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OECD Economic Surveys: United Kingdom


*Chapter 7*

# Raising innovation performance

*A wide range of indicators suggests that UK innovation performance has been mediocre in international comparison. An improvement is often viewed as one important means of closing the productivity gap with the best performing countries. This chapter assesses the appropriate policy response in the context of the government's ten-year plan to boost innovation performance. There are reasons to be optimistic given favourable framework conditions, a strong science base and recent changes in innovation policy. At the same time success should not be judged solely against conventional indicators, which often poorly reflect innovation in certain sectors such as knowledge-intensive services, in which the United Kingdom has shown considerable strength.*

## UK innovation performance: is it really mediocre?

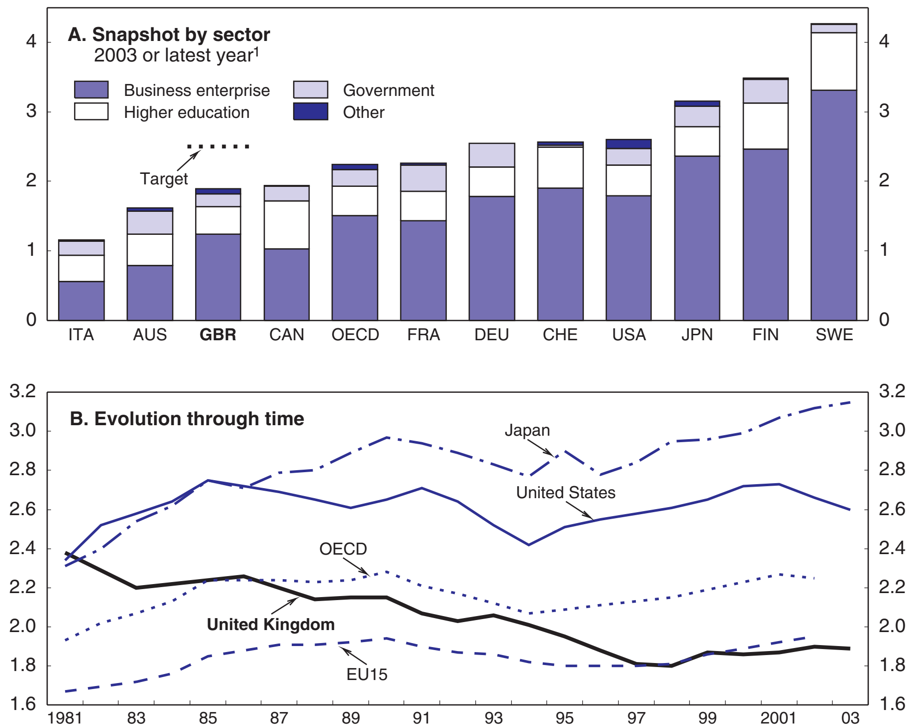
### *Traditional measures of innovation imply a disappointing performance*

Innovation – the successful commercial development and application of new knowledge – involves a number of different stages from research and discovery through development, patenting and commercial implementation. A range of indicators is available for each stage of the innovation process and there is a high correlation in the ranking of countries across these indicators (OECD, 2005a). According to many of these measures the United Kingdom is close to the OECD average, but often ranks poorly among the G7.

The current level of research and development (R&D) intensity (R&D as a percentage of GDP) ranks sixth among the G7 (Figure 7.1, Panel A), despite having ranked second (to Germany) at the beginning of the 1980s. The Government has recently published a 10-year plan for science and innovation (discussed below) which includes a target to raise R&D intensity from the current level of 1.9% to 2.5% of GDP by 2014. While it appears more credible than those set by many other OECD countries,[1] it is an ambitious target which

Figure 7.1. **R&D intensity**

Gross domestic expenditure on R&D in per cent of GDP




1. 2002 for Australia, France, Italy and EU15; 2001 for Sweden and 2000 for Switzerland.

*Source:* OECD (2005), *Main Science and Technology Indicators*, Vol. 1.

would require the reversal of a trend decline: the UK is the only OECD country for which R&D intensity fell over both the 1980s and 1990s (Figure 7.1, Panel B). Moreover, although R&D intensity has broadly stabilised since the mid-1990s, in many other OECD countries it has picked-up since then. The UK's low country ranking also holds for R&D performed in the business sector, which is usually identified as being the most effective in raising growth performance.[2] R&D intensity outside the business sector is also relatively low, although this is due to low R&D intensity performed in the government sector whereas that performed in the higher education sector is on a par with most other G7 countries.

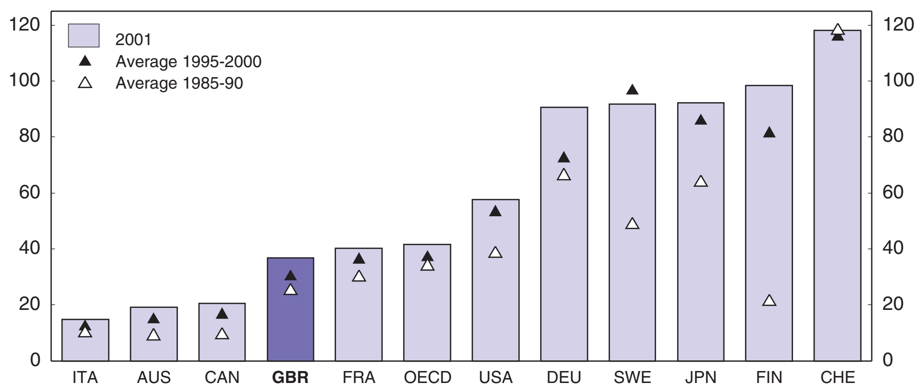
The number of researchers employed is an important input into the innovation process. Despite a relatively strong academic science base the share of researchers in total employment is relatively low and employers regularly report shortages, particularly in engineering jobs.[3] A different problem concerns the low general skill level of the labour force which may limit the benefits from the adoption of new technologies.

Patent-based indicators provide one measure of R&D output, although individual patents can differ considerably in their usefulness and hence value. Survey evidence generally suggests that UK firms do not place great emphasis on formal methods of intellectual property rights (IPR), preferring informal methods because they are more cost effective. The number of triadic patents per capita is well below that in the United States, Japan, and Germany. This measure of the propensity to patent has barely increased, again in contrast with the experience of most other OECD countries (Figure 7.2). If, however, the number of triadic patents is normalised on business R&D spending, then UK spending appears relatively efficient, ranking close to the United States and well ahead of Japan and Germany (OECD, 2005a).

Alternative measures of innovation outputs are provided by survey evidence, although such indicators are more subjective as judgement regarding innovations is left to the performer. The European Community Innovation Survey (CIS) provides data collected at firm-level, although many of the more detailed survey responses are not available for the United Kingdom on a comparable basis with other countries.[4] According to the latest survey the United Kingdom had one of the lowest shares of successful innovative firms

Figure 7.2. **Patent indicators**

Triadic patent families, per million population[1]




1. According to the residence of the inventors and by priority year (the year of the first international filing of a patent). 2001 figures are estimates. Triadic patent families are defined as patents filed at the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japanese Patent Office (JPO).

*Source:* OECD (2005), *Main Science and Technology Indicators*, Vol. 1.

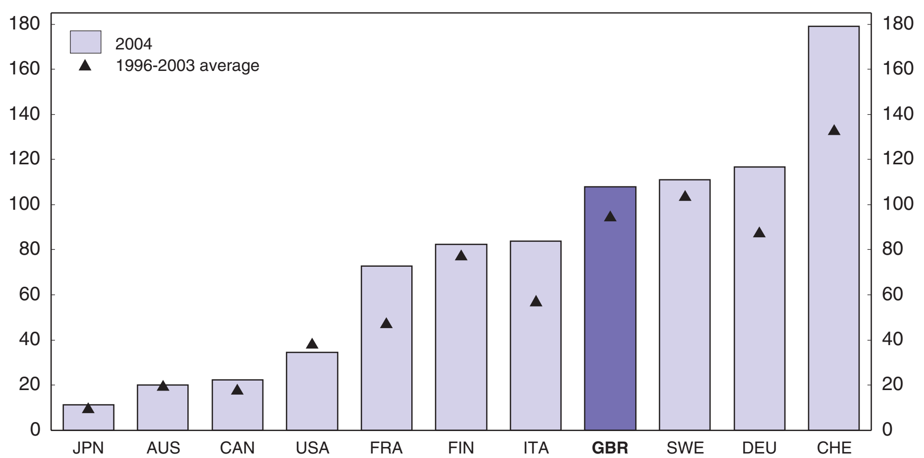
over the period 1998-2000, around 20%, less than half the proportion in Germany. For product innovations, a further distinction can be made between imitations and true innovations, depending on whether the innovation is new to the market or just the firm. On this basis the United Kingdom has the lowest proportion of firms that are true product innovators of any of the 16 countries surveyed, about 10% compared with 28% in the country (Finland) with the highest proportion.

### *... but this may understate the extent of innovation, particularly in services*

While performance judged by many traditional innovation indicators appears poor, "softer" indicators suggest a stronger performance, particularly in the service sector. For example, although according to the CIS the proportion of firms applying for a patent is among the lowest in the European Union, the proportion of firms using some form of protection (whether through a patent, trademark, design registration, copyright, secrecy, complexity or lead-time) for their innovation is the highest in the European Union (OECD, 2005a). Moreover, recent trademark trends, which may be a better measure of non-technical innovation, show a much stronger increase than patents, with applications in the United Kingdom expanding seven-fold between 1993 and 2000 (Greenhalgh *et al.,* 2003). Applications for European Community trade marks on a per capita basis since the mid-1990s are among the highest in the G7 (Figure 7.3). The widespread use of these other forms of protection, as well as strength in many of the creative industries, may help to explain why the UK balance-of-payments surplus on international technology transfers is among the highest in the OECD relative to GDP (0.6% of GDP in 2000).[5, 6]

Traditional measures of innovation may thus understate aggregate performance. The service sector is very heterogeneous. As well as being important users of new technology, certain services are carriers of new technology (consultancies and training services) while others are integral producers of new technology (computer, software and telecommunications services). The United Kingdom has experienced rapid growth in many knowledge-intensive services (Chapter 1) where the scope for innovation is greater than in other services. Even in retailing there have been many innovations in the way shops are

Figure 7.3. **European Community trademark applications**
Per million population




*Source:* Office for Harmonization in the Internal Market, OHMI Statistics.

built, organised and run, but these have mainly involved changes in design (the move to bigger store), in processes (supply chain management) or the introduction of information and communication technology (ICT) (for stock control). Their application has, however, not required large R&D investments as conventionally measured.[7] Other examples are the "creative industries" or "cultural services", areas of comparative strength both in terms of employment and export performance (Box 7.1), where commercial exploitation of new ideas is an integral part of the activity, but is not well reflected in conventional measures of innovation.

