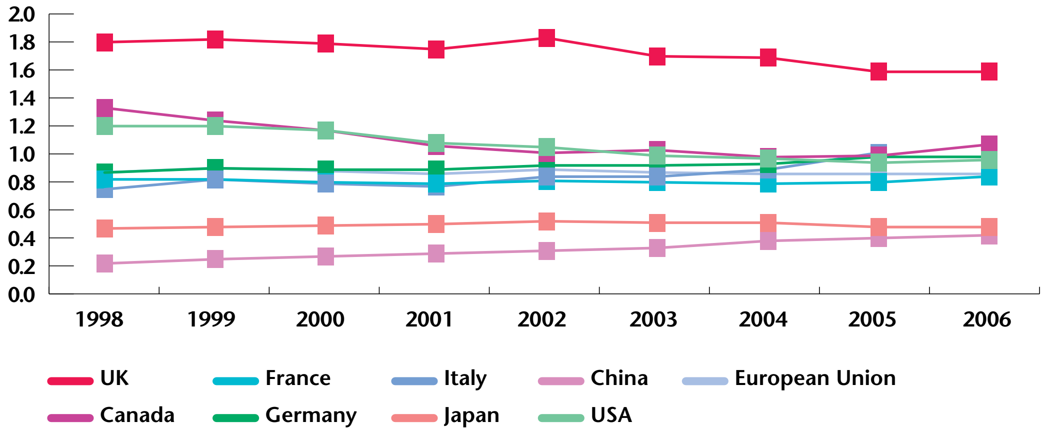
Share of world citations – % of total



Citations per publication, relative to world baseline (world =1.0)



Citations per unit of R&D performed in public sector, relative to average (average = 1.0)



Source: International comparative performance of the UK research base, 2008. Note that the average for citations per R&D is calculated for 25 countries, which includes the full G8 and a combination of larger and smaller countries from different continents with research bases both similar and contrasting in structure to the UK.

Research Councils play a key role in adding to the stock of publicly available knowledge. Highlights of outputs reported this year are shown in Table 6.

Table 6: Examples of additions to the stock of publicly available knowledge

Research Council	Case study example
AHRC	• The UK is a close second to the US in producing the largest proportion of articles in internationally significant arts and humanities journals. In 2007 the UK published 29.8% of articles in peer-reviewed quality journals with the US publishing 30.2%. • AHRC funded research produced 3,766 outputs in 2007/8 These included performance and visual media, electronic outputs and conferences, and these are increasing over time, relative to paper based outputs.
BBSRC	• BBSRC is one of the main funders of biological research in the UK, and a rolling programme of evaluations of responsive mode funding indicates the quality of research has been good and improving over time. • BBSRC sponsors a number of research institutes and the number of publications per research leader has remained stable at around 6.7 since 2005, with the number of refereed publications per research leader increasing to over 4 in 2007.
ESRC	• The proportion of research funded by ESRC rated as 'outstanding' and/or 'good' has been over 95% since 2005/6. A series of international benchmarking reviews are being carried out to assess the standing of UK social science, and results so far show the UK to perform strongly in economics and political science. • The number of publications arising from ESRC funded research continues to rise, from 4695 in 2005 to 5265 in 2007. Publications arising from directive-mode investments rose to 4319 in 2007/8, from 2610 in 2006/7.
EPSRC	• Around one quarter of all publications arising from EPSRC research grants are co-authored with international authors. Over half of completed grants report at least one published paper with an international co-author. • The number of publications arising from EPSRC research grants was 19,652 in 2007/8, and the average number of publications per grant continues to rise, to around 20 in 2007/8.
MRC	• The number of publications arising from research in MRC Institutes and units has increased since 2005, with 2064 publications in refereed journals in 2007. • Researcher productivity has increased since 2005, to be around 7 publications per lead researcher in 2007.
NERC	• NERC performs evaluations of research receiving funding, and three major evaluations reported in 2007/8. The evaluations concluded that important outputs arose from the Ocean Margins LINK Programme and the QUEST programme, and that the UK Energy Research Centre has made good progress towards achieving its objectives. • The number of publications arising from NERC funding has increased by around 5% since 2005, with 6960 publications in 2007. The number of publications in internationally recognised journals has increased by around 6% since 2005, to over 4000 in 2007.
STFC	• STFC facilities have been used consistently by users from 5 and 5* rated university departments over the past three years. International usage of the Research Facilities continues at a good level and invited talks at international conferences continue to increase year on year. • The number of publications arising from funding of Astronomy and Particle Physics in the UK increased in 2007.

Source: Research Council Economic Impact Reporting Frameworks

D.2. Human capital

The ten year framework and the 2006 "Next Steps"[27] document set out ambitions to ensure that the supply of those trained in Science, Technology, Engineering and Mathematics (STEM) remains strong. This section sets out the indicators underpinning these ambitions.

Schools

In 2007/8, 50% of pupils at the end of Key Stage 4 attained two or more A*-C grades in Science subjects, with little change from 2006/7. Tables 7, 8 and 9 show the latest data on GCE and VCE A level entries. DCSF are working towards target entries for 2014 set out in the Next Steps document of 56,000 in mathematics, 37,000 in chemistry, and 35,000 in physics.

Table 7: GCE A level entries by subject, 1999/2000 – 2007/08

Academic year ending	2000	2001	2002	2003	2004	2005	2006	2007	2008
Mathematics	53,674	54,157	44,156	44,453	46,017	46,037	49,805	53,331	57,620
Chemistry	35,290	33,871	32,324	31,065	32,130	33,164	34,534	35,077	36,360
Physics	28,191	28,031	27,860	26,278	24,606	24,094	23,657	23,887	24,700
Biological sciences	46,190	44,592	45,407	43,902	44,235	45,664	46,624	46,797	48,430
Other science	3,834	3,587	3,740	4,029	3,773	3,779	3,599	3,920	3,980
TOTAL	**167,179**	**164,238**	**153,487**	**149,727**	**150,761**	**152,733**	**158,219**	**163,012**	**171,090**
All subjects	**672,362**	**681,553**	**645,033**	**662,670**	**675,924**	**691,371**	**715,203**	**718,756**	**741,160**

Source: Table 2, GCE/VCE A/AS and Equivalent Examination Results in England, 2007/08 (Provisional)
http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000816/index.shtml

Table 8: Percentages achieving GCE A level A-E grades by subject, 1999/2000 – 2007/08

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Mathematics	89.4	88.6	94.2	95.3	96.3	96.8	97.6	97.6	97.9
Chemistry	91.1	91.5	95.0	96.0	96.7	96.6	97.0	97.0	97.3
Physics	89.9	89.8	93.6	94.7	95.2	95.3	95.7	96.2	96.5
Biological sciences	89.1	89.4	92.2	93.8	94.7	95.1	95.7	96.1	96.6
Other science	87.7	89.0	94.1	94.7	95.9	96.0	96.6	96.4	97.1
All Subjects	**89.5**	**90.0**	**94.8**	**96.1**	**96.6**	**96.8**	**97.2**	**97.4**	**97.7**

Source: Table 2, GCE/VCE A/AS and Equivalent Examination Results in England, 2007/08 (Provisional)
http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000816/index.shtml

[27] HM Treasury, DTI, DfES, DH (2006) http://www.hm-treasury.gov.uk/d/bud06_science_332v1.pdf

Table 9: VCE/ GCE Applied entries of 16-18 year old students in 2007/08

	Science	ICT	All subjects
VCE/GCE Applied A level entries	1,150	11,120	29,490
VCE/GCE Applied Double Award entries	630	2,150	11,590

Source: Table 4 and 6, GCE/VCE A/AS and Equivalent Examination Results in England, 2007/08 (Provisional)
http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000816/index.shtml

Further Education

FE makes a considerable contribution to delivering the STEM agenda, and key statistics for 2006/7 include:

- over 445,000 Learning and Skills Council funded learners (covering further education, work-based learning, and adult and community learning) in the Information and Communication Technology (ICT) subject group;
- nearly 95,000 learners in Science and Maths; and
- 216,000 in Engineering and Manufacturing Technologies.

