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**DTI ECONOMICS PAPER NO.11**

# R&D Intensive Businesses in the UK

MARCH 2005

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# DTI Economics Papers

The reviews of the DTI in Autumn 2001 placed analysis at the heart of policy-making. As part of this process the Department has decided to make its analysis and evidence base more publicly available through the publication of a series of DTI Economics Papers that will set out the thinking underpinning policy development. Previous titles include:

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3 **UK Competitiveness: Moving to the next stage**, Professor Michael Porter and Christian H M Ketels (Institute of Strategy and Competitiveness, Harvard Business School), May 2003

4 **Options for a Low Carbon Future**, June 2003

5 **DTI Strategy – The Analysis**, November 2003

6 **UK Productivity and Competitiveness Indicators 2003**, November 2003

7 **Competing in the Global Economy – The Innovation Challenge**, November 2003

8 **Raising UK Productivity – Developing the Evidence Base for Policy**, March 2004

9 **The Benefits from Competition – some Illustrative UK Cases**, Professor Stephen Davies, Heather Coles, Matthew Olczak, Christopher Pike and Christopher Wilson (Centre for Competition Policy, University of East Anglia), July 2004

10 **Liberalisation and Globalisation: Maximising the Benefits of International Trade and Investment**, July 2004

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**A NOTE ON TERMINOLOGY**

Throughout this paper the use of the term R&D intensity refers to R&D divided by some measure of output. This can be sales or value added. The use of intensity measures takes into account differences in size when making R&D comparisons between businesses, sectors and countries. For example, economically large countries will, by virtue of their size, often have higher levels of R&D than smaller countries. But this may simply reflect their size rather than any qualitative difference in the use of R&D in that economy. Hence, to account for differences in scale, R&D is deflated by some measure of output.

# Acknowledgements

Every Government publication receives input from a wide range of people. This paper is no exception. Rob Stones, Simon Penney and Ben Lucking have all provided first-rate statistical support. The lot of commenting on drafts, in various states of intellectual and grammatical disarray, fell to David Hughes, John Barber, Mark Beatson, Ray Lambert, David Humphry and Ben Marriott. Helpful comments were also received from the Inland Revenue, from Tristan Slinger, and Helen Watson and Daniel Storey, both from HM Treasury. Tony Pedrotti, Nick Munn, Mike Tubbs and Norman Price provided access to the R&D Scoreboard data and considerable encouragement. Needless to say any remaining errors or omissions are my own.

Neil Golborne
15th March 2005

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# Foreword

The Government's ten-year framework for investment in science and innovation, published last year, set a challenging target for a step-change in levels of R&D in the British economy. Our central aim is that R&D should grow to 2.5% of GDP by 2014, from its present level of 1.9% – continuing to reverse the long decline of past decades.

This is a formidable challenge for policy – and it is critical that policymaking is grounded in the best-possible evidence and analysis. This paper is therefore intended as one contribution to our evolving assessment of the UK's science, technology and innovation performance.

The material presented here is very much work in progress, and it is itself innovative in that it seeks to bring together several data sources for the first time. However, it begins to draw out a number of key themes with important implications for policy:

- in general, the paper finds limited evidence that where UK firms do R&D, they do less than one would expect given the markets they serve;
- it does, however, find that the UK has fewer firms, particularly large ones, that do R&D at all – outside a few sectors, large UK owned firms tend to be concentrated in non-R&D-intensive sectors;
- moreover, it finds that – again, outside a few sectors – large foreign-owned firms are more likely to get their R&D input from overseas.

The paper's analysis therefore resonates with a number of the policy priorities highlighted in the 10 year framework, especially:

- maintaining or growing R&D in sectors where the UK is strong;
- attracting R&D investment into the UK from multi-nationals;
- increasing R&D intensity in firms or sectors that are lagging behind their peers; and
- developing new R&D intensive sectors through the creation and growth of R&D-intensive SMEs.

These will be central themes of our analytical and policy work in pursuit of the ambitions set out in the ten-year framework.

Our Departments would very much welcome views and comments on the analysis set out in this paper.

Vicky Pryce
Chief Economic Adviser and
Director General, Economics
Department of Trade and Industry

John Kingman
Director, Enterprise and
Growth Unit
HM Treasury

# Executive Summary and Conclusions

The Government's ten-year Science and Innovation investment framework showed that a significant increase in business Research and Development (R&D) would be required to increase the amount of R&D performed in the UK to 2.5 per cent of GDP by 2014, the ambition set by the Government. The framework document also provided some analysis of business R&D in the UK that showed how the required growth in business R&D would require different business responses. These were:

- Maintaining or growing R&D where the UK is strong;
- Attracting investment into the UK from multinationals in an already highly internationalised system;
- Increasing R&D intensity in firms or sectors that are lagging behind their peers; and
- Developing new R&D intensive sectors through the creation and growth of R&D intensive small and medium sized enterprises (SMEs).

The material presented in this paper provides more analysis on the UK's business R&D performance that is relevant to each of these business responses. In coming to these judgements we have had to bring together several data sources, which are not commonly looked at side by side. This makes the analysis innovative and further research would be useful to test and expand on the findings set out here. It forms part of a broader annual assessment by the Government of the UK's performance across the full range of outputs and attributes of the UK's science and innovation system.

## UK R&D – headline trends

Total UK R&D currently stands at 1.9 per cent of GDP, having stabilised and then risen slightly from its nadir of 1.8 per cent in 1998. This followed some decades of decline in total R&D intensity. Trends in government funding were the main influence on UK R&D intensity during the 1980s. This was largely related to cuts in defence spending. However, the main influence on the UK's relative R&D performance during the 1990s was the slower rate of growth in industry-funded R&D. Taking both periods together, the most significant factor behind the UK's R&D performance was the relative decline in industry funding. Generally, growth rates in industry-funded R&D have not matched GDP growth rates so the R&D intensity of UK business has fallen. Relative to their competitors in the Group of Seven industrialised countries (G7), UK businesses have become less R&D intensive.

One reason for differences in R&D intensity between the US and UK was the strong growth of service sector R&D in the US. The US service sector R&D

figures are, however, hard to interpret because the classification of US R&D does not represent the ultimate use to which the R&D is put. Without access to US records we can only speculate about the extent to which R&D for manufacturing purposes is under-estimated. But we believe that up to a third of all US service sector R&D could in fact be directed at manufacturing purposes.

The major sources of growth in UK business R&D were in chemicals (including pharmaceuticals), transport equipment and service sector product groups. Privatisation of the nationalised utilities led to a fall in their R&D spending, although this had a modest impact on total UK business R&D performance. The growth of R&D in service sector product groups is more significant and may reflect growth in the market for contract R&D.

## Why is UK business R&D relatively low?

We take as our starting point the analysis in the ten-year science and innovation framework. This showed that generally R&D intensities within UK manufacturing sectors were significantly lower compared to the same sectors in competitor countries. This was especially true in motor vehicles, medical, precision and optical instruments, IT and electronics. This paper investigates three potential reasons for the lower R&D intensities in UK sectors. These are:

- **UK based firms that do R&D do not do enough**: Overall, we do not find strong evidence that UK R&D performers do less R&D than one would expect given the markets they serve. In coming to this judgement we have relied on the R&D Scoreboard, which allows the calculation of R&D intensities for individual firms (since it is not possible to compare different countries' business surveys at this disaggregated level). The main message from the R&D Scoreboard analysis is that within any sector UK owned and foreign owned, but UK based, R&D performers have, on average, a similar R&D intensity to their competitors in the same sector.
- **Within sectors, the UK has fewer R&D performers, particularly large ones**: Market and technology characteristics influence the extent to which large firms, accounting for a large share of total sales and R&D, can come to dominate different markets. One determinant of an economy's R&D intensity is therefore likely to be the activities of these large firms. Generally the UK appears to lack very large firms in R&D intensive sectors such as motor vehicles, IT and electronics. According to the Value Added Scoreboard, outside the Pharmaceuticals and Aerospace and Defence sectors, large UK owned firms are more likely to be concentrated in sectors that have lower R&D intensities or do no R&D at all. A common feature of all the R&D intensive sectors where UK owned firms are less well represented is that UK owned firms struggled in these industries to retain a competitive edge in the past. This may indicate that, lacking success in high R&D spending markets, many UK firms find themselves confined to relatively small niches in these markets or are dependent on R&D embodied in capital inputs purchased from other firms.

- **Large foreign owned firms are more likely to get their R&D input from overseas than UK owned firms:** Although there are several major foreign owned investors who make a significant contribution to UK R&D, research suggests that most foreign owned manufacturers tend to rely on their R&D facilities abroad, particularly for more fundamental research inputs. Whilst this may change significantly in the future – as the Lambert Review of Business–University collaboration suggested – it does appear relevant to the UK's historic and current business R&D performance. The UK has been relatively successful at attracting manufacturing investment from abroad, particularly in sectors where UK owned firms struggled. As a consequence, it is likely that at least part of the reason for the low business R&D intensities in UK sectors, such as motor vehicles and IT, is that the foreign owned manufacturers largely depend on R&D inputs from facilities based overseas.