Box 7.1. **The creative industries**

The creative industries are usually considered to include advertising, architecture, fashion, leisure software, film and video, radio and TV, music and the performing arts, and publishing. In 2002 they accounted for:

- 8% of gross value added, having grown 6% per annum between 1997 and 2002, double the rate for the whole economy. The size of this sector is similar in relation to GDP in the United States, but much larger than in other OECD countries. It is, for example, more than three times the EU average.
- 4¼ per cent of all exports of goods and services, having grown 11% per annum over the period 1997-2002 (compared with 3% for all goods and services). They contributed £11.5 billion (1% of GDP) to the trade balance in 2002.
- 1.9 million jobs (nearly 7% of total employment), comprising 1.1 million in the creative industries and an estimated 0.8 million creative jobs in companies outside the creative industries. Employment grew by 3% per annum over the period 1997-2002, three times faster than the whole economy.

*Source:* Department for Culture, Media and Sport (2004), "Creative Industries Economic Estimates", *Statistical Bulletin*, August 2004, *www.culture.gov.uk/*. UNESCO (2000), "International Flows of Selected Cultural Goods 1980-98", *www.uis.unesco.org/*.

***… and there is further scope to exploit the strong science base***

On a range of measures the science base is among the strongest in the world. In 1999 the United Kingdom accounted for nearly 9% of all OECD scientific publications, only exceeded by Japan and the United States (OECD, 2003). A 2004 survey of bibliometric data shows that the UK publishes over 12% of all cited scientific papers and almost 13% of papers with the highest impact (DTI, 2004). On a per capita basis scientific publications are the highest among the G7 and only exceeded by a few smaller countries where both R&D intensity and the employment share of researchers are also the highest in the OECD (Finland, Sweden and Switzerland). The growing importance of industry-science relationships (OECD, 2002b), at the expense of corporate R&D laboratories suggests this is a strength that can be increasingly exploited in the future and all the more so given the increasing mobility of multinational firms and the relative attractiveness of the United Kingdom to foreign direct investment.

## Do composition effects explain why R&D performance has been weak?

The current weak R&D intensity could be due to particular characteristics of the economy, such as the industrial mix, rather than representing evidence of weakness that needs to be addressed by policy. The decline in total R&D intensity over the 1980s to the mid-1990s can be more than accounted for by the decline in government performed R&D and government funding of business R&D (Table 7.1). This ties in with the decline in government budget outlays for defence R&D, which was much steeper than for any other G7 country. Since the mid-1990s total R&D intensity has fallen somewhat, mainly due to a further fall in Government performed R&D. R&D performed in the business sector (BERD) intensity has remained fairly stable since then. There has been a slight further decline in government and industry funding mostly compensated by increased funding from abroad, with the latter currently financing over one-quarter of BERD, a much higher share than in any other G7 country. Nevertheless, the stability in BERD intensity contrasts with developments in most other OECD countries, where there has been a distinct pick-up in BERD intensity since the mid-1990s.

Table 7.1. **R&D intensity by performing sector and by funding**

In per cent of GDP

| | 1981 | 1990 | 1995 | 2003 | Change | | |
|---|---|---|---|---|---|---|---|
| | | | | | 1981-90 | 1990-95 | 1995-2003 |
| **By performing sector** | | | | | | | |
| Business (BERD) | 1.50 | 1.49 | 1.27 | 1.24 | –0.01 | –0.22 | –0.03 |
| Higher education (HERD) | 0.32 | 0.34 | 0.38 | 0.40 | 0.02 | 0.04 | 0.02 |
| Government (GOVERD) | 0.49 | 0.28 | 0.28 | 0.18 | –0.21 | 0.00 | –0.10 |
| Total | 2.38 | 2.15 | 1.95 | 1.89 | –0.23 | –0.20 | –0.06 |
| **By source of funding** | | | | | | | |
| BERD financed by: | | | | | | | |
| Industry | 0.92 | 1.01 | 0.89 | 0.78 | 0.09 | –0.12 | –0.11 |
| Government | 0.45 | 0.25 | 0.13 | 0.14 | –0.20 | –0.12 | 0.00 |
| Abroad | 0.13 | 0.23 | 0.24 | 0.32 | 0.10 | 0.01 | 0.08 |
| HERD financed by: | | | | | | | |
| Industry | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 |
| Government | 0.31 | 0.31 | 0.36 | 0.38 | 0.00 | 0.04 | 0.02 |
| GOVERD financed by: | | | | | | | |
| Industry | 0.05 | 0.03 | 0.02 | 0.02 | –0.02 | –0.01 | 0.00 |
| Government | 0.44 | 0.25 | 0.26 | 0.16 | –0.19 | 0.01 | –0.10 |
| *Memorandum item* | | | | | | | |
| Defence budget R&D | 0.62 | 0.39 | 0.29 | 0.24 | –0.23 | –0.10 | –0.04 |

*Source:* OECD (2005), *Main Science and Technology Indicators*, Vol. 1.

A comparison of the industrial composition across countries can shed light on why BERD intensity is relatively low. R&D intensity is typically highest in manufacturing industries that incorporate a high degree of technology. The share of high technology manufactures (including pharmaceuticals and office, computer and communications equipment)[8] in gross value added is not far behind Japan and the United States and ahead of the other G7 countries (Figure 7.4). However, it is the next rung down the technology ladder the United Kingdom is poorly represented, namely in medium-high-technology manufactures (including electrical machinery, motor vehicles and other transport equipment).

For a more detailed industrial analysis the business sector is disaggregated into 11 manufacturing industries where R&D intensities are typically high, plus utilities (electricity, gas and water combined), all services combined, and a residual "other" sector.



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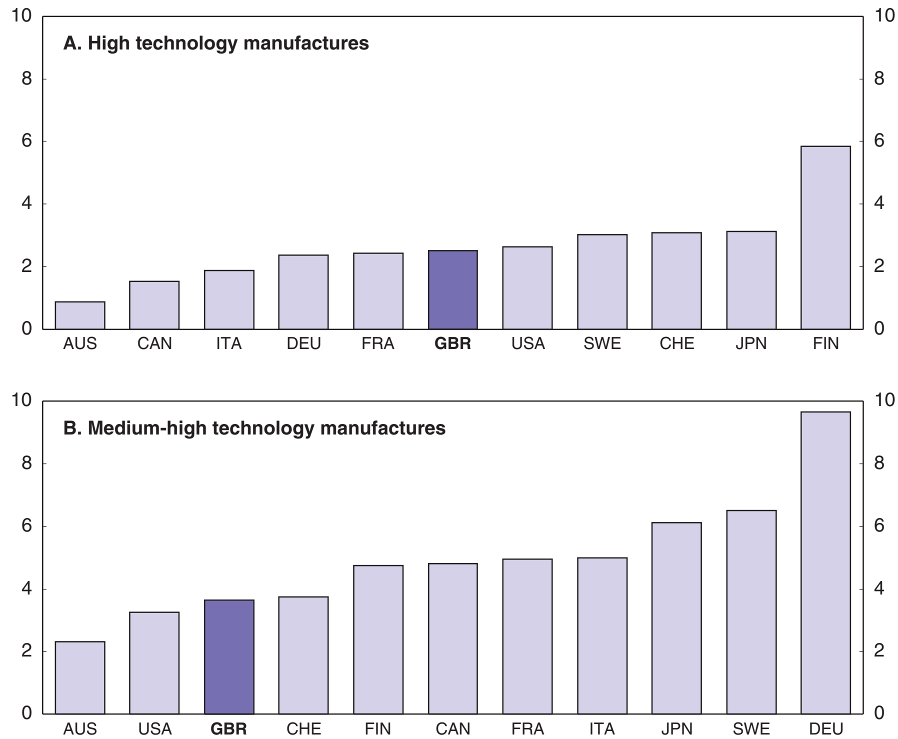
Figure 7.4. **Technology intensive industries**

Per cent of total gross value added, 2002[1]




1. 1999 for Australia; 2001 for Canada.

*Source:* OECD calculations based on the STAN database, July 2005.

The current BERD intensity gap with a comparator country can then be explained by a combination of higher/lower "within-industry" R&D intensities and/or because the industrial composition is more skewed towards industries where R&D intensity is higher/lower. The relative importance of within-industry and mix effects in explaining the R&D intensity gap differs between countries (Table 7.2, with disaggregated details in Turner and Lundsgaard, 2005):[9]

- Between 60% and 80% of the gap with Japan, Germany and France is explained by industry mix effects. Alternative analyses confined just to the manufacturing sector tend to find smaller industry mix effects, but are less pertinent to the issue of explaining differences in measures of R&D intensity commonly used in the policy debate.
- About half of the gap with Finland, but only one-quarter of the gap with Sweden, can be explained by industry mix effects. The larger size of the communications equipment industry in Finland (which includes mobile phone market leader Nokia) accounts for fully 1.0% point of the gap.
- Industry mix effects do not help to explain any of the gap with the United States, although this comparison is subject to much greater uncertainty because of different methods of data collection.[10]

Table 7.2. **The industrial structure and cross-country differences in R&D intensity**
Relative to the United Kingdom, percentage points, 2002[1]

| | France | Germany | United States | Japan | Finland | Sweden |
|---|---|---|---|---|---|---|
| **R&D intensity gap** | **0.20** | **0.53** | **0.63** | **0.88** | **1.36** | **2.08** |
| Due to "within industry intensity" | 0.04 | 0.14 | 0.68 | 0.35 | 0.61 | 1.51 |
| Due to "industry mix" | 0.16 | 0.39 | –0.05 | 0.53 | 0.75 | 0.57 |
| **% of R&D intensity gap accounted for by:** | | | | | | |
| Within industry effect | 20 | 27 | 107 | 39 | 45 | 73 |
| Industry mix effect | 80 | 73 | –7 | 61 | 55 | 27 |

1. 2000 for Sweden and 2001 for the United States.