In addition, 25% of science A-levels and 24% of Maths A-levels are undertaken in the FE sector.

Higher Education

The number of those obtaining first and further degrees in Science, Technology, Engineering, and Mathematics (STEM) remains strong. Table 10 and Table 11 give the breakdown by individual subject for first degree qualifiers and Masters degree qualifiers respectively. Overall, the number of STEM first degree qualifiers from UK HEIs has increased by 11% over the period 2002/03 to 2006/07, whilst the number of Masters qualifiers has increased by 35% over the same period, in line with a general expansion of Masters degrees in STEM and non-STEM subjects.

Table 10: First degree qualifiers at UK HEIs, excluding the Open University[(1)]

Subject of study	2002/3	2003/4	2004/5	2005/6	2006/7	Growth 2002/3 - 2006/7
Medicine and Dentistry	6,175	7,005	7,445	7,700	8,260	34%
Subject allied to medicine	23,665	24,705	27,865	29,775	30,460	29%
Biological Sciences	23,725	24,925	26,375	26,975	28,135	19%
Biology	4,430	4,480	4,580	4,445	4,670	5%
Sports Sciences	3,745	4,975	5,630	6,210	6,325	69%
Psychology (not solely as a social science)	8,900	9,680	10,615	11,345	11,655	31%
Veterinary Science	560	660	690	680	645	15%
Agriculture and related subjects	2,150	2,415	2,225	2,140	2,185	2%
Physical Sciences	12,475	11,980	12,200	12,530	12,270	-2%
Chemistry	2,955	2,735	2,705	2,520	2,665	-10%
Physics	2,205	2,180	2,225	2,345	2,255	2%
Forensic and Archaelogical Science	385	520	745	1,195	1,445	276%
Mathematical Sciences	5,100	5,150	4,990	5,260	5,385	6%
Computer Science	18,240	20,010	19,775	18,495	16,255	-11%
Engineering and Technology	19,455	19,585	19,340	19,535	19,495	0%
Engineering	17,520	17,560	17,300	17,345	17,120	-2%
Technology	1,940	2,030	2,040	2,190	2,380	23%
Architecture, Building and Planning	6,555	6,735	6,565	7,365	7,615	16%
TOTAL STEM	118,105	123,165	127,475	130,450	130,705	11%
TOTAL NON-STEM	156,340	161,825	169,540	175,460	179,960	15%
TOTAL	**274,445**	**284,990**	**297,015**	**305,910**	**310,665**	**13%**
% STEM	43%	43%	43%	43%	42%	

Source: Higher Education Statistics Agency (HESA) Student Record.

(1) Figures exclude those qualifying from the Open University due to inconsistencies in their method of recording subject of study over the time period.

Table 11: All domiciled Masters qualifiers at UK HEIs, excluding the Open University[1]

Subject of study	2002/3	2003/4	2004/5	2005/6	2006/7	Growth 2002/3 - 2006/7
Medicine and Dentistry	1,525	1,855	2,015	2,255	2,350	54%
Subject allied to medicine	3,215	3,910	4,095	4,430	4,930	53%
Biological Sciences	3,880	4,515	4,810	5,485	5,595	44%
Biology	580	545	640	760	750	29%
Sports Sciences	230	285	365	445	445	94%
Psychology (not solely as a social science)	1,990	2,305	2,370	2,855	2,780	40%
Veterinary Science	55	45	75	75	80	46%
Agriculture and related subjects	785	900	895	910	870	11%
Physical Sciences	2,765	3,310	3,370	3,510	3,540	28%
Chemistry	375	450	430	395	410	8%
Physics	290	305	335	335	340	17%
Forensic and Archaelogical Science	295	350	440	575	595	101%
Mathematical Sciences	760	975	1,265	1,120	1,200	58%
Computer Science	6,490	6,365	6,790	6,485	6,145	-5%
Engineering and Technology	6,270	7,635	8,960	9,375	9,215	47%
Engineering	5,435	6,835	8,145	8,555	8,430	55%
Technology	830	800	810	825	790	-5%
Architecture, Building and Planning	1,850	2,225	2,630	3,290	3,305	79%
TOTAL STEM	27,590	31,740	34,900	36,935	37,235	35%
TOTAL NON-STEM	52,930	61,610	65,885	69,270	71,375	35%
TOTAL	**80,520**	**93,350**	**100,790**	**106,200**	**108,610**	**35%**
% STEM	34%	34%	35%	35%	34%	

(1) Figures include dormants – in 2006/7 12% qualified from dormant modes of study. In addition to the figures here, there were 2,044 Master qualifiers at the OU in 2006/7.

The diversity of the UK's participants in higher education is illustrated in Table 12 and Table 13. Table 12 shows that nearly 60% of higher education students are female, with women well represented in subjects relating to medicine, biological and veterinary sciences, education and languages. Women are less well represented in the physical sciences, maths, computer science and engineering. Table 13 shows the number of first year higher education students by ethnicity from 2004/5 to 2006/7.

Table 12: Total UK Higher Education students by subject of study and gender

Female representation in Higher Education – % female *(Coverage: All HE students)*	2004/5	2005/6	2006/7
Total – All subject areas	59%	59%	59%
Medicine and Dentistry	58%	58%	58%
Subject allied to medicine	84%	83%	83%
Biological Sciences	64%	64%	64%
Veterinary Science	74%	74%	75%
Agriculture and related subjects	61%	59%	61%
Physical Sciences	41%	42%	42%
Mathematical Sciences	38%	37%	37%
Computer Science	24%	24%	22%
Engineering and Technology	14%	15%	15%
Architecture, Building and Planning	29%	29%	29%
Social Studies	63%	64%	64%
Law	61%	60%	60%
Business & administrative studies	50%	50%	50%
Mass communications & documentation	58%	57%	56%
Languages	69%	68%	68%
Historical & philosophical studies	56%	55%	55%
Creative Arts & Design	60%	60%	60%
Education	75%	75%	75%
Combined	61%	62%	61%

Source: Students in Higher Education Institutions, Higher Education Statistics Agency

Table 13: First year UK domiciled Higher Education Students by ethnicity

Coverage: All UK domiciled HE students in first year of study (undergraduate or postgraduate)	Total – Postgraduate			Total – Undergraduate		
	2004/5	2005/6	2006/7	2004/5	2005/6	2006/7
White	86.0%	84.9%	84.4%	83.9%	83.7%	83.4%
Total of ethnic minorities	14.0%	15.1%	15.6%	16.1%	16.3%	16.6%
Black or Black British – Caribbean	1.2%	1.2%	1.2%	1.6%	1.6%	1.6%
Black or Black British – African	2.5%	2.7%	3.0%	3.3%	3.4%	3.6%
Other Black background	0.3%	0.4%	0.4%	0.4%	0.4%	0.4%
Asian or Asian British – Indian	3.2%	3.6%	3.4%	3.2%	3.1%	3.2%
Asian or Asian British – Pakistani	1.5%	1.6%	1.7%	2.0%	1.9%	2.0%
Asian or Asian British – Bangladeshi	0.5%	0.5%	0.5%	0.7%	0.7%	0.7%
Chinese	1.2%	1.2%	1.2%	0.8%	0.8%	0.8%
Other Asian background	1.1%	1.2%	1.3%	1.3%	1.3%	1.3%
Other (including mixed)	2.5%	2.7%	2.9%	2.7%	3.0%	3.1%

Source: Students in Higher Education Institutions, Higher Education Statistics Agency

Researcher Careers

The UK is ranked second to Germany in the G7 in the number of PhD awards per head of population, and has maintained this position since the mid 1990s, though the gap with Germany has been narrowing. Table 14 gives the breakdown of doctorate qualifiers by individual subject. Overall, the total number of PhDs in STEM subjects has increased by 18% over the period 2002/03 to 2006/07, although growth is not uniform across subjects.