## Internationalisation of business R&D: an opportunity for the UK?

Overall, the internationalisation of business R&D represents a significant opportunity for the UK. Whilst most business R&D still remains closely tied to headquarters, there are signs that this is changing. Investments in R&D overseas in part reflect merger and acquisition activity and the desire of multinationals to gain access to lead markets. But there is also a trend for businesses to exploit international centres of scientific and technological excellence and also to move R&D closer to major markets. These investment flows are likely, initially at least, to continue to benefit the larger industrialised economies with established research bases. Over time, as other economies such as India and China develop their scientific and technological capabilities, a much greater share of multinational investment may gravitate towards the Far East.

The UK is well placed to benefit from the trends towards internationalisation. It already hosts several major foreign investors. In most outsourcing decisions labour costs and skills are key factors when firms decide on locations. The costs of UK R&D are competitive. The numbers of scientists and engineers in the UK have expanded strongly alongside the expansion of higher education, although some disciplines have been more favoured than others. Furthermore, the quality of UK research is high and judged by several indicators, such as the share of public research funded by business, the UK Science and Engineering base is relatively open to collaboration.

In the same way that foreign businesses are looking to exploit sources of UK knowledge, UK businesses are also looking overseas. They are, for example, the largest investors in the US after Germany. And there are signs, in Pharmaceuticals particularly, of a step change in the level of their investment outside the UK. Since 1995 UK business funded, but overseas performed, R&D has increased at a faster rate than business R&D performed in the UK (10.4% compared to 2.5%). A recent survey by the European Roundtable of

Industrialists (ERT) indicates that member companies invest almost 40% of their R&D outside of Europe. These firms plan to increase their R&D in future years, but the bulk of that increase will be spent outside Europe.

For as long as the UK retains access to centres of science and technological excellence and is an attractive place to do business, it will remain an attractive place to do R&D for UK owned and foreign owned firms. But a survey carried out by the Engineering Employers' Federation (EEF) suggests that some indigenous manufacturing capability is required in order to anchor R&D capability in the UK.

## Business responses

The analysis above has several implications that can be grouped under the business responses outlined in the ten-year Science and Innovation framework. These are:

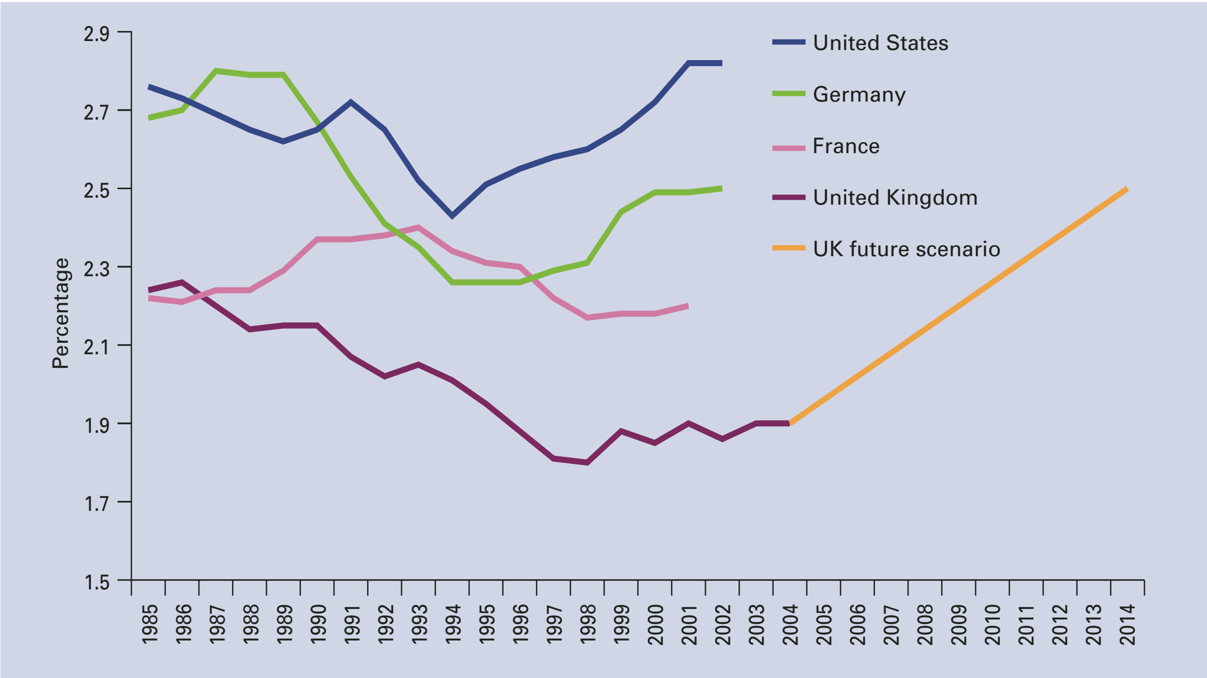
- **Maintaining or growing R&D in sectors where the UK is strong:** The UK has a few strong sectors, notably Pharmaceuticals and Aerospace and Defence. Worldwide differences in the respective regulatory regimes and procurement practices in these sectors could affect future decisions on the location of R&D, with both positive and negative potential impacts for the UK's business R&D base. However, UK research is strong in these areas, particularly life sciences, and provides a good underpinning, through Government funded research, to business R&D. This will need to be maintained to retain and attract business R&D in these sectors.
- **Attracting R&D investment into the UK from multinationals:** A high share (40%) of UK business R&D is already carried out by foreign businesses. If current trends persist, this could rise significantly. But it would depend on maintaining relatively low R&D costs, the high quality of UK research, an openness to business-university collaboration and an appropriate supply of qualified scientists and engineers.
- **Increasing R&D intensity in firms or sectors that are lagging behind their peers:** Relatively low R&D intensities in these UK sectors do not appear to be due to lower R&D intensities amongst UK R&D performers in these sectors; rather the UK appears to lack sufficient numbers of domestic firms, particularly large ones, in these sectors which do R&D. Large foreign owned manufacturers, based in the UK, have done much to maintain the UK's manufacturing base in these sectors. But it appears that the UK's relative success at attracting this investment may have contributed to the falling business R&D intensity as foreign owned firms helped keep UK output up, but largely relied on their R&D facilities abroad. Growth in R&D in these sectors is therefore likely to depend, in part, on the UK's ability to attract the associated foreign investment in R&D. This depends on the UK's ability to build upon its sources of relative technological strength and the ability of foreign businesses to access these.

- **Developing new R&D intensive sectors through the creation and growth of R&D intensive SMEs:** Several indicators suggest that the number of R&D intensive small and medium sized businesses is growing in the UK, including in sectors where the UK has historically fared less well, e.g. IT. R&D amongst small and medium sized firms has risen strongly compared to total business R&D. Amongst those who are most likely to be eligible for the tax credit for small and medium companies, growth in R&D has been even stronger with an increase of 100% between 1998 and 2003. Although SMEs as a group account for a relatively modest share of total UK business R&D (independent SMEs account for around 3%), the sector has the potential to launch some firms which will eventually turn into the large R&D intensive firms that the UK currently appears to lack. Much depends on the opportunities they face and whether they can find multiple applications for the technologies developed through the firm's R&D effort; or the development of a specific product with significant global market potential. Policies to stimulate these firms' R&D efforts provide one element of a successful policy mix, but success is likely to depend on a wider range of policies, such as those to promote economic stability, entrepreneurship, effective supply chain relationships, managerial and technical skills and innovation friendly regulation.

# I. Introduction

Although R&D is only one measure of innovation performance (box one), various studies have shown that investment in R&D is an important source of productivity growth. As a result R&D investment is a major policy priority in many countries. At Barcelona in 2002, EU Heads of Government set a target for EU R&D to reach 3% of GDP by 2010, with two thirds to come from business. In response, many EU states set national R&D targets, including the UK. In the ten-year Science and Innovation framework, the UK set a long-term ambition to increase the R&D to GDP ratio from 1.9% to 2.5% by 2014[1]. This would put the UK amongst the EU's leading economies (Figure 1).

**Figure 1**
**R&D as share of GDP implied by Government's long term ambition**




Source: DTI estimates.

1 DTI/DFES/HMT (2004)

**Box one:**
**Business R&D as a measure of innovation**

R&D is only one, albeit important, measure of innovation performance. Other measures have been developed using patent data and innovation surveys. Unlike some other innovation indicators, R&D measures an input not an output. R&D is a measure of technological innovation and does not capture non-technological aspects. For example, UK innovation surveys suggest that R&D accounts for around 40% of all innovation expenditures. Other innovation related expenditures include design, training, marketing and acquisition of machinery and equipment.

R&D expenditure tends to be concentrated in relatively few sectors (ONS, 2004). So in the first instance, R&D expenditures are only likely to influence firm performance in those sectors where R&D is considered to be an important input. Longer lasting effects do occur because products, embodying R&D inputs, may often be used in the processes of other firms through a process of diffusion. Or R&D workers may apply the knowledge gained to generate new applications in different markets.