*Source:* OECD calculations based on the STAN and ANBERD databases, July 2005.

The most important differences in (within) industry R&D intensities are as follows:

- The only industry in which the United Kingdom has a consistently higher level of R&D intensity is pharmaceuticals. Pharmaceuticals alone account for about one-quarter of all UK BERD.
- There is a longer list of manufacturing industries in which R&D intensity is consistently lower, particularly the communications equipment industry, motor vehicles, computing machinery and instruments.
- The services sector R&D intensity reduces the aggregate gap with France, Germany and Japan, but by less than 0.1 percentage point. However, R&D intensity is higher in services in Finland, Sweden and the United States. Indeed, nearly all of the gap in R&D intensity with the United States can apparently be explained by higher within-industry intensity of services. However, in this case, differences in data collection methods matter.

### *Policy implications*

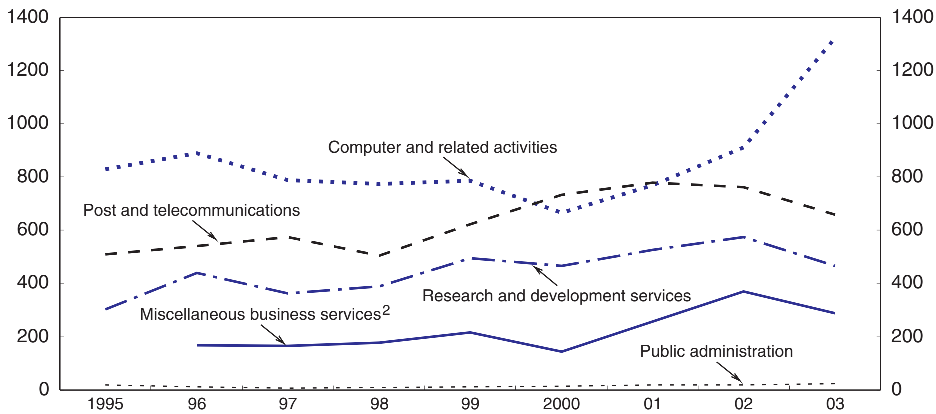
The finding that much of the R&D intensity gap with Germany, France and Japan can be explained by industry mix effects, suggests caution in targeting a similar level of R&D intensity. This is because on other criteria the industrial composition, notably the strong performance of the services sector, has contributed positively to the overall strong macroeconomic performance. Further caution is warranted by the fact that the list of manufacturing industries where R&D intensity is low include many of those – such as motor vehicles, information technology (IT) and electronics – where UK-owned firms have struggled to compete in the past, but output has been kept up by high levels of foreign inward investment. As multinational firms tend to have a home bias in carrying out R&D it is unsurprising that within-industry R&D intensities in these key sectors are often relatively low. Griffith *et al.* (2004) show that across a majority of sectors UK-owned multinationals have a significantly higher R&D intensity than foreign-owned multinationals based in the United Kingdom. However, the same foreign-owned multinationals have at least as high an R&D intensity as, and in many sectors significantly higher than, UK domestic firms (which are not multinationals). Thus, the relative attractiveness of the United Kingdom to inward investment has probably boosted R&D relative to a counter-factual in which the alternative would have been greater production by domestic firms.

One particularly striking example is that almost all the aggregate R&D intensity gap with Germany can be explained by differences in the motor vehicle industry. Although there is considerable car production in the United Kingdom, all the main volume car manufacturers are overseas-based multinationals, with much of the R&D performed in the home country. Consequently R&D intensity in the UK car manufacturing industry is low, although the industry is quite successful with seven out of ten vehicles built being exported. Public policy attempts to promote a "national champion" in the motor vehicle industry during the 1960s and 1970s were woefully unsuccessful (Pryke, 1981 and Owen, 2000) and in the light of this experience few would advocate a more active sector-specific industrial policy which attempted to imitate success in Germany. On the contrary, the evidence suggests that the adoption of more sector-neutral policies from the early 1980s has been an important factor in improving the UK's subsequent macroeconomic performance (Owen, 2000).

On the other hand, in comparison with the United States industry mix effects are small and much of the deficit in R&D intensity is apparently in the services sector where the United Kingdom would seem to have considerable strengths. The comparison with the United States would seem all the more appropriate given that it is the most obvious role model among the G7 in terms of providing evidence that higher R&D spending since the mid-1990s has played a part in raising aggregate productivity growth. It is, however, frustrating that issues of data comparability make it difficult to be sure how much of the difference is genuinely due to the service sector or whether (if genuinely comparable data were available) within-industry differences would be more widespread. Even allowing for problems in data comparability, it does, however, seem likely that some of the difference is accounted for by greater R&D undertaken in the service sector in the United States. Curiously, while service sector R&D intensity rose in all six comparator countries between the mid-1990s and 2001, there was no such rise in the United Kingdom. More recent UK data, however, suggest much stronger growth, with most of the growth concentrated in computer services which now account for nearly half of all R&D in the services sector (Figure 7.5). Nevertheless, these comparisons do raise the issue as to whether more could be done to promote R&D in the service sector.

Figure 7.5. **Real R&D expenditure in services**[1]

£ million, 2003 prices




1. No R&D is performed in two service sectors: wholesale and retail trade, transport and storage.
2. Includes technical testing and analysis.

*Source:* ONS (2005), *Research and Development in UK Businesses*, 2003.

## What should policy do about innovation?

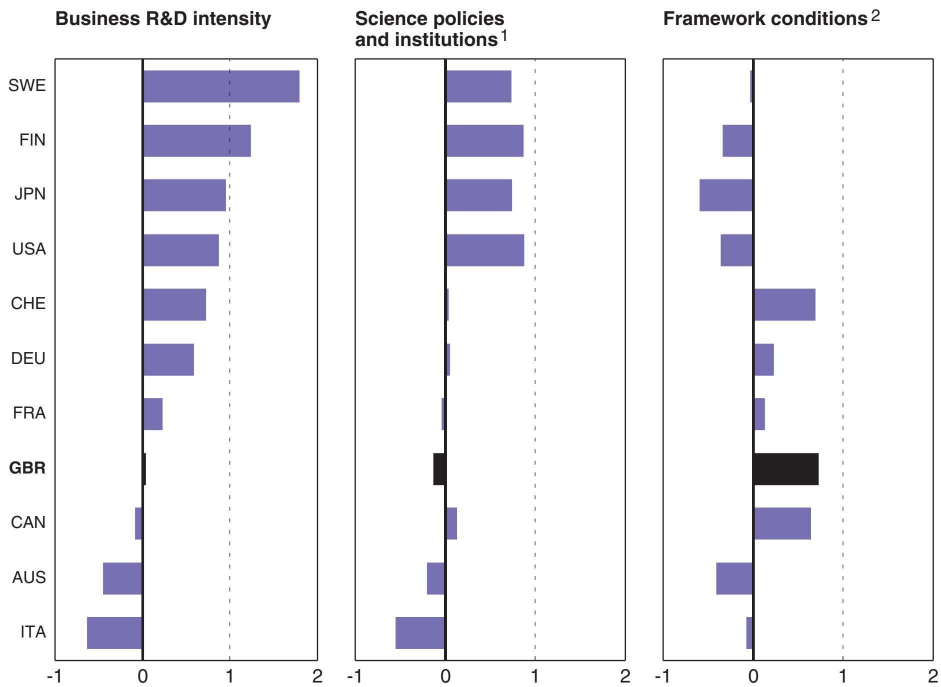
A wide range of policies potentially influence innovation, both those affecting framework conditions as well as policies specifically directed towards promoting science and innovation. These are considered below, in the context of recent OECD empirical work (OECD, 2005a) to explain business R&D, distinguishing the role of these policies in explaining changes in BERD intensity and in explaining differences in BERD intensity relative to the OECD average.

### *Framework conditions*

The OECD *Growth Study* found that framework conditions and policy settings are important for growth and more recent OECD empirical work (OECD, 2005a) also finds that they are important for innovation. Thus factors such as strong output growth, low inflation, well developed financial markets, pro-competitive regulations in labour and product markets and openness to trade all tend to have a positive impact on various stages of innovation. In particular, overall framework conditions in the United Kingdom are estimated to be among the most supportive for R&D in the OECD (Figure 7.6). However, while *changes* in framework conditions are estimated to have had a positive effect on BERD intensity over the 1990s, in most other OECD countries there was an even larger positive

Figure 7.6. **The role of science policies and framework conditions in explaining BERD intensity across countries**

Percentage point deviation of R&D intensity relative to OECD average, 2000




1. Science policies include R&D tax incentives, subsidies for private R&D, business funding of non-business R&D, non-business R&D intensity, intellectual property rights, the share of scientists in total dependent employment and absorptive capacity (capacity to understand and make use of foreign knowledge).
2. Framework conditions include financial factors, real interest rates, real exchange rates, foreign exposure (foreign R&D stock and openness), import penetration and product market regulation.