In 2006/07, of the 86,100 former postgraduate students (including both UK and EU domiciled students, and both full-time and part-time) whose destination was known, 77% (66,275) were in employment, the same as in 2005/06. 11% (9,150) were in a combination of work and study (10% in 2005/06), 6% (5,070) were involved in further study only (unchanged from 2005/06), and 3% (2,635) were assumed to be unemployed (unchanged from 2005/06). Section F2 provides more details on the occupations and destinations of former postgraduate students.

Table 14: Doctorate qualifiers at UK HEIs, excluding the Open University

Subject of study	2002/3	2003/4	2004/5	2005/6	2006/7	Growth 2002/3 - 2006/7
Medicine and Dentistry	1,362	1,532	1,563	1,747	1,730	27%
Subject allied to medicine	883	877	930	906	953	8%
Biological Sciences	2,348	2,378	2,468	2,472	2,596	11%
Biology	680	631	608	623	670	-1%
Sports Sciences	47	69	72	80	84	78%
Psychology (not solely as a social science)	774	728	797	826	894	15%
Veterinary Science	71	59	94	85	79	12%
Agriculture and related subjects	228	260	216	231	173	-24%
Physical Sciences	2,162	2,266	2,313	2,275	2,384	10%
Chemistry	993	1,033	1,019	965	1,038	5%
Physics	605	564	557	630	658	9%
Forensic and Archaelogical Science	39	46	52	41	49	25%
Mathematical Sciences	369	413	410	447	467	27%
Computer Science	372	464	544	709	714	92%
Engineering and Technology	2,003	2,031	2,003	2,189	2,385	19%
Engineering	1,733	1,797	1,800	1,951	2,137	23%
Technology	270	234	203	238	248	-8%
Architecture, Building and Planning	172	186	239	196	248	44%
TOTAL STEM	9,970	10,464	10,780	11,255	11,729	18%
TOTAL NON-STEM	4,785	4,679	4,860	5,129	5,678	19%
TOTAL	**14,755**	**15,144**	**15,640**	**16,385**	**17,407**	**18%**
% STEM	68%	69%	69%	69%	67%	

Source: Higher Education Statistics Agency (HESA) Student Record.

(1) Including dormants – in 2006/07 22% qualified from dormant modes of study. In addition to the figures here, there were 138 PhD qualifiers at the OU in 2006/07

The UK performs much less strongly in the number of researchers[28] as a proportion of the workforce, and is sixth in the G7.

Figure 20 shows there has been little change in the UK's performance over the last decade.

[14] The OECD defines researchers as 'professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems' and includes individuals within both the public and private sectors.

Figure 19: No. of PhDs per capita (per thousand population)

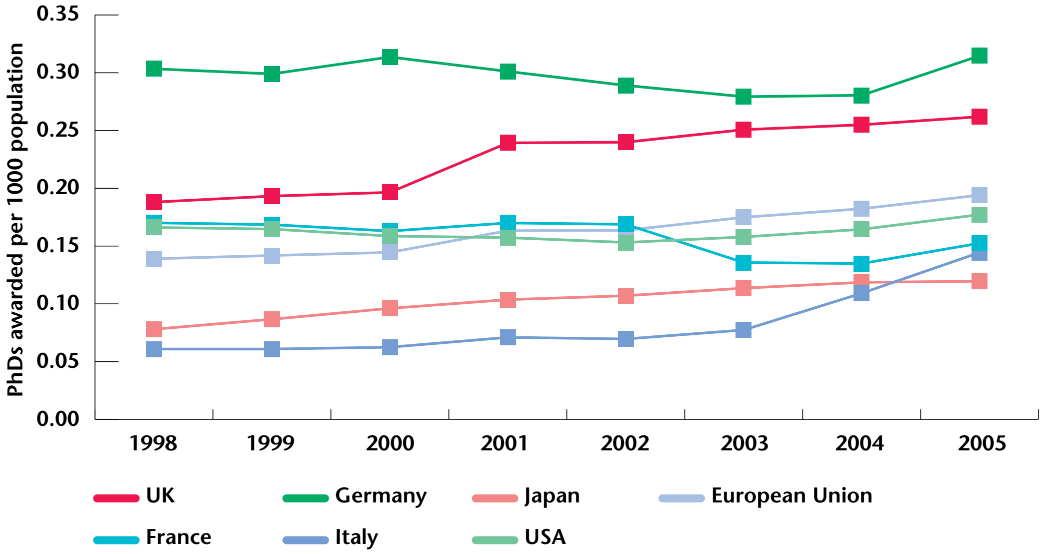
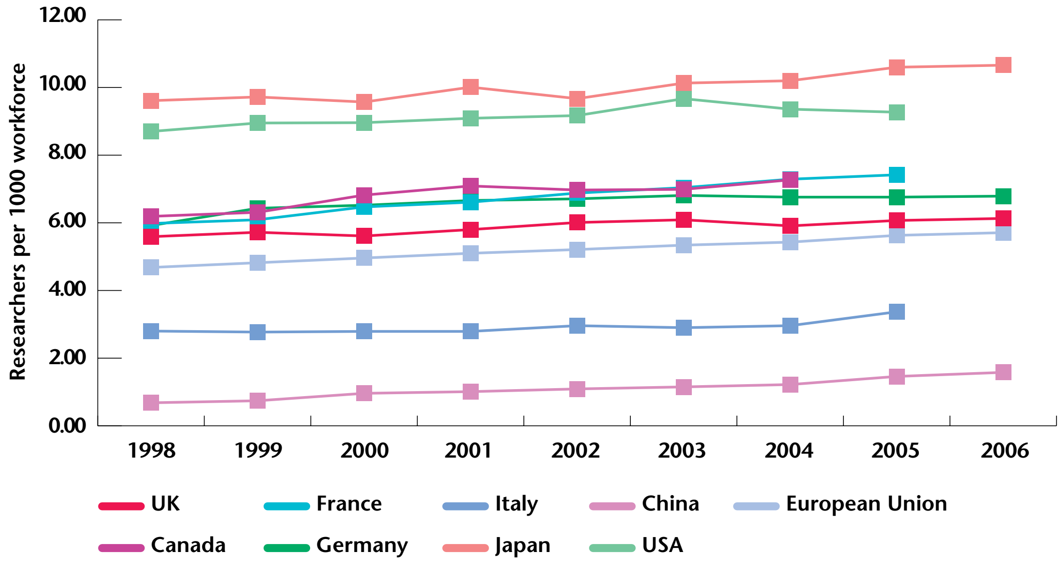


Figure 20: Researchers per thousand workforce (all sectors)



Source: International comparative performance of the UK research base, 2008. Note data is unavailable for some countries in 2006 for researchers per thousand workforce.