Most of the economic benefits are likely to occur during this process of diffusion. The rate of diffusion of new technologies will depend upon the costs of exploiting and adapting the new technology and the performance improvement it brings. This is likely to depend on a wide range of factors, such as the availability of skills and finance, competitive pressures and the type and degree of regulation. An assessment of these wider influences on the UK's economic performance was set out in a recent DTI publication, DTI (2003).

The scenario illustrated in the ten-year framework envisages that R&D performed in business (BERD) could reach 1.7% of GDP by 2014 with publicly performed R&D (in Higher Education and Government laboratories) making up the balance.

Such an ambition implies a real increase in R&D expenditure of around £15 billion from an estimated £21 billion per annum in 2004 to £36 billion per annum in 2014[2] (Figure 2).

2 This assumes that the R&D intensity in 2002 – latest available year – remains constant until 2004 and that GDP increases in line with HM Treasury forecasts of the UK's trend rate of growth. Expenditures in 2002 prices.

**Figure 2**
**Increase in R&D implied by 2.5% GDP ambition**


Source: DTI estimates.

Achievement of this ambition largely depends on the private sector making substantial additional investments in R&D. As the framework set out, the required growth in business R&D would need to be delivered through a combination of:

- Maintaining or growing R&D where the UK is strong;
- Attracting investment into the UK from multinationals in an already internationalised system;
- Increasing R&D intensity in firms or sectors that are lagging behind their peers; and
- Developing new R&D intensive sectors through the creation and growth of R&D intensive small and medium sized enterprises (SMEs).

To understand how to achieve these ends, the Government has established a regular forum between Ministers, business leaders and scientists. This forum will support the goal of improving the UK's R&D and innovation performance, and will contribute directly to the evidence informing future public spending decisions on investment in the science base and technology development. This paper provides an updated assessment of UK business R&D across sectors to inform debate at the forum's next meeting. It forms part of a broader annual assessment by the Government of the UK's performance across the full range of outputs and attributes of the UK's science and innovation system.

# II. UK R&D – headline trends

Total UK R&D currently stands at 1.9% of GDP, having stabilised and then risen slightly from its nadir of 1.8% in 1998. This follows some decades of decline in total R&D intensity. In real terms, i.e. taking into account inflation, total R&D in the UK has increased steadily since 1981, with an average annual growth rate of about 1.5%. But total UK R&D spending as a percentage of GDP has fallen since then as growth in R&D expenditures have not matched GDP growth rates.

**Box two**
**Data sources for measuring business R&D**

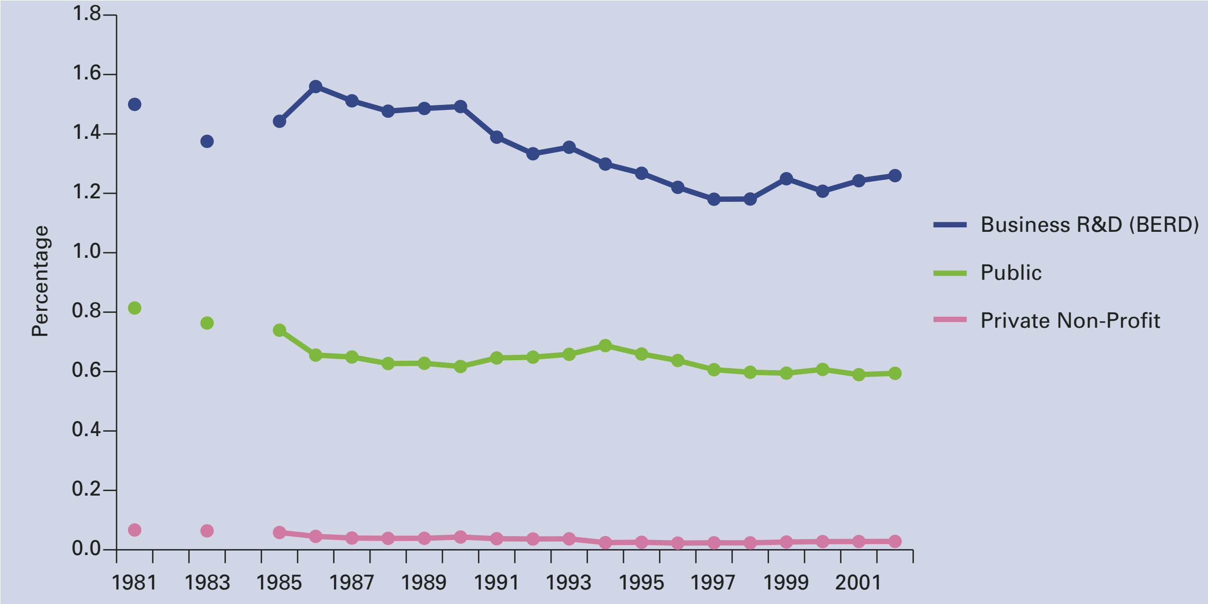
The main data sources on business R&D in the UK are:

- Data from the Business Enterprise R&D (BERD) survey, which is an annual survey of known R&D performers. This only covers R&D performed in the UK. Key points from the 2004 ONS BERD survey are set out in box three. Similar surveys are also carried out in other OECD countries. Standard practices to ensure comparable data for international comparisons are set out in Annex A.
- Company accounts data contained within the UK R&D scoreboard. This source captures most of the major UK spenders, although a number of small R&D performers will not be included. This data source includes expenditure on R&D financed by the company but performed abroad. It includes R&D reported by UK owned groups. Where UK owned groups do not report R&D, it includes R&D by subsidiaries if this information is available. It also includes UK operations of foreign owned groups if sufficient information is available in the group's accounts.

Differences between these two sources are set out in Annex B.

Slower growth in total R&D has been significantly due to trends in business performed R&D. Between 1981 and 1997 business R&D as a percentage of GDP fell from 1.5% to just below 1.2%. After 1997, business R&D as a percentage of GDP stabilised and started to show signs of recovery. Between 1981 and 2002, publicly performed R&D declined from 0.8% of GDP to 0.6% of GDP (Figure 3).

**Figure 3**
**Components of UK R&D as a % of GDP**




Source: OECD Main Science & Technology Indicators (MSTI)

The UK's relative R&D performance can be broken down into two distinct phases.[3] Between 1981 and 1990 the difference between total US expenditure on R&D and total UK expenditure widened by approximately 0.54% of GDP (Table 1).[4] Differences in government funding of R&D are a significant cause of differences in total R&D – approximately 80% of the gap between the UK and US is due to differences in government funding. This largely reflects cuts in UK defence expenditure.

**Table 1**
**Explaining the gap between UK and US R&D**

| | 1981–1990 | | 1990–2000 | | 1981–2000 | |
|---|---|---|---|---|---|---|
| **Total gap (% of GDP)** | **-0.54** | | **-0.34** | | **-0.88** | |
| Of which: | | | | | | |
| BERD | -0.25 | | -0.40 | | -0.65 | |
| *(Industry-funded)* | | *(-0.09)* | | *(-0.52)* | | *(-0.61)* |
| *(Government-funded)* | | *(-0.16)* | | *(0.12)* | | *(-0.04)* |
| GOVERD | -0.20 | | 0.03 | | -0.17 | |
| *(Industry-funded)* | | *(-0.02)* | | *(0.00)* | | *(-0.02)* |
| *(Government-funded)* | | *(-0.18)* | | *(0.03)* | | *(-0.15)* |
| HERD | -0.05 | | 0.05 | | 0.00 | |
| *(Industry-funded)* | | *(0.01)* | | *0.00* | | *(0.01)* |
| *(Government-funded)* | | *(-0.06)* | | *(0.05)* | | *(-0.01)* |
| Other | -0.04 | | -0.02 | | -0.06 | |
| ***Total industry-funded*** | ***-0.10*** | | ***-0.52*** | | ***-0.62*** | |
| ***Total government-funded*** | ***-0.40*** | | ***0.20*** | | ***-0.20*** | |

Note: Totals may not sum exactly due to rounding.
Source: Griffith and Harrison 2003