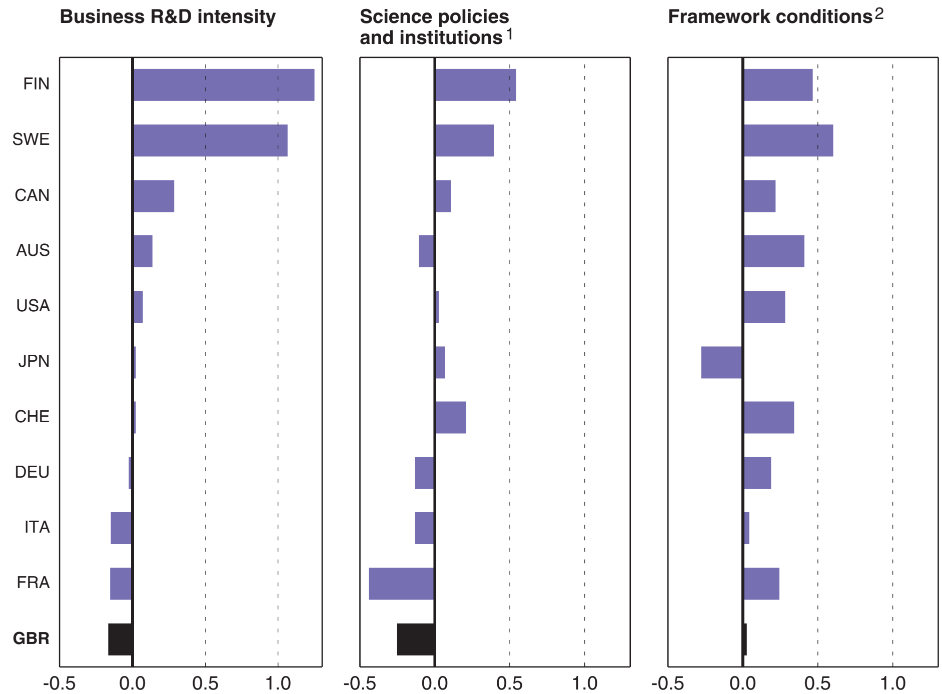
*Source:* OECD (2005), "Innovation Policies: Innovation in the Business sector", *Economics Department Working Papers*, OECD, Paris, forthcoming.

effect (Figure 7.7). Particular strengths which are identified as being supportive of BERD intensity are:

- *Financial factors*: The availability of internal and external finance boosts innovation outlays, with improved corporate profitability and higher stock market capitalisation both having a positive effect on R&D spending. Stock market capitalisation is found to have a positive effect on patenting in addition to the effects it has through R&D suggesting that equity-based financial systems such as that in the United Kingdom may provide more favourable conditions for firms seeking to raise external finance for innovation. When all financial factors are combined, the United Kingdom and Switzerland are found to have the most favourable financing conditions across the OECD, although many countries have begun to catch up over the course of the 1990s.
- *Product market and labour market regulations*: Although the theoretical links are ambiguous, empirical work finds that less stringent product market regulation helps to raise R&D intensity, while reduced employment protection mainly boosts patenting. With the United Kingdom having among the most flexible product market regulations in the OECD this factor helps to boost R&D intensity by 10% above the OECD average. On the other hand, improvements of a similar, or in many cases greater, degree were made in

Figure 7.7. **The role of science policies and framework conditions in changing BERD intensity**

Percentage point deviation of R&D intensity between 1991 and 2000




1. Science policies include R&D tax incentives, subsidies for private R&D, business funding of non-business R&D, non-business R&D intensity, intellectual property rights and absorptive capacity (capacity to understand and make use of foreign knowledge).
2. Framework conditions include financial factors, real interest rates, real exchange rates, foreign exposure (foreign R&D stock and openness), import penetration, product market regulation, employment protection legislation, human capital and the domestic economy-wide average wage.

*Source:* OECD (2005), "Innovation Policies: Innovation in the Business sector", *Economics Department Working Papers*, OECD, Paris, forthcoming.

other countries. Thus, while the United Kingdom remains at the frontier in terms of the flexibility of product market regulation, many countries have closed the gap over the course of the 1990s and the implied boost to BERD intensity was smaller for the United Kingdom.

The empirical work also suggests that other changes in framework and general economic conditions might explain why other countries had a stronger R&D performance over the 1990s, including:

- Exposure, measured by trade openness corrected for the size of the country, to the stock of foreign knowledge (as proxied by the stock of foreign R&D) improved less in the United Kingdom than in some other countries, especially the United States, Canada, Australia and Switzerland.
- The fall in real long-term interest rates over the 1990s has boosted BERD intensity across virtually all OECD countries, but real long-term interest rates fell by less than in many other countries.
- The appreciation of the real exchange rate over the second half of the 1990s is estimated to have reduced BERD intensity by 0.1 to 0.2 percentage point. Becker and Pain (2003) find an even stronger effect.[11] Various explanations for this effect are possible. It may be because foreign-owned multinational firms that use the United Kingdom as an export base postpone R&D expenditure when the exchange rate is high or may even relocate such spending if it remains high. Alternatively it may be because the real exchange rate is picking up pressures on corporate profitability, disproportionately affecting R&D intensive manufacturing firms.

The general finding that the United Kingdom is close to best practice in terms of favourable framework conditions, suggests that the emphasis for policy reform to promote innovation lies elsewhere, although there is no doubt further room for improvement. The specific policy implications of the finding that the appreciation of the exchange rate had a negative, and possibly large, effect on BERD intensity over the second half of the 1990s are less clear. It is difficult to score this as a "policy failure", partly because of the difficulty of permanently influencing the exchange rate. Moreover, the higher level of sterling had wider macroeconomic benefits through raising the terms of trade and consumption possibilities and containing inflationary pressures.

### *Specific policies to promote science and innovation*

There are many reasons for public policy intervention to support innovation by correcting "market failures" that would lead to a less than socially desirable level of innovation. In particular, the ability of competitors to benefit from new knowledge means that the social rate of return to new knowledge is likely to exceed the private return. In addition imperfections in financial markets, a lack of skilled researchers or a lack of information or even awareness about research advances in other sectors and countries could lead to a lower level of innovation. At the same time such interventions may not always be successful and could even have a negative impact on innovation if not carefully designed. For example, fiscal measures to raise innovation may have significant deadweight costs and need to be financed.

OECD empirical work based on OECD indicators up to 2000, measuring policies to stimulate R&D and technology based innovation, suggested that there was scope to improve the existing policy environment for R&D in the United Kingdom (Figure 7.6).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Moreover, changes in these policies are estimated to have had a negative effect on BERD intensity over the 1990s, whereas in some other OECD countries, notably the United States, Japan, Finland and Sweden there was a substantial positive effect (Figure 7.7). The results would imply that the major weakness is capacity to absorb knowledge, represented in the empirical work by the product of the stock of foreign R&D and the proportion of researchers in employment. In particular, the proportion of researchers in employment is much lower than in the United States or Japan, as well as the stronger performing smaller countries such as Finland and Sweden. It is also a main factor explaining both the absolute and relative decline in BERD intensity over the 1990s, because the United Kingdom is one of the few countries to have experienced a decline in the share of researchers in employment over this period. However, it is difficult to be sure of the direction of causality in these studies, as discussed further below.

Other factors which help to explain the UK's relatively weak R&D performance are:

- Non-business R&D intensity is relatively low and fell slightly over the 1990s, although the only G7 country for which non-business R&D intensity rose significantly over this period was Japan.
- The empirical work confirms a positive effect of tax incentives on R&D, but these were only introduced in 2000, and given the time lags involved may only now beginning to have an effect. A number of OECD countries introduced R&D tax credits much earlier, which may have boosted their BERD over the 1990s.

Overall, the estimated negative impact of science and innovation policies compared with the large positive impact in some of the other OECD economies suggests that there may have been potential for improving these policies. But it should also be recognised that there has been a shift in government polices since the late 1990s, for example through the introduction of R&D tax incentives in 2000, the publication of a review of science, engineering and technology skills in 2002, and the publication of an Innovation Report and a review of business-university collaboration in 2003. These developments culminated in the government's ten-year Science and Innovation Investment Framework in July 2004 (Box 7.2). This set out a comprehensive set of policies to improve the sustainability of the public science base; stimulate increased business investment in R&D; create incentives for knowledge transfer and university-business collaboration; improve the teaching and learning of science and engineering subjects at all levels; and achieve greater public engagement with science. The Government committed over £1 billion in additional funding for the public science base between 2005-08 to help achieve these objectives, ensuring that the UK science budget will have increased by more than half in real terms between 1997 and 2008, to £3.4 billion (0.29% of GDP). The range of science and innovation policies considered below includes: fiscal measures to promote R&D; polices to promote partnerships between business and tertiary education; and finally policies to promote a fluid labour market for researchers and scientists.

### *Fiscal measures to promote R&D*

Fiscal incentives can take the form of direct funding of private sector R&D or tax incentives to encourage R&D. The former may be more appropriate where particularly high social, as opposed to private, rates of return are suspected, for example for research in defence, space, health and the environment. They may also be more appropriate for young firms that have little taxable income or face borrowing constraints. Tax incentives are

### Box 7.2. **Objectives of the Science and Innovation Framework, 2004-14**

**Increase business investment in R&D and business engagement in drawing on the UK science base for ideas and talent**

- Increase business investment in R&D as a share of GDP from 1¼ per cent towards 1.7% over the decade.
- Narrow the gap in business R&D intensity and business innovation performance between the UK and leading EU and US performance in each sector, reflecting the size distribution of companies in the United Kingdom.

**A strong supply of scientists, engineers and technologists by achieving a step change in**

- The quality of science teachers and lecturers in every school, college and university, ensuring national targets for teachers' training are met.
- The results for students studying science at GCSE level (to age 16).
- The numbers choosing Science, Engineering and Technology (SET) subjects in post-16 education and in higher education.
- The proportion of better qualified students pursuing R&D careers.
- The proportion of minority ethnic and women participants in higher education.

**World class research at the United Kingdom's strongest centres of excellence**

- Maintain overall ranking as second to the United States on research excellence, and current lead against the rest of the OECD; close gap with leading two nations where current performance is third or lower; and maintain UK lead in productivity.
- Retain and build sufficient world class centres of research excellence and leading universities, to support growth in its share of internationally mobile R&D investment and highly skilled people.

**Raise responsiveness of the publicly-funded research base to the needs of the economy and public services**

- Research Councils' programmes to be more strongly influenced by and delivered in partnership with end users of research.
- Continue to improve performance in knowledge transfer and commercialisation from universities and public laboratoires towards world leading benchmarks.

**Sustainable and financially robust universities and public laboratories**

- Ensure sustainability in research funding accompanied by robust financial management by universities and public laboratories to achieve sustainable levels of research activity and investment.