Research Councils support the current generation of researchers and foster future generations through the funding of fellowships. Table 15 illustrates the scale of support given:

Table 15: Research Council postgraduate funding

Research Council	Number of PhDs funded
AHRC	566 AHRC-funded PhDs were due for submission in 2007. Around 1,700 PhDs completed in the 2005/6 academic year were in arts and humanities, around 17% of all PhDs. This proportion has risen slightly since 2005.
BBSRC	BBSRC funds between 600-650 PhD students every year and is typically supporting around 2000 studentships at any one time.
ESRC	ESRC funds around 700-800 new PhD studentship awards per year, with 743 new awards in 2007. In total, 2962 studentships are currently supported.
EPSRC	EPSRC funds over 2000 new PhD students per year, with 2354 new awards in 2007/8. The total number of PhD students supported was over 8200 in 2007/8.
MRC	MRC funds over 400 new PhD students per year, with 427 starting in October 2007. In total there are estimated to be over 1400 active funded studentships.
NERC	NERC funds over 300 new PhD students per year, with 332 funded in 2007/8. The total number of PhDs funded was 969 in 2007/8.
STFC	STFC funds over 250 PhD studentships per year, with 272 funded in 2007/8. In total around 700 PhD students are supported.

Source: Research Council Economic Impact Reporting Frameworks

E. Framework conditions

This section covers a range of conditions affecting the science and innovation system and the system's ability to work together to generate economic impacts. These conditions are:

- The attractiveness of the UK to overseas investment;
- The intellectual property framework;
- Public engagement;
- Financial sustainability; and
- Standards.

E.1. Attractiveness of the UK to overseas investment

The UK has a relatively high share of total R&D funded from abroad of around 17% in 2006 (as shown by the most recent data from the Office for National Statistics), which suggests the UK is an attractive place for foreign owned firms to perform R&D. The proportion remains significantly above those of other G7 countries. In 2006, around 23% of R&D performed in the UK's business sector was funded from abroad.

Figure 21: Gross expenditure on R&D financed from abroad

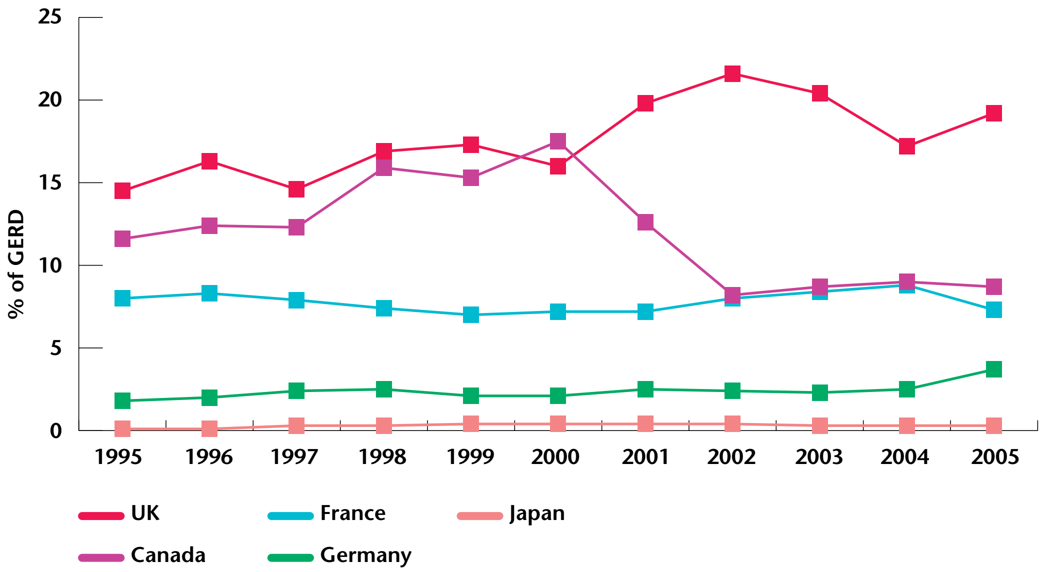
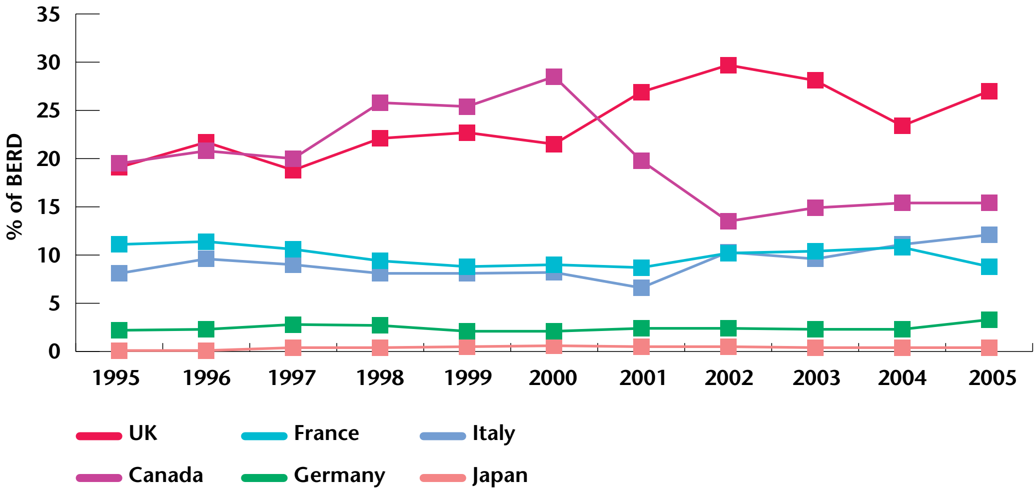


Figure 22: R&D performed in business enterprise sector, financed from abroad



Source: OECD Main Science and Technology Indicators. Data is not available for the US and Italy for Gross expenditure on R&D financed from abroad.

A survey of firms which invested in the UK in 2006-7[29] suggests that for many firms (68%), the reputation of the UK for research and innovation is not the most important factor when deciding where to locate. Indeed, only 14% of firms cited being close to important centres of knowledge or research as a primary aim of locating in the UK.

While the UK's research and innovation system may not be the main motivating factor for inward flows of investment, inward and outward flows of investment will enhance the UK's efficiency and ability to carry out research and innovation. A recent OECD paper[30] shows that international trade is playing an increasingly important role in stimulating innovation, with firms open to global competition tending to be better able to access the latest technological advances and thus be more profitable.

[29] UKTI (2008). 88 firms were surveyed.
[29] OECD (2008).

E.2. The intellectual property framework

The UK's performance on IP indicators (as set out in section B3) will be affected by the structure of the UK system and international arrangements. In the UK, intellectual property is administered by the UK Intellectual Property Office (UK-IPO, formerly the Patent Office). This body is responsible for award, registration and enforcement of IP in the UK, alongside policy formulation and responsibility for raising awareness of IP issues.