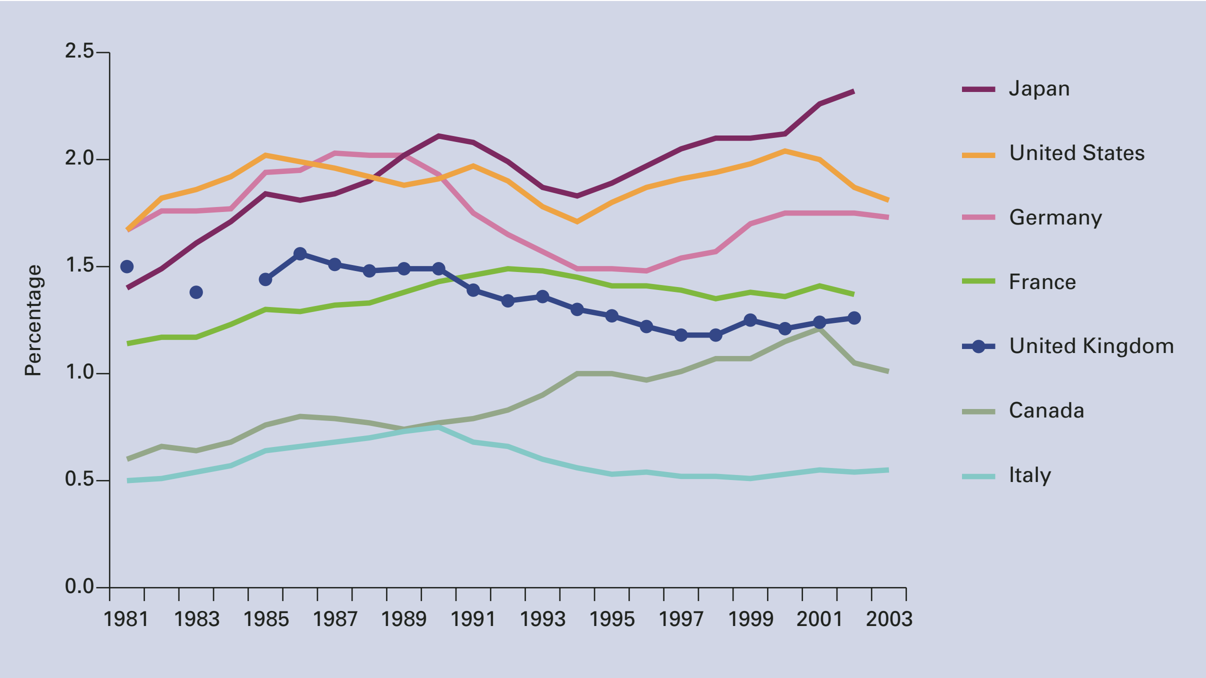
3 Griffith and Harrison (2003)

4 Total UK R&D intensity fell from 2.38% to 2.16% whereas US intensity rose from 2.34% to 2.66%. The change in the gap over this period is therefore (2.38-2.16)+(2.66-2.34) or 0.54.

Between 1990 and 2000 the difference between total US and UK expenditure on R&D widened by a further 0.34% of GDP. But during this period, the UK's R&D performance compared to the US was almost entirely due to lower growth in R&D conducted and funded by UK businesses. The UK's relative decline in business funding and performance of R&D during the 1990s was due to lower within sector growth, largely concentrated within a few manufacturing industries, particularly those related to machinery, equipment and transportation, rather than a shift in output towards low R&D sectors. Taking both periods together, the most significant factor behind the UK's R&D performance has been the relative decline in industry funding of R&D.

Generally, other G7 economies have seen a constant or growing ratio of business R&D to GDP. Therefore, relative to their competitors in these countries, UK businesses have become less R&D intensive (Figure 4).

**Figure 4**
**Business R&D as a % of GDP, G7 countries**

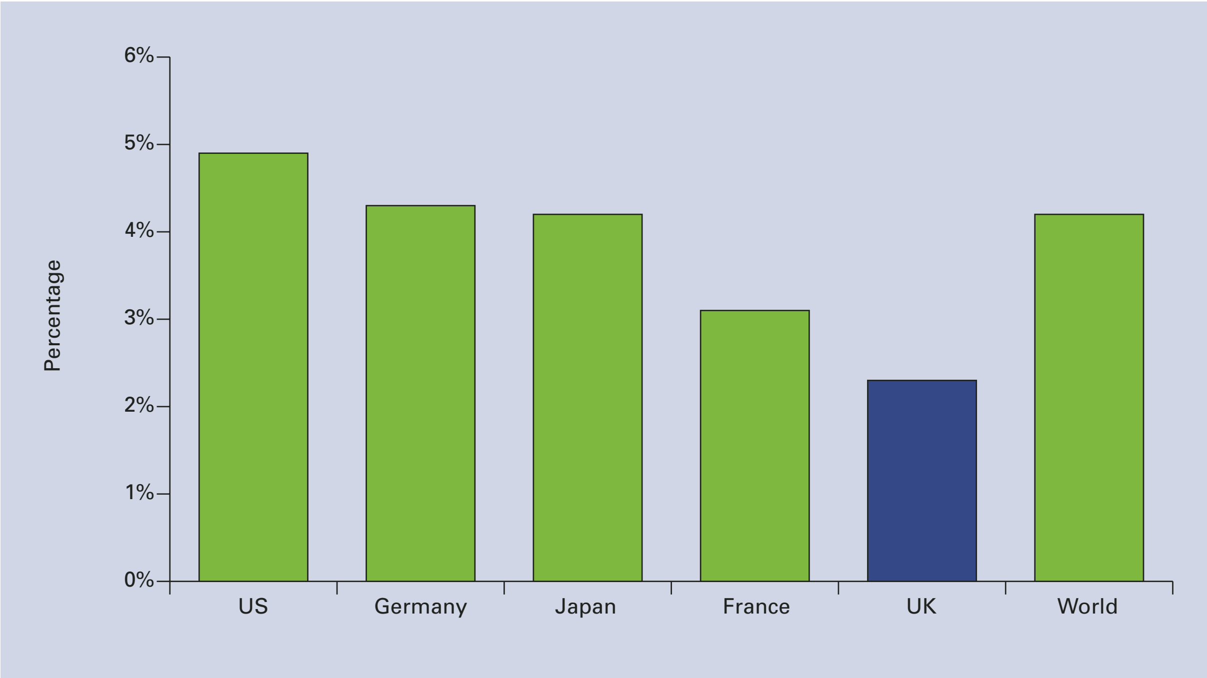



Source: OECD MSTI

Analysis of the R&D scoreboard[5] also shows that there are very different R&D intensities between countries' largest R&D spenders (Figure 5).

5 DTI/Company Reporting (2004a). The R&D scoreboard identifies 700 of the worlds largest R&D spending companies

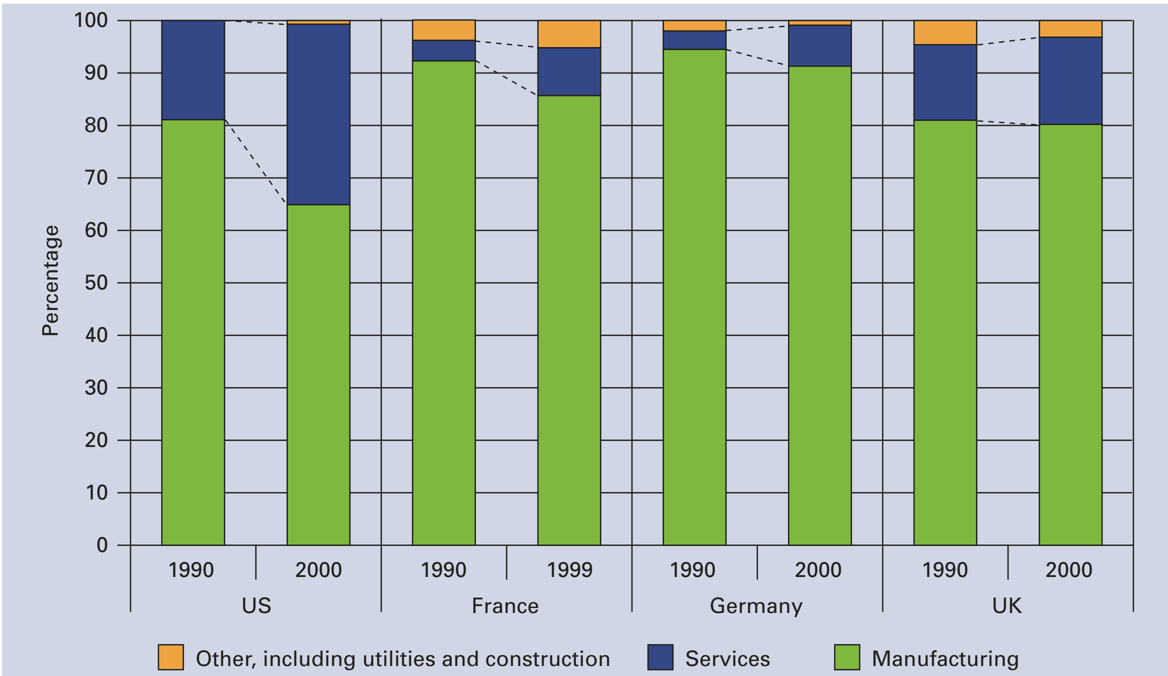
**Figure 5**
**International comparisons of R&D Intensity (R&D/Sales)**




Source: DTI R&D Scoreboard 2004 (International 700)

One reason for differences in R&D intensity between the UK and US has been the rapid growth of US service sector R&D, mainly due to increased R&D in the wholesale and retail trade sector (Figure 6).