**Confidence and increased awareness across UK society in scientific research and its innovative applications**

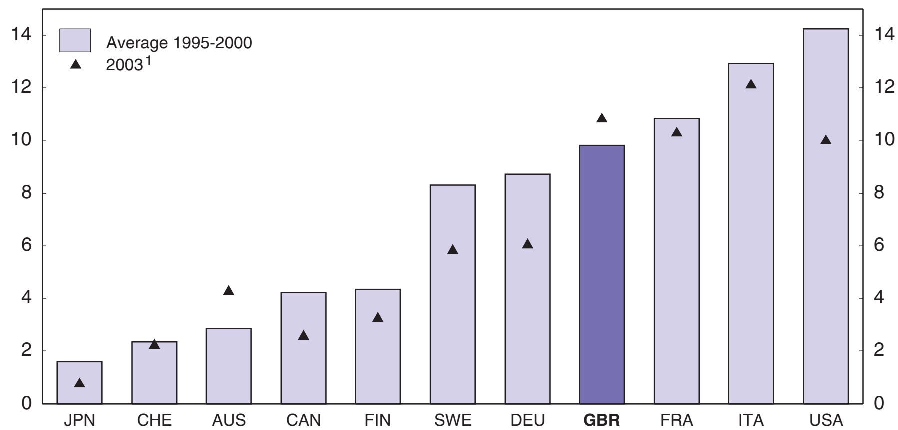
- Demonstrate improvement against a variety of measures, such as trends in public attitudes, public confidence, media coverage, and responsiveness to public concerns by policy-makers and scientists.

Each of these objectives is supported by a range of indicators. Progress will be assessed annually, with a more comprehensive assessment every two years. The first annual assessment was published in July 2005 (HM Treasury *et al.*, 2005).

likely to broaden the range of market-driven research activities and may be less susceptible to capture, but may also increase the risk of duplication. There has been a marked decline in the proportion of direct funding of BERD across most OECD countries, driven both by declining spending on defence R&D and the needs for fiscal consolidation. This change has been particularly marked in the United Kingdom, with this proportion falling from 30% in the early 1980s to around 10% since the late 1990s (Figure 7.8). At the same time there has been a greater shift towards the use of tax incentives across OECD countries, again mirrored in the United Kingdom where they were introduced in 2000.

Figure 7.8. **Government funding of BERD**

Per cent of total




1. 2000 for Switzerland; 2002 for Australia, France and Italy.

*Source:* OECD (2005), *Main Science and Technology Indicators*, Vol. 1.

The evidence reviewed in OECD (2005a) suggests there is little consensus regarding the effectiveness of direct funding and specific subsidies for private R&D. In the United Kingdom there are a number of schemes providing subsidies to encourage innovation (Box 7.3). In some cases this may mean that there are a number of schemes with a similar rationale in terms of addressing the same underlying market failure, although a range of interventions were judged necessary to meet the needs of different target audiences and to provide different types of support (grants, expert staff, information). According to the *Lambert review* many businesses found that while individual government schemes to promote knowledge transfer were welcome the number of different schemes often caused confusion. This may, however, reflect a transition period when the number of programmes was being rationalised to the set listed in Box 7.3. Nevertheless, the portfolio of schemes should be kept under periodic review.

A feature of government-financed support for BERD is that it is more than proportionately benefits larger firms, which is a different pattern from the highest R&D performing smaller countries (Figure 7.9). As some of the rationales for intervention (such as informational failures) are probably more acute for SMEs, this raises questions for policy design.[12] The Government recently announced a mandatory target for Government departments and agencies to place 2.5% of their extra-mural R&D contracts with SMEs under the Small Business Research Initiative (SBRI), to provide enhanced support for SME innovation.

### Box 7.3. **Schemes providing direct funding for R&D**

The Department for Trade and Industry (DTI) administers or is responsible for a number of programmes to promote *Knowledge Transfer and Innovation* amounting to £350 million in fiscal year 2005/06 (0.03% of GDP). One-quarter of this total is accounted for by remaining commitments to schemes which have been closed to new entrants. The most important elements of the current portfolio of support to businesses and researchers include:

*Higher Education Innovation Fund* (£91 million, rising to £110 million by 2007/08) supports the commercialisation of university research and fosters industry-academia collaboration.

*Public Sector Research Exploitation Fund* (£8 million) to stimulate knowledge transfer from the public sector research establishment base.

*Technology Strategy* (£38 million, rising to £178 million by 2007/08) guided by an independent board with strong business representation aims to identify emerging technologies in which there is research capacity and potential to exploit. It is mainly implemented through two schemes:

- *Collaborative R&D* supports research collaborations between firms and universities. Evaluation evidence from the previous LINK programme found evidence that participation raised business turnover, implying a benefit-to-cost ratio of between 1.1 and 3.8 to 1 (Annex F of DTI, 2003).
- *Knowledge Transfer Networks* (building on the previous *Faraday Partnerships* scheme) provide grants to set up networks to promote the flow of people, technology and innovative business concepts between the science base and industry.

*Knowledge Transfer Partnerships* (£19 million) support graduates to work on innovative projects in firms, with staff from the company and the research partner jointly supervising the graduate.

*Grant for Research and Development* (£27 million) (building on the previous SMART/SPUR scheme) provides funding towards the costs of R&D projects in small and medium-sized enterprises (SMEs), and is one of the few grant schemes not requiring collaboration in order to qualify. The rationale for the scheme is that SMEs would otherwise find it difficult to raise relatively small sums due to the cost of due diligence. Evaluation evidence suggests that each £1 million programme expenditure increased turnover by £2.4 million and exports by £1.3 million (Annex F of DTI, 2003).

*National Measurement System* (£75 million) responsible for funding measurement research and its dissemination to users.

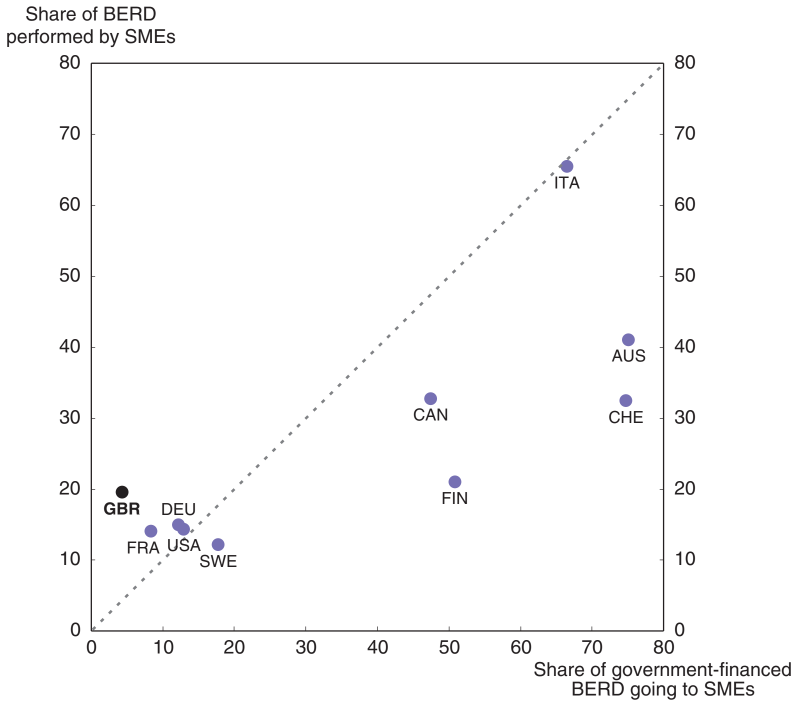
*Space* (£33 million) mainly contributes to the European Space Agency.

The cost of any individual scheme, listed above, is relatively small either in relation to the estimated support through R&D tax credits of £720 million (0.06% of GDP) or support for the science base, which is mainly in the form of funding science in higher education channelled through the Research Councils, of over £3 billion (0.24% of GDP).

**R&D tax incentives.** R&D tax incentives have only been introduced in 2000 for SMEs and extended to larger firms in 2002. The tax incentives operate on a volume rather than incremental basis (*i.e.* all R&D is eligible, rather than just new R&D relative to some baseline period), which has the advantage of being simpler to operate and more transparent for firms, although it inevitably means that there is a large deadweight loss from R&D outlays that would have been undertaken anyway but are also subsidised. Using one measure of the generosity of R&D tax incentives across countries, the B-index, the

Figure 7.9. **Government R&D funding is concentrated on larger firms**

Per cent, 2002[1]



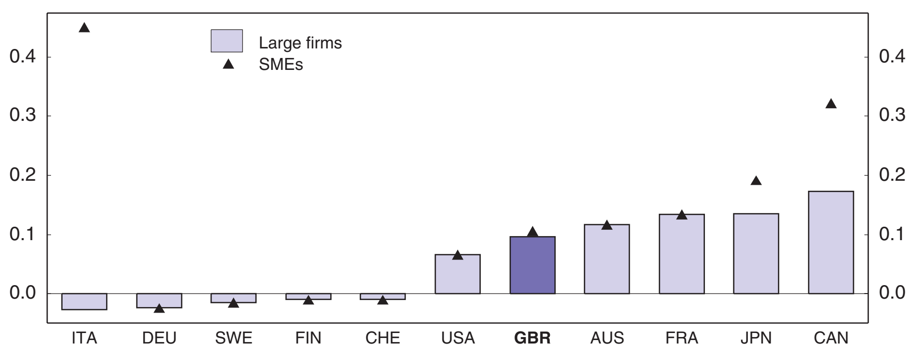

1. 2003 for Finland, Sweden and the United Kingdom; 2000 for Italy and Switzerland; 1999 for Germany.

*Source:* OECD (2005), *Science, Technology and Industry Scoreboard.*

level of tax incentives for the R&D performed by large firms is at the median among the G7 countries. There are some smaller OECD countries where the tax incentives for large firms are between two and four times more generous (Figure 7.10), although the B-index does not fully reflect the restrictive features of some other countries' schemes that potentially limit relief for large firms. The level of support for SMEs is similar to that

Figure 7.10. **Tax treatment of R&D**

Rate of tax subsidies for $1 of R&D, 2004[1]




1. Tax subsidies are calculated as 1 minus the B-index. The B-index for Australia was adjusted to show the correct weights of the volume-based 125% tax concession and the 175% incremental tax concession for R&D. The B-index in Japan covers only large firms with a ratio of R&D to sales of less than 10% (the B-index is 0.831 for those with a R&D-to-sales ratio above 10% and 0.782 for research conducted in collaboration with universities).