The Gowers Review of Intellectual Property (December 2006) examined all the elements of the UK's IP system, to ensure that it delivers incentives while minimising inefficiency. The Review concluded that the system was performing broadly satisfactorily, though made recommendations grouped around three main themes: stronger enforcement of rights, lower costs for business, and balanced and flexible rights.

The UK-IPO corporate plan published in the spring of 2008 sets out how this agenda is now being taken forward. An important element is to establish a fuller understanding of the economics of IP – how firms use IP, and the impact of the statutory framework. The UK-IPO has established an economics capability to take this work forward and an important contribution will come from the new Strategic Advisory Board on Intellectual Property (SABIP), which came into being in the summer of 2008.

The UK-IPO has been actively pursuing various IP awareness raising measures. The Office leads an "IP Awareness Campaign" in the business sector. This work will increasingly provide the evidence base to underpin the UK-IPO's work to support businesses to make the most of IP. That work is currently focused in particular on designing IP awareness measures capable of having a national impact, including training all UKTI export and RDA business advisors, developing an online version of the 'IP health check' for companies, and a major exhibition at the Science Museum in 2009.

E.3. Public engagement and science & innovation across government

Evidence on public attitudes to science

In 2008 Research Councils UK and DIUS published a national survey of public attitudes to science[31], the third in a series. Key findings from the survey include:

- Interest in science has increased since 2000. 82% agree they are "amazed by the achievements of science," up from 75% in 2000.
- Confidence in science has grown since 2005, with 25% expressing concern about science, down from 35% in 2005.
- The proportion of people who say they are very or fairly well informed about science and scientific developments has increased significantly since 2005, rising from 39% to 56% of adults.

The importance of public attitudes to science and engagement to social and economic well being is reflected in the Government's development of a new science and society strategy.

The latest data published by Research Councils, a selection of which is shown in Table 16, demonstrate the scope of their activities in engaging with the public, which include media and public events.

[31] Public attitudes to Science, 2008

Table 16: Research Council public engagement

Research Council	Indicators and data
AHRC	• AHRC awards ending in 2007/8 led to 344 performance-based or visual media outputs, including public performances and exhibitions. • A number of awards made in AHRC strategic programmes contain projects that promote collaborations with communities that are the subject of their research.
BBSRC	• BBSRC's public engagement activities cover a wide range, including undertaking consultations on topics such as biodiversity research and animal genomics, and public exhibitions and discussion meetings on stem cell science.
ESRC	• ESRC's 2008 Festival of Social Science was attended by around 9400 people, more than double the number in 2007. • 69% of attendees stated that the event had raised their general awareness of the social sciences, and 76% of attendees stated that the event had raised their awareness of ESRC and its work.
EPSRC	• EPSRC support a live radio show 'The Naked Scientists' which achieves a global weekly audience of around 1 million and over 50,000 pod cast downloads per week. • The number of internet articles covering EPSRC increased to 813 in 2007/8 from 632 in 2006/7.
MRC	• MRC launched its public panel in 2007/8, which involves calling on a network of individuals, from a variety of backgrounds, to provide a range of public views, experiences and expertise on aspects of MRC's work. • MRC and BBSRC are undertaking the largest project ever conducted in the UK on public attitudes towards stem cell research. The project is due to be completed in 2008.
NERC	• NERC and NERC's wider community organise a number of public events including open days, lectures and school activities. • The number of events organised by the NERC community continues to rise with over 3000 events 2007/8.
STFC	• STFC's public engagement activities include hosting school visits, interactions with overseas organisations and the activities of Science and Engineering Ambassadors. • In 2007/8 on-site events attracted 3041 school pupils and 4172 members of the public and off-site events reached 1472 school pupils and 233 members of the public.

Source: Research Council Economic Impact Reporting Frameworks

Science Reviews and Science and Innovation Strategies

The Science Review team has continued its rolling programme of authoritative and independent reviews of science in Government Departments. The Home Office/ Ministry of Justice review was published in December 2007 and the review of the Department of Health (DH) was published in October 2008. An independent review of the Science Review process has been carried out and the recommendations are being implemented to provide greater business value to departments while also improving review efficiency.

Almost all departments have Science & Innovation (S&I) Strategies (or their equivalent) in place. Three Agencies (HSE, FSA and the Environment Agency) and two of the Devolved Administrations (Welsh Assembly and Scottish Executive) have also produced S&I Strategies voluntarily. These strategies show how research programmes and other science related activities contribute to the delivery of departmental priorities and objectives and Public Service Agreement (PSA) targets.

E.4. Financial sustainability of research institutions

The ten year framework emphasised that in order to achieve continued levels of research activity and investment, research funding must be sustainable and universities and public laboratories should demonstrate robust financial management.

The financial sustainability of the UK University system is assessed biennially by the Funding Councils based on a set of 18 'trigger metrics' updated annually and consideration of university sustainability plans prepared every 2 years. The latest biennial assessment (July 2008)[32] concluded that in 2006/07 Higher Education Institutions (HEIs) over which there were concerns about long-term sustainability undertook only a small proportion (1.7%) of research.

The 2008 trigger metrics show an increase in universities overall operating surpluses and whilst the level of capital expenditure fell in 2006-07 the condition of buildings continues to show improvement for the UK as a whole.

The data for all UK higher education institutions for publicly and non-publicly funded research is given in Table 17.

[32] Report to the Research Base Funders Forum, 2008

Table 17: Transparency Review data 2006-07 for UK HEIs

	Publicly funded research £m	Non-publicly funded research £m
Income	4,499	1,447
Costs	5,728	2,184
Surplus/(deficit)	(1,229)	(737)
Surplus/(deficit) as % of income	(27)%	(51)%
Surplus/(deficit) as % of total income from publicly and non-publicly funded research	(6)%	(3)%

Source: HEFCE Circular Letter 14/2008 June 2008

At the end of 2007/8 around 40% of the total Research Councils grant portfolio was funded on the basis of 80% of full economic costs, and it will be 2010/11 before the whole portfolio is funded on this basis. Research Councils UK (RCUK) are currently undertaking a review of full economic costing in HEIs to see how the system is working in practice. The review is due to report early in 2009. In addition each Research Council publishes a number of indicators on financial sustainability, as part of reporting on their individual Economic Impact Reporting Frameworks.

A third monitoring exercise has been completed on the financial sustainability of Public Research Establishments (PSREs)[33]. This assessment helps PSREs and their sponsor departments to assess their long term sustainability. The third monitoring exercise showed overall, the major improvements made between round 1 and round 2 have been sustained and the PSREs continue to report progress on sustainability. However, the progress since round 2 has been more gradual, reflecting the fact that there are less difficult issues to address, and some of these represent long term problems.

[33] More detail on the monitoring exercise can be found at: http://www.berr.gov.uk/dius/science/science-funding/ripss/page22675.html

E.5. Standards

Effective standards are an important part of the context in which innovation is undertaken. The Department for Innovation, Universities and Skills (DIUS) provides funding and works closely with the British Standards Institution to support the development of standards and standards-making (in areas of public interest), and the United Kingdom Accreditation Service (UKAS). DIUS also manages the National Measurement System (NMS) on behalf of Government. The NMS provides the infrastructure through which measurements are traceable to international standards, and supports innovation in business by developing improved measurement techniques and instrumentation.

DTI commissioned research[34] has demonstrated the role of standards as a mode of innovation with an estimate of standards accounting for around 13% of productivity growth over the period since 1948.