**Figure 6**
**Share of R&D in manufacturing and services, 1990, 2000 or latest year**




Source: OECD, ANBERD database

It seems likely, however, that a significant factor behind US growth in service sector R&D lies in different methods of data collection.[6] The very large increase in R&D in the US wholesale and retail trade sector is, we believe, largely a result of several large manufacturing firms moving production offshore, leaving a residual R&D and sales function in the US. This has led to the R&D being reclassified, for statistical purposes, as belonging to the retail and wholesale trade sector. This sector accounts for nearly 13% of all US business R&D (Table 2).

**Table 2**
**Share of business R&D accounted for by services, latest year**

| Country | Share of total business R&D accounted for by services (%) | Share of total business R&D accounted for by wholesale and retail trade (%) |
|---|---|---|
| UK (2001) | 18.8 | 0.4 |
| US (2000) | 34.4 | 12.6 |

Source: OECD STI Outlook (2004)

However, in the UK, which uses a different methodology, the R&D would still be allocated to manufacturing. The implication of this is that, if the US adopted the UK's approach, manufacturing R&D would be higher during the period and service sector R&D would be somewhat lower. Without access to detailed US statistical records it is difficult to determine exactly the extent to which R&D for manufacturing purposes is under-estimated in the US. But, if we assume that the share of UK R&D accounted for by the wholesale and retail trade is a truer reflection of the R&D invested in these products, then up to one third of all US service sector R&D could in fact be directed at manufacturing purposes.[7]

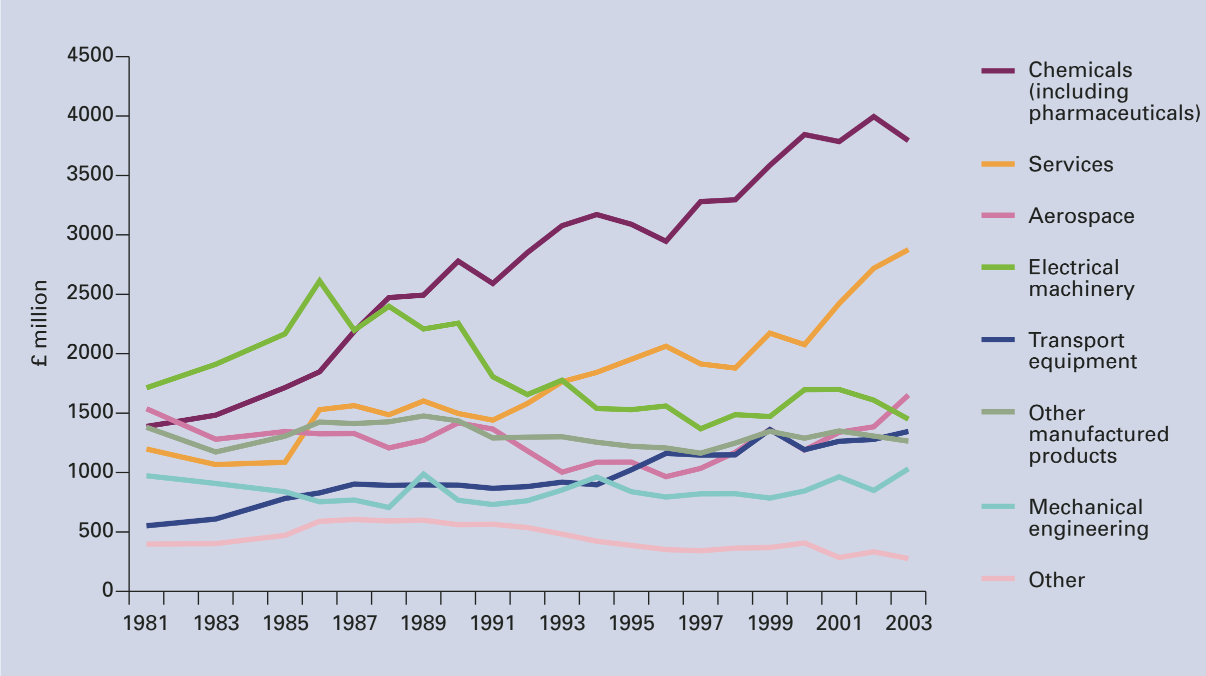
## Changes by sector in UK business R&D

By broad product group, increases in real UK business R&D between 1981 and 2003 have been largely due to increased expenditure in chemicals (including pharmaceuticals), transport equipment and services (Figure 7).

6 Countries can classify R&D by sector, using a standard industrial classification, or by product group – which represents the intended use of the R&D. These two methods give very different results. For example using a sector method the R&D of an aeronautics firm would be entirely attributed to the aerospace sector. A product group definition allows firms to attribute the same R&D to a wide variety of product groups such as aerospace, mechanical engineering or instruments. Unlike the UK, the US attributes a firm's R&D according to the firm's sector classification. See annex A.

7 The UK figure is not too far out of line with other, particularly European, countries. OECD (2004a). The US is not unique however. Other countries also report very high shares of R&D accounted for by retail and wholesale trade, e.g. Canada and Denmark.

**Figure 7**
**Real terms UK business R&D by broad product groups (£ million)**



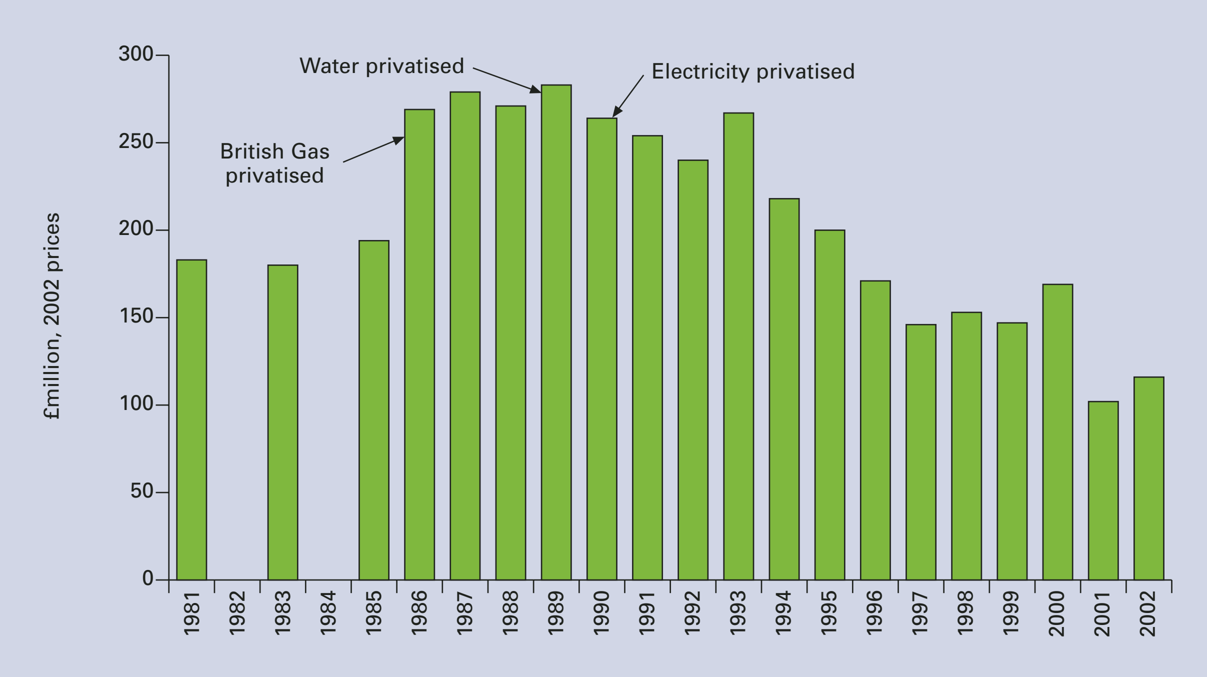

Source: ONS

Privatisation of the nationalised utilities appears to have had a modest impact on total UK business R&D performance. Business R&D in the electricity, gas and water supply product group[8] fell, in real terms, from £183m in 1981 to £116m in 2002 – a fall of 37%. The most significant decline in R&D occurs post 1993, some time after privatisation[9] (Figure 8). If the R&D in the electricity, gas and water supply product groups had remained at 1993 levels, total business R&D in 2002 would be £151m higher in real terms. And the UK's business R&D to GDP ratio would have been 1.25%, not 1.24%, in 2002.

8 This product group captures most of the activities of the privatised utilities. It includes: the production, distribution and supply of electricity; the manufacture and distribution of gas; steam and hot water supply and the collection, purification and distribution of water. However R&D related to the extraction of gas is not included in these figures.