*Source:* OECD (2004), *OECD Science, Technology and Industry Outlook.*

provided for larger firms in the United Kingdom, but an important difference is that for SMEs the tax credit has a repayable aspect so that SMEs making losses can claim a cash payment equal to 24% of eligible R&D spending.

Bloom *et al.* (2002) find robust cross-country evidence that tax incentives are effective in increasing R&D intensity. They estimate a long-run elasticity with respect to the user cost of about unity, implying that a 10% fall in the user cost raises R&D by 10% in the long run. Recent OECD empirical work (OECD, 2005a) tends to confirm this estimate, although it is an upper bound and sensitive to what other factors are controlled for. This would imply that the recent introduction of tax credits might be expected to eventually raise R&D intensity by up to 0.13 percentage point, equivalent to about one-quarter of the increase required to hit the government's R&D target. There are, however, likely to be long lags: the median lag is about five years according to Bloom *et al.* (2002) and eight to nine years according to the OECD study.[13] These lags may be even longer because the tax incentives have been introduced for the first time.

So far the take-up of R&D tax credits is impressive compared to initial estimates. In any case, both the number of firms involved[14] and the sums being claimed are much larger than for any of the direct funding schemes described in Box 7.3, raising the question of whether there is overlap. For example, the R&D grant for SMEs and R&D tax credits both tackle the same market failures, namely spillovers and the high cost of due diligence in evaluating a project. Moreover, there are arguments for suggesting that R&D tax credits are a more appropriate policy instrument. In particular, the difficulty in evaluating projects also applies to Government when assessing the case of R&D grants and if a principal rationale for intervention is to overcome a financing constraint for small firms then effectively providing subsidised loans through the R&D tax credit would appear more appropriate than R&D grants (Abramovsky *et al.*, 2004).

A series of evaluations of the effectiveness of R&D tax credits are planned from 2005 onwards, although even before these are available the Government has published a consultative document to consider further enhancing R&D tax credits to respond to changes in the pattern of business R&D (HM Treasury *et al.*, 2005). This rules out, at least for the time being, changing the definition of expenditure covered as well as raising the tax credit rate for larger firms. Instead, it highlights the emergence of pockets of new R&D intensity outside the traditionally innovative industries and proposes enhancing R&D tax credits for these firms. However, in the absence of evaluation results, there is not yet a clear case for further extending the generosity of R&D tax incentives. Tax incentives should continue to be market based, and it is also important to ensure that they are well understood by businesses and provide certainty that they will be maintained at existing levels.

### *Polices to promote partnerships between business and the tertiary education sector*

The share of R&D performed in the higher education sector that is financed by business was about 6% in 2002, which is close to the OECD average and little changed from previous years. Given the excellence of the science base as reflected in the high ranking for publications and citations, this does raise the question as to whether there is untapped potential for closer collaboration.

Funding of universities is sometimes blamed as putting an over-emphasis on pure science at the expense of the possibilities for commercial exploitation of research. The majority of public funding for universities is related to research excellence, which in practice is assessed mainly on academic benchmarks, and distributed *via* Research Councils and Funding Councils with funds increasingly concentrated on a few universities.[15] These also tend to receive the most funding in the form of research grants or contracts from businesses, although there are some notable exceptions (Lambert, 2003). Thus, there are some universities that have a strong track record of collaborating with businesses, despite not being among the highest ranked for the much larger pot of public research funding, leading to a concern that such universities may become increasingly squeezed in the future. This is recognised in so called "third-stream funding" under the *Higher Education Innovation Fund* (HEIF) in England and similar funding streams in other parts of the United Kingdom, which aim to promote the transfer of knowledge from university research to the business sector. The HEIF money builds capacity in universities to enable greater collaboration with business. Indeed, on such measures – the number of staff employed in commercialisation or industry liaison offices, the number of spin-out companies, the number of patent applications by universities – there has been a considerable increase in business-university interaction in response to increases in such funding since 1998 (HM Treasury *et al.,* 2004). The Lambert review, a recent review of university-business collaboration undertaken for Government by Richard Lambert, advocated, among a raft of other proposals, increasing such funding (Box 7.4). In response, the Government made a commitment that HEIF funding would rise to £110 million per year by 2007/08, up by about 10% in real terms from 2004/05. In addition, in line with the

### Box 7.4. **Main recommendations of the Lambert review of business-university linkages**

- Additional funding of about £100-200 million should be made available to university departments that can demonstrate a strong demand from business for their research.
- A higher proportion of government funding of BERD should be directed towards SMEs.
- R&D tax credits should be better marketed.
- A number of barriers to commercialising university intellectual property (IP) were identified; in particular, a lack of clarity about ownership of intellectual property, especially when there was part funding by business, as well as lack of sufficient expertise within universities to support such activity. A group has subsequently been set up to draw up a range of model collaborative contracts between universities and businesses and to develop an IP protocol.
- Regional Development Agencies should be given greater responsibility to co-ordinate university-business collaboration.
- Universities should be encouraged to place less emphasis than currently on spin-outs and more on licensing.
- A league table of the world's best research intensive universities should be developed.
- A code of governance for universities should be developed to represent best practice, with voluntary implementation on a "comply or explain" basis.
- Universities that demonstrate that they are well run should be subject to a lighter regulatory regime.

*Source:* Lambert, R. (2003), *Lambert Review of Business-University Collaboration: Final Report*, HM Treasury, December, *www.lambertreview.org.uk*.

Lambert review recommendations, the Regional Development Agencies were given a greater role in facilitating university-business collaboration, and are investing significantly in science and innovation (£360 million in 2005/06, an increase in real terms of about 40% since 2002/03). Other key Lambert review recommendations that have been taken up include publication of new guidance on university governance by the Committee of University Chairmen, and the launch of a set of model intellectual property agreements (the "Lambert Agreements") for businesses and universities engaged in research collaboration.

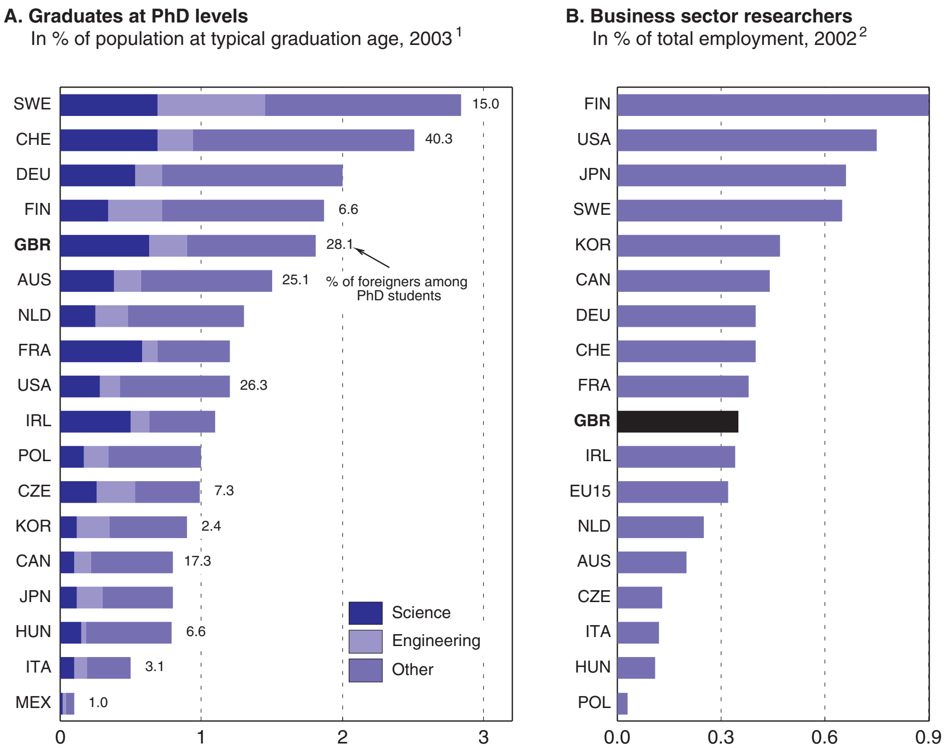
***Ensuring a fluid labour market for researchers and scientists***

A recent government-commissioned review, the *Robert's review* (HM Treasury, 2002), expressed concern about weaknesses in the teaching of science, engineering and technology (SET) subjects and a "disconnect" between a growing demand for SET graduates and a waning supply (apart from IT and biological sciences for which supply is increasing). To increase the number of graduates in mathematics, engineering and physical sciences, it recommended measures to both stimulate the interest in sciences during school and make academic and R&D careers more attractive. With the 2004 spending review, the Government has committed itself to action along the lines of the review (HM Treasury, *et al.*, 2004). These proposals appear sensible in addressing identified weaknesses for which Government has a direct responsibility – such as shortages of secondary school teachers in mathematics, the course content in secondary schools or the level of stipends paid to persons with PhDs. However, it is unclear whether they will be sufficient to hit the government's objective of a "step change" in students studying science at secondary school and/or SET subjects in higher education, but neither is it clear that such a step change is needed.

In international comparison, there is already a relatively high number of SET graduates in relation to the relevant youth cohort (Figure 7.11, panel A).[16] Despite this relatively abundant *potential* supply the number of *actual* researchers relative to the size of total employment is lower than in many comparable countries (Figure 7.11, panel B).[17] Thus many SET graduates are not attracted to careers in R&D, mostly because employers offer insufficiently competitive remuneration packages (HM Treasury, 2002). In 2003 about half of those with a first degree in science or engineering were not working in either a science and engineering occupation or teaching, with this proportion rising to over 60% for first degrees in physical sciences, technology or engineering. Instead, the financial services sector and the public sector are the largest employers of science and technology graduates.

It is not clear, however, whether further government intervention is needed as skilled labour resources are being attracted to the most successful sectors, such as financial services, where returns are highest. Whilst there is evidence that the labour market for science and engineering occupations is tight it is no more so than for other professional occupations: the relative wages of those in science and engineering occupations show no sign of any trend increase relative to wages in all professional occupations; and whilst the employment rate of those with a first degree in science and engineering is high, it is similar to the employment rate of those with first degrees in other subjects. Moreover, the success of the chemical and pharmaceutical industries are a testament to scarcity of scientists not being a major constraint in science-based industries (Owen, 2000). In summary, there is not a compelling case that the capacity of the economy to absorb new ideas is currently being held back by a shortage of scientists and researchers, although it remains important to

Figure 7.11. **PhD graduates and researchers**




1. 2000 for Canada, 2002 for graduates in Finland and Italy, 2001 for foreign students enrolled in the United States.
2. 2000 for Switzerland and United States, 2003 for Sweden.