[34] DTI Economics Paper No 12 (2005)

F. Knowledge exchange efficiency

This section reports on indicators that captures the effect of government policies aimed at strengthening linkages with the science and innovation system. Reporting covers two areas:

- Views from firms on the extent of networking for innovation that takes place;
- Information flows as reflected in indicators reported by Higher Education Institutions and Public Sector Research Establishments and movements of people between the research base and industry.

The importance of knowledge exchange was highlighted in the 2003 Lambert Review of Business-University Collaboration. Evidence of the effects of knowledge exchange includes:

- Analysis of the UK Innovation Survey 2005 shows that firms who tend to have higher effects of innovation on their range of goods and services, market share, quality of goods and services and value added, are more likely to have collaborated with universities;[35]
- A study of US firms showed that firms with links to 'star' (or well known) scientists exhibited superior performance.[36] Firms with more than 10 articles co-authored with a star scientist had notably better performance than those with no co-authored articles, with approximately 10 times as many patents, 6 times as many products in development and 3 times as many products on market. Benefits were also observed in the market value of listed biotechnology firms.[37]
- A study of Italian academics in the microelectronics industry found that the highest ranking academic centres in terms of scientific performance are those which include the professors most closely connected to industry and engaged in the most collaborations with industry.[38]

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[35] DTI Occasional paper no 6, 2006.

[36] Zucker et al (2001). These relationships were usually formal and exclusive, with the scientists either employed by the firms temporarily whilst on sabbatical from their university posts, or contractually linked to the firm in some other way, and often involved the granting of equity to the scientists.

[37] Darby et al. (1999) in their study of medium to large biotech firms with initial public offerings between 1980 and 1992 found that, ceteris parebis for a firm with average values for debt and commercialisation success the first linkage with a star scientist increased its market capitalisation by $15.73 million, or almost 8 per cent from the average of US$201 million. Additional linkages produced a further benefit to market capitalisation, although at a diminishing rate.

[38] Balconi & Laboranti (2006)

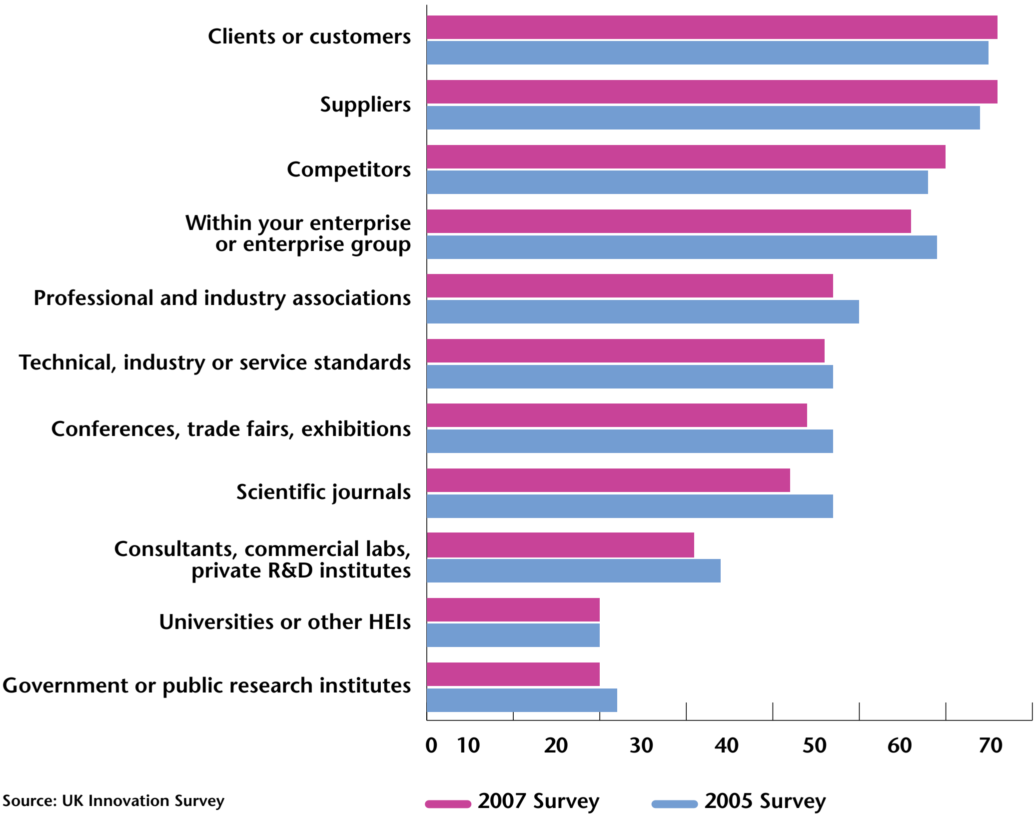
- Analysis of the Swedish Community Innovation Survey found research collaboration between universities and large manufacturing firms had a positive influence in terms of increased propensity to apply for patents and an increased share of sales related to innovative products.[39]

F.1. Networking for innovation

This section covers indicators drawn from the UK Innovation Survey and its European counterparts firms' views on the usefulness of knowledge exchange interactions. The Survey asks firms about the different sources of information used to support their innovation activities.

In the UK, around a fifth of enterprises rate universities or other Higher Education Institutions as a source of information of some importance. A similar proportion rate information from government or public research institutes of some importance although Figure 23 shows that this proportion fell between 2002-04 and 2004-06.

Figure 23: Sources of information for UK firms, all respondents rating information of some importance.



Source: UK Innovation Survey

[39] Broström & Loof (2006)

The proportion of innovation active firms who regard directly obtaining information from universities and public research institutes as being of "high" importance is fairly small in the UK at around 2-3%, but this is in line with other EU countries.[40]

Table 18: Importance of sources of information, 2005, % of innovation active firms considering source is of "high" importance

	Consultants, commercial labs or private R&D institutes	Universities or other higher education institutes	Government or public research institutes
United Kingdom	6%	3%	2%
Germany	3%	3%	1%
France	5%	2%	2%
Italy	11%	2%	1%
Finland	2%	5%	2%
Denmark	8%	3%	0%
The Netherlands	4%	3%	3%
Norway	6%	3%	3%

Source: Fourth Community Innovation Survey

F.2. Flows of information

This section covers key indicators reported by higher education institutions and public sector research establishments on their interactions with business and other users. The Higher Education Business-Community Interaction Survey gathers data from Higher Education Institutions (HEIs) on the nature and scale of exchanges[41].

[40] However Swann (2005) suggests there is evidence that other important sources of business information may depend on the publicly funded research base.

[41] For more information see http://www.hefce.ac.uk/econsoc/buscom/hebci/

Table 19 shows positive trends in knowledge transfer activities reported by HEIs. Income from business for UK HEIs has risen to over a billion pounds in 2006-07[42]. UK HEIs have experienced growth in the number of licenses and licensing income from business which has exceeded that in the US over the last few years.