9 British Gas was privatised in 1986. Electricity privatisation took place in 1990 and Water was privatised in 1989.

**Figure 8**
**R&D performed by the business sector: Electricity, Gas & Water supply product group**



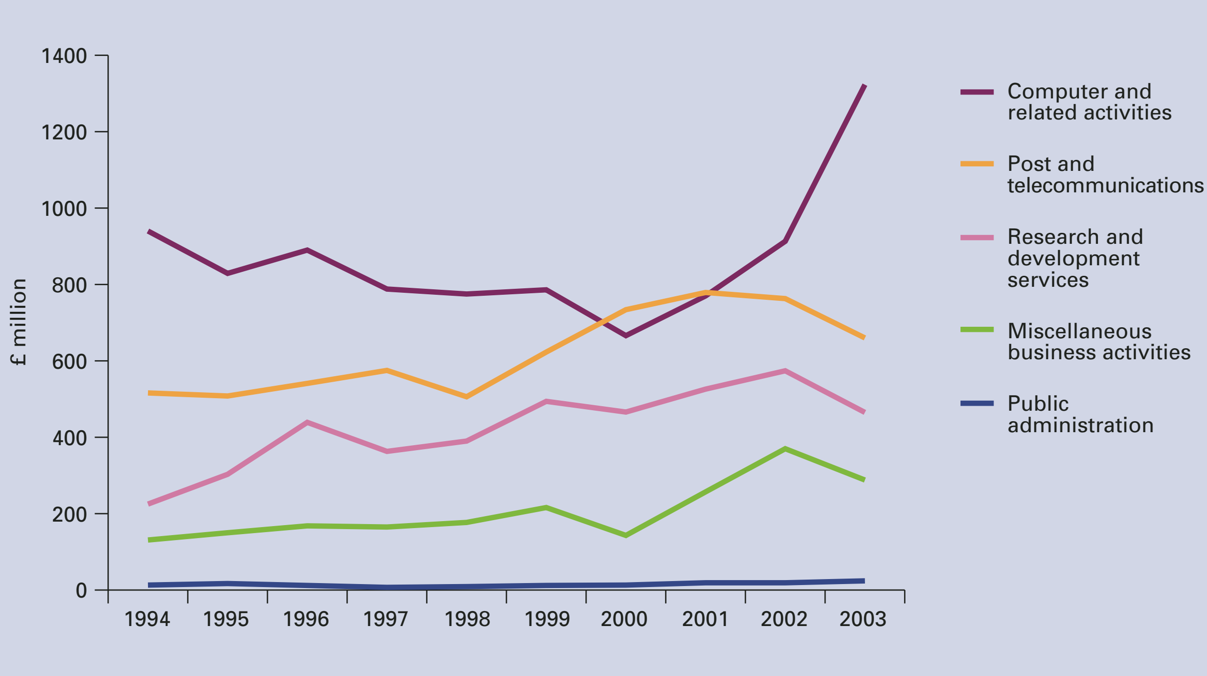

Source: ONS.

It is likely that the R&D carried out by the nationalised utilities contained a 'public good' element, which as monopolies they could finance by charging higher prices to consumers. This research would have been long term, relatively high risk and potentially unattractive to private investors. And would often have been carried out at the Government's request. The data shows that immediately after privatisation, levels of R&D remained broadly unchanged. But after 1993, significant cuts in R&D took place. This coincided with a period of cuts in real utility prices and increasing competition in supply.

Real R&D increased in most service sector product groups, although recently the most significant increase occurred in computer related activities (Figure 9).[10]

10 Further investigation of these figures suggests that at least part of the reason for the large recent increase in computer related activities was the reclassification of existing R&D to these product groups.

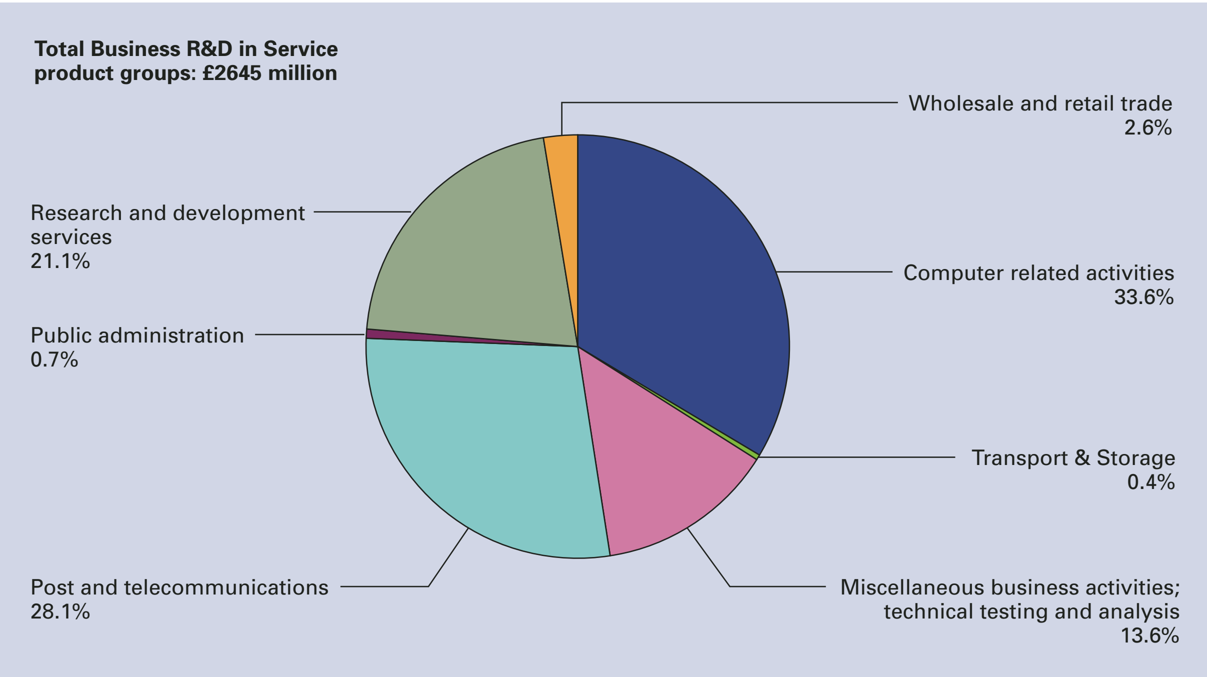
**Figure 9**
**Real terms UK business R&D in service sector product groups (£ million)**




Source: ONS

A detailed breakdown of service sector R&D shows that the product groups that account for the largest proportion of service R&D are computer related services, post and telecommunications and R&D services (Figure 10).

**Figure 10**
**UK business R&D in service product groups 2002**




Source: ONS

The growth in R&D in service sector product groups clearly reflects changes in the nature of innovation and patterns of demand. New R&D intensive industries have emerged – e.g. software – which can count towards service R&D. Growth in R&D services may also reflect growth in the market for contract R&D.

# III. Why is UK business R&D relatively low?

Within any industry firms are only likely to invest in R&D if they can earn sufficiently high profits to cover the cost of that R&D spending. Industries will differ in the extent to which customers are willing to pay for performance improvements caused by an increase in R&D spending. And differences in the scope and effectiveness of intellectual property protection will also affect returns to a company's R&D. This can lead to differences in R&D intensities between sectors.

Sector differences also occur because of differences in technological opportunities and the extent to which technology development falls inside or outside the definition of R&D.[11] More generally, R&D will be highest where the potential opportunities for technological innovation are greatest. This is most likely to be the case where both the market and the underlying technology (or combination of technologies) are relatively new. R&D will also be higher where the product is research based rather than engineering based and where there are rapid developments in the underpinning science.

**Table 3**
**R&D to value added ratio by sector**

| Technology Intensity | Industry | France | Germany | United Kingdom | United States |
|---|---|---|---|---|---|
| | TOTAL MANUFACTURING | 6.9% | 7.7% | 6.0% | 8.5% |
| High – tech | Pharmaceuticals | 26.3 | 23.6 | 54.1 | 20.2 |
| | Office, accounting and computing machinery | 13.4 | 16.5 | 3.9 | 30.7 |
| | Radio, television and communication equipment | 33.2 | 32.3 | 13.5 | 18.6 |
| | Medical, precision and optical instruments, watches and clocks | 16.5 | 10.7 | 9.1 | 30.2 |
| Medium – high tech | Chemicals excluding Pharmaceuticals | 7.1 | 12.3 | 6.7 | 8 |
| | Machinery and equipment, n.e.c. | 5.3 | 5.5 | 5.7 | 5.5 |
| | Electrical machinery and apparatus, n.e.c. | 6.8 | 3.3 | 7 | 9.6 |
| | Motor vehicles, trailers and semi-trailers | 13.8 | 21.4 | 10.3 | 15.4 |
| | Other transport equipment | 24.8 | 33.4 | 18.4 | 17.5 |
| Medium – low tech | Coke, refined petroleum products and nuclear fuel | 2.4 | 0.9 | 6.6 | 3.1 |
| | Rubber and plastics products | 5.1 | 3 | 0.7 | 2.9 |
| | Other non-metallic mineral products | 2.4 | 2.5 | 1 | 2.2 |
| | Basic metals | 3.6 | 1.6 | 1.4 | 1.2 |
| | Fabricated metal products, except machinery and equipment | 0.7 | 1.3 | 0.6 | 1.8 |
| Low tech | Food products, beverages and tobacco | 1.2 | 0.6 | 1.3 | 1.1 |
| | Textiles, textile products, leather and footwear | 1 | 2.1 | 0.4 | 0.5 |
| | Wood, paper, printing, publishing | 0.3 | 0.3 | 0.2 | 1.6 |
| | Manufacturing n.e.c. | 2.5 | 1.5 | 0.4 | 1.3 |

Source: Business Enterprise Research and Development (BERD) 2000

11 Cohen (1995)

For example, sectors such as pharmaceuticals, instruments and office and computing machinery typically have very high ratios of R&D to value added (Table 3). On the other hand sectors such as wood products or textiles have very low ratios.[12] A country's industrial specialisation will therefore influence its overall business R&D intensity; and differences in business R&D intensity between countries may reflect differences in industry specialisation.