*Source:* OECD (2005), *Main Science and Technology Indicators*, Vol. 1 and calculations based on the OECD Education database, September 2005.

ensure an adequate supply of scientists and researchers to meet future needs. By contrast international benchmarking does suggest that the general level of skills of the adult population is low – for example nearly one-quarter of the adult population lacks basic literacy skills – and this is likely to be a more serious handicap to absorptive capacity (Chapter 8).

Another key issue is to ensure that UK universities operate in framework conditions conducive to developing a top position in the world, challenging the dominant US universities (Box 7.5). This is essential as presumably one of the most important factors attracting talented researchers is to be in an intellectually stimulating environment among world leading academic colleagues. It helps that from 2006 universities will be allowed to set tuition fees of up to £3 000 a year, replacing the current £1 150 tuition fee charged uniformly for all courses. These fees come on top of government per-student funding of £3 500 to £14 000 a year (level depending on type of course), research grants and other revenues. Most universities have announced that they will charge the full £3 000, indicating that the cap preventing universities from charging more – even if students were willing to pay – is a straitjacket. Average per-student spending on tertiary education institutions in the United States equalled 57% of GDP per capita in 2001, but only 30% in the United Kingdom (excluding funding for university R&D). Allowing universities to charge £3 000 instead of the current £1 150 a year will add resources equivalent to 11% of GDP per capita, but does not close the gap *vis-à-vis* the US average – not to mention the gap *vis-à-vis*

### Box 7.5. **The world's top universities**

World rankings of the universities are dominated by the United States, although the United Kingdom usually fares better than continental European countries.

A ranking published in November 2004 by the Times Higher Education Supplement was based on surveying academics in 88 countries on the institutions in the fields they had expertise in. It found that Oxford and Cambridge universities are among the world's top ten, and that eight UK universities were among the top fifty.

An alternative ranking by academics at Shanghai Jiao University in China, weighted together several indicators of academic or research performance, including alumni and staff winning Nobel prizes, highly cited researchers, and publication citations. It also placed Oxford and Cambridge in the top 10, with 5 UK universities among the top 50.

Table 7.3. **Alternative rankings of top world universities**

| Source | Number in top 10 | | | Number in top 50 | | |
|---|---|---|---|---|---|---|
| | United States | United Kingdom | Other European Union | United States | United Kingdom | Other European Union |
| Times Higher Education Supplement | 7 | 2 | 0 | 20 | 8 | 2 |
| Shanghai Jiao Tong University | 8 | 2 | 0 | 35 | 5 | 5 |

*Source:* Institute of Higher Education, Shanghai Jiao Tong University *http://ed.sjtu.edu.cn/ranking.htm*. The Times Higher Education Supplement *www.thes.co.uk/worldrankings/*.

the top academic institutions in the United States. As part of the legislation paving the way for the introduction of graduate contributions, it has been agreed that an independent review is to be prepared and presented to Parliament in 2009 on all aspects of the new arrangements, based on the first three years' operation of the policy. The Government will consider the report before submitting any recommendation to Parliament on raising the tuition fee cap. In the OECD's view, a removal or at least an increase of the cap would be warranted. A better university governance structure would also seem crucial, and the Lambert review pointed to the need for reforming the often very conservative collegial structures with senates and councils at the older universities to become more dynamic. In response to this recommendation, guidance on university governance was published by the Committee of University Chairmen, and all universities are currently reviewing their governance arrangements.

#### *International mobility*

International mobility can have a large impact on the future availability of researchers and scientists. One aspect is the alleged "brain drain", particularly to the United States.[18] The tendency for more educated persons to be over-represented in US-bound migration is shared with continental European countries, but the volume of migration from the United Kingdom is significantly larger (EEAG, 2003),[19] possibly reflecting the absence of language barriers. Outflow of academic staff is part of this, leading the Roberts review to recommend enhanced and more market-related salaries for key academic staff. On the other hand there is a considerable inflow of talented students; 10% of those pursuing higher education come from abroad, with the United Kingdom hosting 12% of the world's foreign students (only exceeded by the United States). Nearly half of all engineering and technology doctorates are already awarded to non-UK nationals. In order to take advantage of this substantial and growing pool of potential researchers, the Government has announced that overseas science and engineering graduates studying in specific shortage subjects will have the automatic option of working in the United Kingdom for one year following graduation.

## Summary and conclusions

Across a range of conventional indicators, innovation performance is mediocre in comparison to the best performing OECD countries. Nevertheless, strengths in knowledge intensive services and creative industries, where innovation is less likely to be picked up in such indicators, probably mean that aggregate performance is under-stated.

- Much of the R&D intensity gap with Germany, France and Japan can be explained by industry mix effects, which suggests targeting a similar level of R&D intensity may be inappropriate. On the other hand, while industry mix effects apparently do not help to explain the gap with the United States, issues of data comparability mean that is difficult to be sure in which industries the main differences are located.
- While patenting performance is only mediocre there has been extremely rapid growth in other forms of intellectual property protection, such as the use of trademarks, and the balance-of-payments surplus on technology transfers is among the highest in the OECD.
- While the share of researchers in total employment is unexceptional, this is not because of a shortage in PhD graduates in science and technology subjects which are relatively numerous by international standards, but who are often attracted to other careers.

All in all, these considerations suggest a degree of caution is warranted in pursuing the government's targets for innovation. At the same time the cross-country evidence linking innovation with aggregate growth performance means that this should be a policy area under constant review, and there is a growing body of evidence which, while far from conclusive, is at least suggestive regarding which policies are most helpful in promoting innovation.

Framework conditions are already among the most favourable for R&D in the OECD. Nonetheless there is room for further improvement. For example, the previous OECD *Survey* found that overly strict planning regulations may have significant economic costs and a recent government-commissioned report recommended streamlining regulatory regimes (Hampton, 2005). Moreover, the tax burden, particularly for the corporate sector, could rise in the near future highlighting difficult choices, discussed further in Chapter 3, regarding how far the United Kingdom wishes to move to a higher level of welfare provision and taxation.

As regards specific policies to support science and innovation, empirical work based on OECD indicators up to 2000 suggests there was some scope for improvement. However, since then the Government has introduced a range of new policy measures to boost science and innovation, culminating in the 2004 *Science and Innovation Investment Framework*, whose impact will not yet be reflected in the indicators currently available. The OECD empirical work highlighted "absorptive capacity" as a particular weakness compared with other countries and the Roberts review has highlighted falling numbers of graduates in SET subjects. Where the Government has a direct responsibility, for example in the provision of science and mathematics teaching at secondary level or in the level of stipends paid to PhD researchers, it has responded positively to weaknesses identified in the Roberts review. But given the relatively high numbers of SET graduates by international comparison and success in some science-based industries, such as pharmaceuticals, it is difficult to argue that a shortage of researchers is currently a binding constraint.

A much higher priority for raising absorptive capacity to harness the benefits of innovation is raising the low *general* skill level of the labour force, as discussed further in Chapter 8. While the number of persons having university degrees and advanced research degrees (PhDs) is not much different from that in comparable countries, the United Kingdom stands out internationally with a large share leaving school before completion of the upper secondary level and without an education giving specific competence within a professional field. Continuously improving the relevance and quality of vocational programmes is, however, as important as expanding their provision. That is because a key factor determining the success of such an expansion will be that the vocational route gains esteem *vis-à-vis* academically-oriented secondary education – something that appears to be lacking more in the United Kingdom than elsewhere. Unifying the current very mixed array of vocational programmes and diplomas into a limited number will make continued education more attractive for those leaving at age 16 today. And the government's initiative to establish high-quality vocational academies in disadvantaged neighbourhoods with intensive involvement of businesses *via* sponsorships, etc., will help raise the profile and esteem of professionally oriented programmes.

The recent shift in emphasis away from grants towards tax incentives is likely to be beneficial in boosting R&D spending, although it is too early to judge the results. Given this lack of results, there is not yet a clear case for further extending the generosity of R&D tax incentives. Tax incentives should continue to be market based, and it is important to ensure that they are well understood by businesses and provide certainty that they will be maintained at existing levels.

Despite a recent streamlining of fiscal measures to support R&D, there is still potential overlap between R&D tax incentives and remaining grant schemes. There is a need for improved evaluation of fiscal measures to support R&D as officially acknowledged. Future evaluations of all fiscal measures should also address the extent of overlap between different policy instruments, whether there are barriers to take-up in the services sector; whether measures encourage firms to become innovative (rather than increasing the extent of innovation already taking place within a firm). In addition, the balance of direct funding for R&D between SMEs and larger companies who receive most current support might need to be reconsidered.

There is further scope to exploit the strength of the science base through further promoting university-business collaboration. The emphasis of current university funding on research excellence will help to foster elite universities which should attract increasingly mobile multinational companies. However, to compete with the best universities in the United States further changes will be required, including: a streamlining of university governance procedures and clearer guidelines concerning intellectual property rights. These issues are being addressed in line with the recommendations of the Lambert review. Eventually, an upward adjustment on the current cap on university fees is also likely to be required to provide additional financial resources to attract and retain the best academic talent. In line with the recommendations of the Lambert review, consideration should also be given to the modest increases in funding targeted at those universities which have shown a track record of successful collaboration with businesses, which are not always the same universities that appear at the top of the academic rankings that determine the bulk of university funding.