Table 19: Key knowledge transfer indicators for UK HEIs

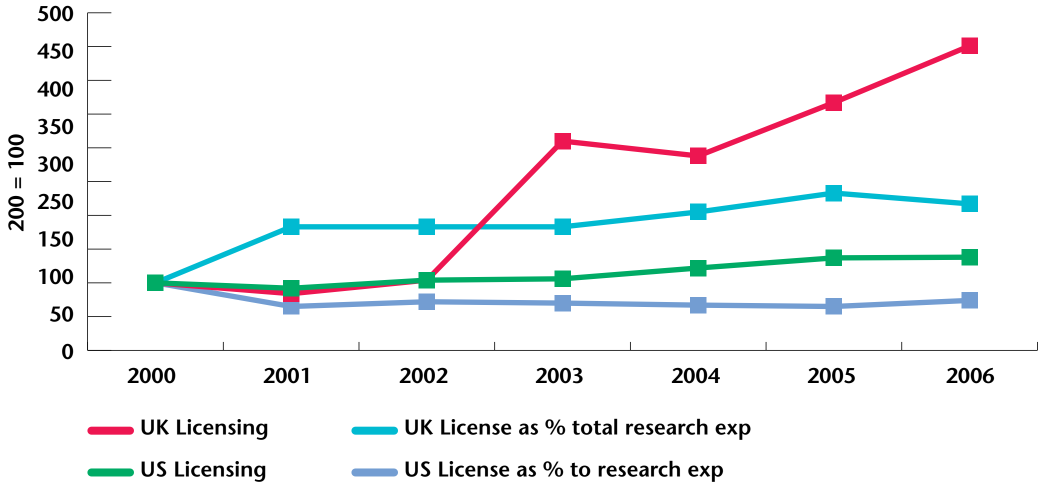
Indicator	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Number of new patent applications filed by Higher Education Institutes (HEIs)	896	967	1,222	1,308	1,648	1,536	1,913
Number of Patents granted	250	199	377	463	711	579	647
Number of licensing agreements	728	615	759	2154	2,099	2,707	3286
Income from licensing intellectual property (£ million)	18	47	37	38	57	58	58
Number of spin-outs	248	213	197	161	148	187	236
Income from business (value of consultancy contracts) (£ million)	104	122	168	211	219	242	288
Income from business (contract research and consultancy contracts £million) *	362	450	457	788	836	893	1070

Source: Higher Education Business-Community Interaction Survey. The numbers in the table above reflect the latest Survey published on July 2008.

*** 2000-2003 Income from business data does not include contract research with non-commercial organisations**

[42] This measure covers HEI income from contract research and from consultancy work. We report this measure for consistency with previous Economic Impacts of Investment in Research and Innovation reports. Using a much wider definition, the HE-BCI survey reports total HEI income has increased from £2,267 million in 2005-06 to £2,641 million in 2006-07, an increase of 17 per cent.

Figure 24: Relative changes in US and UK indicators of licensing from HEIs



Source: HE BCI & AUTM U.S. Licensing Activity Survey

Public Sector Research Establishments (PSREs) also transfer knowledge through research collaboration and contract research on behalf of industry, licensing of technology to business users, and sales of services, data and software. Key PSRE indicators are given in Table 20.

Table 20: Key knowledge transfer indicators for UK PSREs

Aggregate (All PSREs responding to each survey, 135 establishments in the fourth survey)	2003-04	2004-05	2005-06	2006-07
Business representatives on governing bodies	175	214	247	207
FTE staff employed in commercialisation offices	385	368	513	669
Number of patent applications	316	335	290	316
Number of patents granted	228	148	193	172
Number of licensing agreements	621	1,673	1,604	604
Income from IP licensing	£33m	£46m	£186m	£116m
Number of spin-outs	69	84	74	101
Income from business (consultancy)	£36m	£31m	£26m	£43m

Comparable (PSREs responding to all four surveys, 92 PSREs)	2003-04	2004-05	2005-06	2006-07
Business representatives on governing bodies	128	128	130	101
FTE staff employed in commercialisation offices	233	231	226	193
Number of patent applications	257	235	229	203
Number of patents granted	212	111	169	144
Number of licensing agreements	454	135	169	254
Income from IP licensing	£30m	£33m	£158m	£93m
Number of spin-outs	55	53	61	58
Income from business (consultancy)	£19.3m	£3.5m	£7.5m	£1.5m

Source: Annual Survey of knowledge transfer activities in the public sector research establishments

The data show positive trends in many indicators, although some of the individual indicators can be quite volatile from year to year. This tends to be due to large one-off changes in a very small number of institutions (e.g. a single very large commercial transaction).

Research Council Institutes and Facilities

Within the Research Council system the Research Council Institutes and Facilities play an important role in the exploitation and commercialisation of research. Because of the different sectors in which each Council operates, different models of IP ownership and management are applied by different Councils, but selected indicators of the overall contributions made by the Institutes and Facilities to the exploitation of research results are set out below. Further details for each Council are available in their individual Economic Impact Reporting Framework documents.

Table 21: Research Council Institutes and Facilities: Exploitation Metrics, 2007-08[1]

	BBSRC	MRC	NERC	STFC
Number of patents granted[2]	10	15	0	2
Income from licensed intellectual property (£M)	0.7	74	4.7	0.1
Number of spin-outs set up	5	1	2	1

1 Financial year
2 Figures for BBSRC include plant breeder's rights

A further important mechanism by which knowledge is exchanged between the research base and industry is through the movements of people. The Higher Education Statistics Agency survey of destinations of leavers from Higher Education covers the movements from those leaving higher education from both part-time and full-time programmes. Table 22 shows the range of sectors that postgraduates are employed in.

Table 22: Total UK domiciled leavers who obtained postgraduate qualifications and entered employment, 2006/07

	N=68,520	
Employment by standard industrial classification:	Number	% of total
Property development, renting, business & research activities	9,730	14.2%
Public administration & defence; social security	6,565	9.6%
Education	29,620	43.2%
Health & social work	10,785	15.7%
Other community, social & personal service activities	2,965	4.3%
Manufacturing	2,835	4.1%
Financial activities	1,860	2.7%
Wholesale & retail trade; repair of motor vehicles, motorcycles & personal & household goods	1,395	2.0%
Electricity, gas & water supply	340	0.5%
Construction	585	0.9%
Hotels & restaurants	385	0.6%
Transport, storage & communication	860	1.3%
Agriculture & forestry	110	0.2%
Mining & quarrying	265	0.4%
Private households with employed persons	30	0.0%
International organisations & bodies	115	0.2%
Fishing	0	0.0%
Not known	70	0.1%

Source: Destinations of leavers from higher education, Higher Education Statistics Agency

Research Councils have identified within the survey a sample of PhD students who have received Research Council funding and their destinations. Table 23 illustrates the proportions of students who enter each sector:

Table 23: First destination of Research Council funded PhD students

	Higher education	Government and public sector	Industry & Commerce	Not employed	Other
AHRC students completing in 2005/6	48	9	10	7	26
BBSRC students completing in 2005/6	37	11	34	6	12
ESRC students completing in 2005/6	51	27 (business or public services)		6	16
EPSRC students completing in 2005/6	33	49 (business or public services)		8	10
MRC students starting in 2003	68	-	14	7	11
NERC students completing in 2005/6	28	12	34	7	19
STFC students completing in 2005/6:					
PPARC	38	6	20	10	26
STFC	38	8	23	4	26

Source: Research Council Economic Impact Reporting Frameworks

G. Demand for innovation

In order for the science and innovation system to deliver economic impact, there must be sufficient demand for innovative goods and services. The private and public sectors must have the capacity to adopt and adapt outputs of the research base and develop innovation outputs. This section reports indicators which capture aspects of the demand for innovation, and firms' and the Government's innovative capacity.