**Box three**
**R&D is not a good measure of innovation in some sectors**

The fact that some industries carry out little or no R&D should not lead to the conclusion that they do not innovate. Many of these industries are highly capital intensive. It is likely, therefore, that these industries receive R&D inputs embodied in the plant and machinery they purchase. This plant and machinery will be used to produce new products or lead to the development of new processes in that industry. In addition, some expenditure on technology is not included in the official definition of R&D. Sectors which rely on such technologies may undertake more technological innovation than their R&D intensity would suggest.

Other industries will be heavily reliant on other inputs. For example, the design of products is especially important in financial services but it may not involve any R&D. Other services – e.g. retail – have seen considerable innovations in the way shops are built, organised and run but these have mainly involved changes in design (e.g. move to bigger stores), changes to processes (e.g. supply chain management) or the introduction of ICT (e.g. stock control). All these innovations may have been facilitated by advances in Science and Technology, caused by investments in R&D in another industry, but their application has not involved large investments in R&D, as defined.

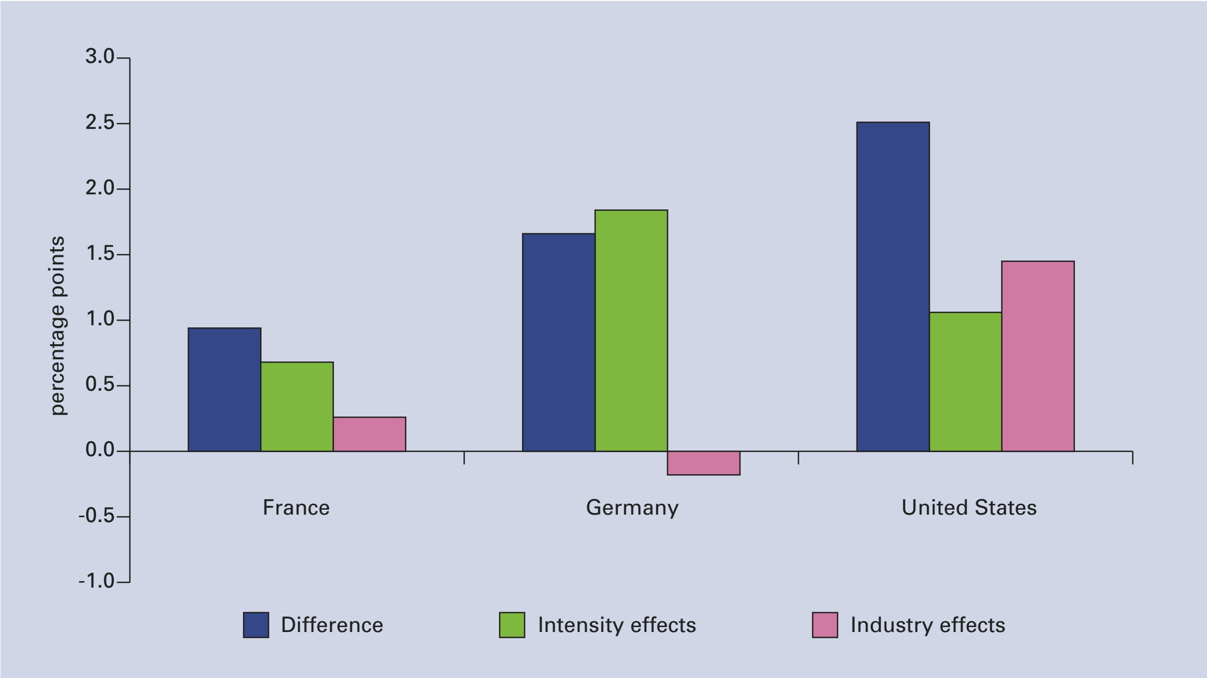
Country differences in sector intensities may reflect either differences in the propensity of businesses to do R&D; differences in the intensity of their R&D effort; or differences in the global distribution of production. We take as our starting point the analysis in the ten-year Science and Innovation framework. This showed that UK manufacturing sectors had significantly lower R&D intensities compared to the same sectors in competitor countries[13] (Figure 11). This was especially true in sectors related to motor vehicles, medical, precision and optical instruments, IT and electronics[14] (Figure 12).

12 Volumes of R&D expenditure by low R&D intensity firms can, however, be substantial. For example, according to the R&D scoreboard, Shell spent £326.4 million on R&D in 2003/04 earning it 9th place in the UK Scoreboard. But its sales were £113 billion. Hence Shell's low R&D intensity.

13 Although between 1991 and 2000, differences in intensities within sectors between the UK and US and between the UK and France narrowed (see annex C).

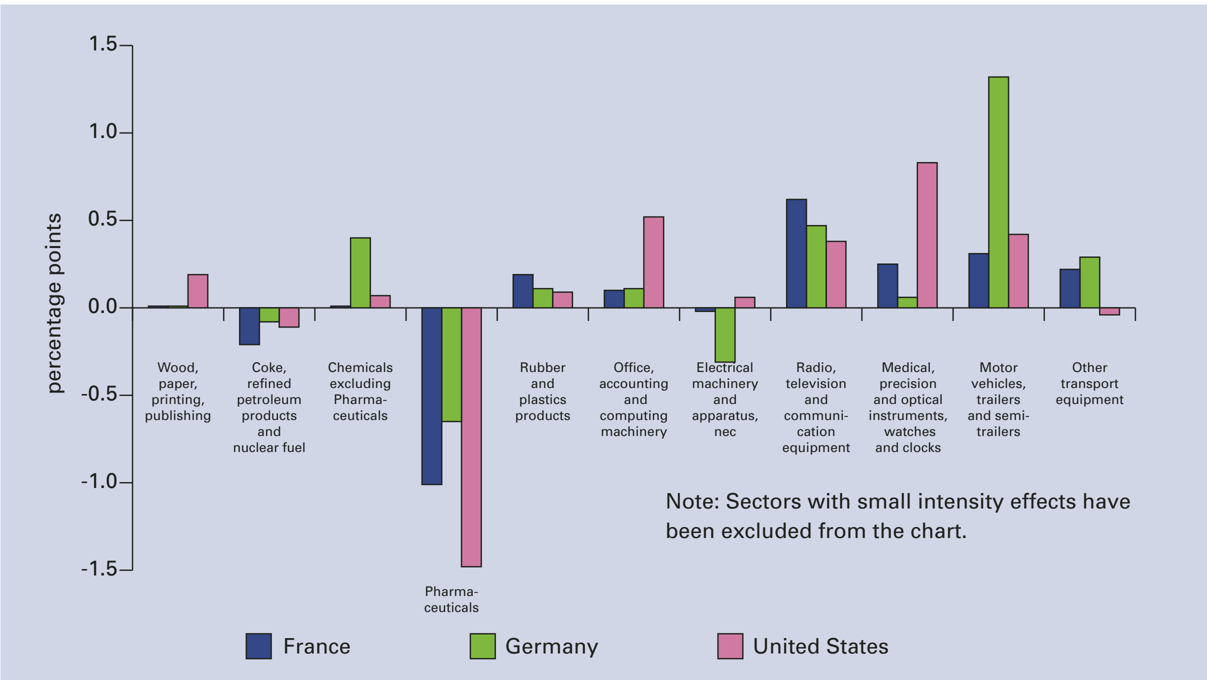
14 Manufacturing accounts for the majority, around 80%, of all R&D. We deliberately left out service sectors from this analysis because of the known difficulties of ensuring data comparability particularly between US and other countries. Decompositions between the UK and France and UK and Germany, including services, produce similar results. See Abramovsky et al (2004).

**Figure 11**
**Differences in manufacturing R&D as a % of value added between UK and competitors: industry and intensity effects, 2000**




Source: DTI estimates, OECD

**Figure 12**
**Differences in manufacturing R&D intensity between UK and competitors caused by differences in sector R&D intensities, 2000**




Source: DTI estimates, OECD

On their own, however, these sector comparisons of R&D intensities do not tell us **why** UK business R&D is relatively low in the sectors. Sectors are aggregates of firms who may perform R&D or may not. Sectors are also broad and are likely to contain a range of activities, some will be R&D intensive and others will be less so. Differences in R&D intensities between UK sectors and the same sectors in France, Germany and the US could be due to at least three reasons:

- UK based firms that do R&D may not do enough;
- Within some sectors, the UK has fewer R&D performers, particularly large ones; and
- Large foreign owned firms are more likely to get their R&D input from overseas than UK owned firms.