Box 7.6. **Summary of recommendations to strengthen innovation**

- The target for R&D is ambitious, particularly given the industrial mix, but is also an imperfect measure of innovation input, particularly given strength in sectors such as knowledge intensive services, so there should be no presumption that being off-track should automatically result in further policy actions.
- Continue to strive for improvements in framework conditions, notably by relaxing planning restrictions, reducing business red tape and avoiding further increases in the general level of taxation.
- Keep the portfolio of measures to support R&D under periodic review.
- Consider the balance of direct funding of R&D between SMEs, where market failures concerning the ability to raise finance are more likely, and larger firms where support is focused at present.
- Improve evaluations of fiscal measures to support R&D. Future evaluations of all fiscal measures should also address whether there are barriers to take-up in service sectors and whether measures encourage firms to become innovative (rather than increasing the extent of innovation taking place within a firm).
- It is important to ensure that R&D tax incentives are well understood by businesses and to provide certainty that they will be maintained at existing levels.
- Continue to monitor the numbers studying, and qualifications achieved, in science, engineering and technology subjects, both at secondary and tertiary levels. If further pressures become apparent in areas where Government has a direct responsibility through funding decisions, then further action should be taken. For example, higher salaries should be considered to deal with shortages of math and science teachers at secondary school.
- The highest priority for improving the absorptive capacity of the workforce with respect to innovation is to raise the low general skill level (Chapter 8), particularly by strengthening vocational training options to retain more students in secondary education.
- In line with the recommendations of the Lambert review, consideration should be given to raising the funding of the universities which have shown a track record of successful collaboration with businesses.
- The independent commission should be invited to consider the benefits of allowing additional resources to flow to the most successful universities by relaxing the cap on university fees. Also further reform of universities should be encouraged, in particular through: streamlining of university governance procedures; closer contact with their alumni; providing clearer guidelines concerning intellectual property rights.

## Notes

1. The UK target for R&D intensity is less ambitious than the EU-wide target of raising R&D intensity to 3% (from a current level of 2%) set by the Barcelona European Council.
2. Guellec and van Pottelsberghe (2001) find that a 1% rise in the business R&D stock produces a 0.13% rise in the growth of multi-factor productivity and the OECD *Growth Study* (OECD, 2003) finds a positive effect on per capita GDP growth from BERD intensity.
3. In a 1999 survey almost half of engineering employers reported that they could not recruit graduates with the technical skills required (DfEE, 1999).
4. Although the United Kingdom participated in CIS3 for data confidentiality reasons it only provided aggregate data to Eurostat, hence many of the more detailed survey responses are not available for the United Kingdom from EU databases.
5. This consists of money paid or received for the acquisition and use of patents, licences, trademarks, designs, know-how and closely related technical assistance and for industrial R&D carried out abroad.
6. Another example of strong performance in softer innovation indicators in the service sector concerns the introduction of new-to-firm products (rather than new-to-market products). The 2004 European Innovation Scoreboard suggests that whilst the proportion of manufacturing firms introducing new-to-firm products was among the lowest in the EU at 7% (compared with an EU15 average of 21%), the proportion of service sector firms introducing new-to-firm products was the highest at 22% (compared with an EU15 average of 15%).
7. Tesco, the UK retail chain, is often cited as a leading example of innovation in Europe, for example through the use of a clubcard loyalty scheme, a successful online operation and ventures into deregulated areas such as financial services, pharmaceuticals and telecommunications.
8. High technology manufacturing industries are defined as: pharmaceuticals; aircraft and spacecraft; office, accounting and computing machinery; radio, television and communications equipment; and medical, precision and optical instruments. Medium-high technology manufacturing industries are defined as: electrical machinery and apparatus n.e.c.; motor vehicles; chemicals excluding pharmaceuticals; railroad and other transport equipment; machinery and equipment n.e.c.
9. A similar decomposition analysis based on a different data set – namely the Department of Trade and Industry's (DTI) "R&D Scoreboard" which uses data from published company accounts of the top 700 international companies by R&D investment – finds an even greater role for industry mix effects in explaining the gap with major competitors; see Turner and Lundsgaard (2005) for further details.
10. Much of the increase in US service sector R&D has taken place in the wholesale and retail sector, which may be a result of large manufacturing firms relocating production offshore, but leaving behind a residual R&D and sales function in the United States, which for statistical purposes is classified in the retail and wholesale sector. However, in the UK the R&D would still be allocated to manufacturing suggesting that up to one-third of the difference in service sector R&D intensity could be illusory (HM Treasury and DTI, 2005).
11. OECD calculation based on the range of estimated coefficients reported in Becker and Pain (2003).
12. Part of the explanation for this is that much of government direct funding of R&D is directed towards defence where large firms dominate, although this is also true for the United States and France.
13. Based on OECD (2005a), Annex 3 equation (3) of Table A3.1.
14. The number of SMEs claiming R&D tax credits was nearly 4 500 in fiscal year 2002 alone, whereas the total number of firms (mostly SMEs) claiming the R&D grant (previously the SMART scheme) since the launch of the programme in 1986 is about 2 400.
15. Universities are independent institutions with charitable status, although the government provides the majority of support for teaching as well as the two largest streams of research funding, through a dual support system. The largest stream of research funding comes from the Funding Councils and is known as quality-related (QR) funding and is allocated according to a peer review process of past performance measured by the Research Assessment Exercise. The second part comes from Research Councils mostly in the form of project grants allocated to particular researchers in response to proposals to carry out particular pieces of work.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16. In particular this is so for science and engineering PhD graduates who play a central role in business sector R&D. Only Sweden and Switzerland have more PhD graduates in science and engineering relative to the size of the youth cohort.

17. This is quite different from the situation in the early 1980s when only the United States had a larger share of business sector researchers than the United Kingdom. Since then the UK share of business sector researchers has declined by a quarter, while it has grown in all other OECD countries.

18. Among US residents born in the United Kingdom, six in ten have taken tertiary education, compared to three in ten among the UK population. And among recent arrivals, 5% have a PhD, compared to only 1.6% of the UK youth cohort that graduate as PhD.

19. Information based on the 1990 US census.

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# Acronyms

| | |
|---|---|
| **APW** | Average production worker |
| **BERD** | Business Enterprise Expenditure on R&D |
| **CIS** | Community Innovation Survey |
| **CPI** | Consumer price index |
| **DfES** | Department for Education and Skills |
| **DTI** | Department for Trade and Industry |
| **EMU** | Economic and Monetary Union |
| **EU** | European Union |
| **EU15** | European Union, first 15 member states |
| **G7** | Group of 7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) |
| **GCSE** | General Certificate of Secondary Education |
| **GDP** | Gross domestic product |
| **HEIF** | Higher Education Initiative Fund |
| **ICT** | Information and Communication Technology |
| **IPR** | Intellectual property rights |
| **IT** | Information technology |
| **$km^2$** | Square kilometre |
| **MEI** | Main economic indicators |
| **MPC** | Monetary Policy Committee |
| **NHS** | National Health Service |
| **NI** | National insurance |
| **ODPM** | Office of the Deputy Prime Minister |
| **ONS** | Office for National Statistics |
| **PDG** | Planning Delivery Grant |
| **PFI** | Private Finance Initiative |
| **PhD** | Doctor of Philosophy |
| **PPP** | Purchasing power parity |
| **R&D** | Research and development |
| **RDS** | Research and Development Statistics |
| **SET** | Science, engineering and technology |
| **SMEs** | Small-medium sized enterprsies |
| **STAN** | Structural Analysis Database |
| **UK** | United Kingdom |
| **UMTS** | Universal mobile telephone communications systems (third generation mobile telephony) |

# *Table of contents*

**Boxes**



## Tables



## Figures

*This Survey is published on the responsibility of the Economic and Development Review Committee of the OECD, which is charged with the examination of the economic situation of member countries.*

*The economic situation and policies of the United Kingdom were reviewed by the Committee on 20 September 2005. The draft report was then revised in the light of the discussions and given final approval as the agreed report of the whole Committee on 30 September 2005.*

*The Secretariat's draft report was prepared for the Committee by Dave Turner and Jens Lundsgaard under the supervision of Peter Hoeller.*

*The previous Survey of the United Kingdom was issued in January 2004.*

# BASIC STATISTICS OF THE UNITED KINGDOM (2004)

## THE LAND

| | |
|---|---|
| Area (2003, 1 000 km²): | |
| Total | 243 |
| Agricultural | 184 |
| Major cities (2003, thousand inhabitants): | |
| Greater London | 7 388 |
| Birmingham | 992 |
| Leeds | 715 |
| Glasgow (local government district) | 577 |

## THE PEOPLE

| | |
|---|---|
| Thousands: | |
| Population | 59 778 |
| Net increase (annual average 2001-03) | 220 |
| Number of inhabitants per km² | 246 |
| Total labour force (thousands) | 29 882 |
| Civilian employment (% of total): | |
| Agriculture, forestry and fishing | 1.3 |
| Industry and construction | 22.3 |
| Services | 76.2 |

## PRODUCTION

| | |
|---|---|
| Gross domestic product: | |
| In £ billion | 1 164 |
| Per head ($) | 35 683 |
| Gross fixed capital investment: | |
| In % of GDP | 16.3 |
| Per head ($) | 5 827 |

## THE GOVERNMENT

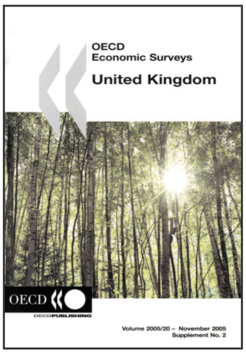
| | |
|---|---|
| Public consumption (% of GDP) | 21.1 |
| General government (% of GDP): | |
| Current and capital expenditure | 43.5 |
| Current revenue | 40.3 |
| Net debt | 36.9 |
| Last general elections: 5 May 2005 | |
| Composition of House of Commons (seats): | |
| Labour | 353 |
| Conservatives | 196 |
| Liberal Democrat | 62 |
| Other | 34 |
| Total | 645 |

## FOREIGN TRADE

| | |
|---|---|
| Exports of goods and services (% of GDP) | 25.0 |
| Main commodity exports (% of total): | |
| Manufactured goods and articles | 24.8 |
| Chemicals | 16.8 |
| Electrical machinery | 15.0 |
| Mechanical machinery | 12.5 |
| Imports of goods and services (% of GDP) | 28.4 |
| Main commodity imports (% of total): | |
| Manufactured goods and articles | 28.9 |
| Electrical machinery | 17.8 |
| Road vehicles | 12.3 |
| Machinery and other transport equipment | 11.1 |

## THE CURRENCY

| | |
|---|---|
| Monetary unit: Pound sterling | |
| September 2005, monthly average of spot rate: | |
| £ per $ | 0.553 |
| £ per € | 0.677 |

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