G.1 Demand-side measures

The demand for new products and services by consumers and users is a significant factor motivating a firm's innovation activities and investment in innovation. If existing products do not meet the needs of users, they will adapt and modify existing products, which may result in firms adopting and taking forward these modifications[43]. Therefore innovations may not always emerge from formal R&D activities undertaken by industry. Users are increasingly playing an active role in the development of new or improved products and services[44]. Data from the 2007 UK Innovation Survey show that clients or customers are an importance source of information to over a third of firms, and perceived importance increased from the previous survey.

Table 24: Clients as sources of information, percentage of firms responding to both 2005 and 2007 surveys

	2002-2004	2004-2006	Importance up	Importance down	Importance unchanged
Clients or customers	31%	35%	29%	26%	45%

Source: UK Innovation Survey

The UK Innovation Survey also asks firms that are not innovation active why they do not engage in innovation. One factor respondents are asked to report on is the degree to which "uncertain demand for innovative goods or service" plays a role in constraining innovation. Table 25 shows the responses to this particular question. The percentage of firms who report uncertain demand as a high or medium degree constraint to innovation has fallen from 27% in 2002-04 to 20% in 2004-06, whilst over 60% of respondents to the latest survey do not regard this factor as an important constraint on their innovation.

[43] Von Hippel (2008)

[44] NESTA (2008)

Table 25: Importance of "Uncertain demand for innovative goods or service" as a factor constraining innovation, percentage of all respondents

Degree of importance	2002-2004	2004-2006
Not important	52	62
Low	21	18
Medium	19	14
High	8	6

Source: UK Innovation Survey

In creating a market environment conducive to innovation, a number of factors have been identified as being significant[45]. These include providing a regulatory environment favourable to innovation and using public procurement to drive demand for innovative goods. DIUS and the Better Regulation Executive in the Department for Business, Enterprise and Regulatory Reform (BERR) will work with the Business Council for Britain and others to identify how regulation may promote or hinder innovation. Public sector procurement was £158 billion in 2006/7, and each Government Department will include an Innovation Procurement Plan as part of its commercial strategy, to be in place by April 2009.

G.2 Business capacity

To meet the demand for new products and services, a firm needs the ability to exploit external knowledge. In addition to their own R&D investments, firms are increasingly drawing on knowledge generated by not only their own R&D investments, but knowledge generated by other firms and universities, both domestically and internationally.[46]

A number of key characteristics of a firm will affect its ability to develop new research ideas and to carry out innovative activities, including whether staff have the range of skills and capabilities needed, and whether staff can sufficiently access information on new technology.

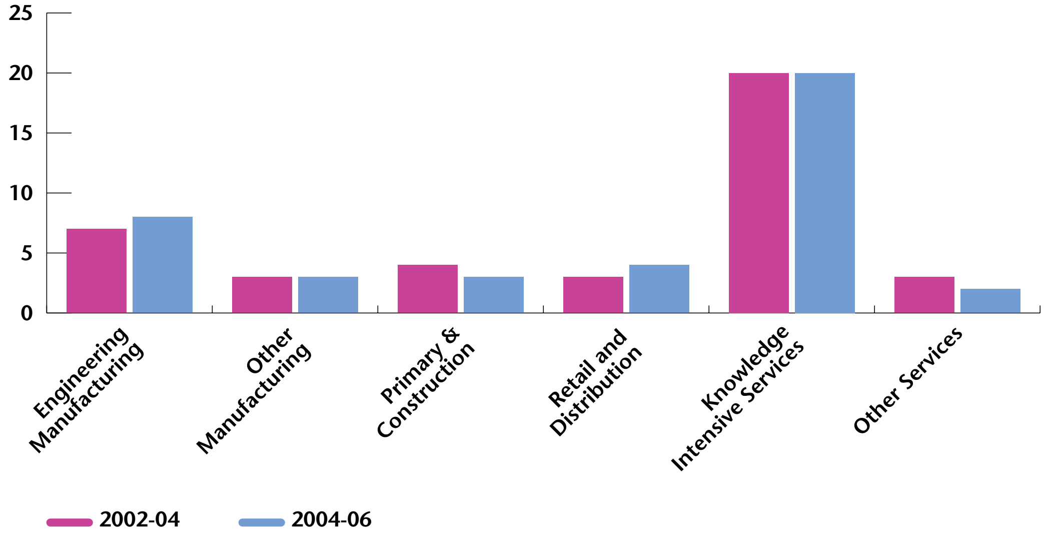
In the UK for 2004-2006, around 11% of firms reported the lack of information on technology as a factor of medium to high importance constraining innovation. Around 22% of firms regard the lack of qualified personnel as a factor of medium to high importance in constraining innovation.

[45] Georghiou (2006)

[46] Chesbrough (2003)

As evidence of one aspect of employee requirements, Figure 25 shows for UK firms the share of employees with degree level qualifications in science and engineering and other disciplines. Knowledge-intensive services had the highest proportion of employees with graduate level qualifications in science and engineering. The proportion of employees educated to degree level in science and engineering subjects has remained relatively unchanged between the two sampling periods.

Figure 25: Average percentage of employees educated to degree level in Science & Engineering subjects, all respondents



Source: UK Innovation Survey

Cost and market factors will also affect a firm's ability to innovate. In the UK, around 25% of firms report the cost of finance as a factor of medium to high importance constraining innovation, and 20% the availability of finance. Around 20% of firms report the market being dominated by established enterprises as a constraining factor of medium to high importance.

Table 26: Constraints faced, in 2004-2006, percentage of all respondents

Factor / Degree of Importance	Not experienced	Low Importance	Medium importance	High importance
Excessive perceived economic risks	63	14	15	9
Direct innovation costs too high	62	12	15	11
Cost of finance	59	16	15	10
Availability of finance	62	19	12	8
Market dominated by established enterprises	62	18	13	6

Source: UK Innovation Survey

Data Sources

Allocations of the Science Budget, December 2007
http://www.dius.gov.uk/publications/sciencebudget.html

Annual Survey of knowledge transfer activities in the public sector research establishments http://www.berr.gov.uk/dius/science/knowledge-transfer/psre/page12062.html

Destinations of leavers from higher education, Higher Education Statistics Agency
http://www.hesa.ac.uk/index.php/content/view/112/154/

Fourth Community Innovation Survey, including UK Innovation Survey
http://www.berr.gov.uk/dius/innovation/innovation-statistics/cis/page10957.html

GCE/VCE A/AS and Equivalent Examination Results in England, 2006/07 (Revised) http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000769/SFR02-2008-corrected.pdf

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http://www.hefce.ac.uk/reachout/hebci/

Higher Education Funding Council for England Circular letter number 14/2008 http://www.hefce.ac.uk/pubs/circlets/2008/cl14_08/

Higher Education Statistics Agency Student Record http://www.hesa.ac.uk/index.php?option=com_studrec&Itemid=232&mnl=07051

OECD Main Science and Technology Indicators Database
http://www.oecd.org/document/26/0,3343,en_2649_34451_1901082_1_1_1_1,00.html

OECD Productivity database http://www.oecd.org/topicstatsportal/0,3398,en_2825_30453906_1_1_1_1_1,00.html

Office for Harmonization in the Internal Market
http://oami.europa.eu/en/office/stats.htm

Office for National Statistics http://www.statistics.gov.uk/

Public attitudes to Science 2008 http://www.rcuk.ac.uk/sis/pas.htm

Research Council Economic Impact Reporting Frameworks
http://www.rcuk.ac.uk/aboutrcuk/eirf

International comparative performance of the UK research base 2008 http://www.dius.gov.uk/publications/IntComparativePerformanceUKResearch.pdf

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