## Is it the case that UK firms that do R&D do not do enough?

The R&D Scoreboard provides information on the largest 700 UK R&D performing businesses, which can be used to calculate R&D as a percentage of sales for individual firms.[15] These are predominantly UK owned firms but they do include UK subsidiaries of foreign owned groups. The R&D Scoreboard also includes data on the largest 700 R&D performing firms worldwide, which permits some international comparisons. Forty-one UK owned firms, accounting for a large proportion of UK R&D in the Scoreboard, are included in the international comparisons.[16]

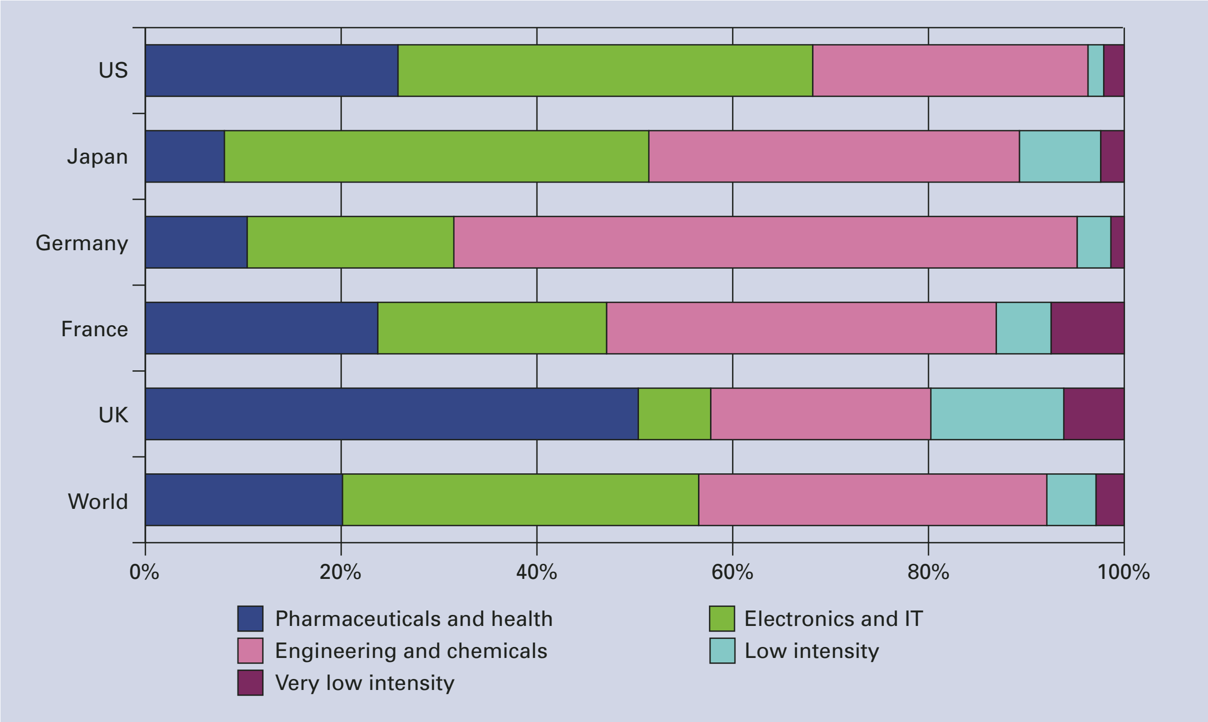
Compared to other countries' firms in the international element of the R&D Scoreboard, the largest UK businesses are highly concentrated in pharmaceuticals and aerospace – very R&D intensive sectors – and low intensity sectors such as food producers, utilities and natural resource based companies (Figure 13).[17]

15 In principle, different countries' business surveys could provide data at this level of disaggregation but issues of data confidentiality and the difficulty of gaining access to foreign data at this level makes this data source impractical.

16 The 41 UK firms in the international 700 accounted for R&D totalling £10.6 billion or 64% of the amount reported by all 700 UK companies in the R&D Scoreboard.

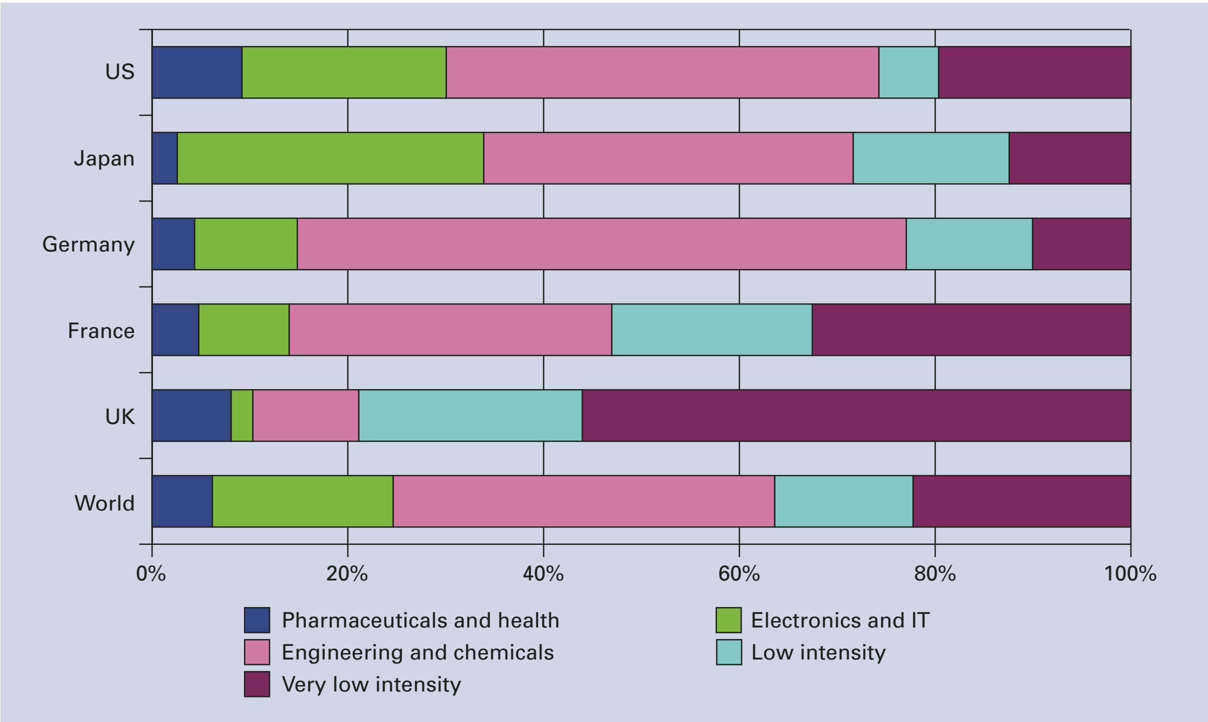
17 The five groups used in this analysis are set out in annex D.

**Figure 13**
**Proportion of R&D expenditure in each sector**




Source: DTI R&D Scoreboard 2004

**Figure 14**
**Proportion of sales in each sector**




Source: DTI R&D Scoreboard 2004

Overall R&D intensity also depends, however, on the distribution of sales. Here the least R&D intensive group has a major impact on the overall R&D intensity for the largest UK R&D performers. Firms in the two lowest intensity sectors account for nearly 80% of all sales of UK owned firms in the International R&D Scoreboard (Figure 14).

We can quantify this effect using a method called shift-share analysis. This method breaks down differences in R&D intensity between two groups of firms into two contributing factors. The first is the contribution due to differences in R&D intensity levels between firms in the same industry, and the second is the contribution attributable to the difference in industrial makeup of R&D performing businesses.

**Table 4**
**Accounting for differences in R&D intensity**

| Comparison | Difference in intensity | Explained by intensity levels within industries | Explained by differences in industrial structure |
|---|---|---|---|
| UK vs France | -0.79% | 0.25% | -1.04% |
| UK vs Germany | -1.99% | 0.33% | -2.32% |
| UK vs Japan | -1.89% | 0.66% | -2.54% |
| UK vs US | -2.62% | 0.27% | -2.89% |
| UK vs World (excl UK) | -2.03% | 0.32% | -2.35% |

Source: DTI R&D Scoreboard 2004 (International 700)

This shows that the difference in R&D to sales ratio between UK R&D performers and R&D performers in each of the other countries is entirely attributable to differences in the industrial mix of R&D performing businesses (Table 4). In fact, more than the total difference in overall R&D to sales ratio can be explained by this effect. This means that, on average, the largest UK owned R&D performing businesses within any given sector tend to spend slightly more on R&D as a percentage of sales than their foreign counterparts. Although, the average masks some differences: UK owned firms tend to have a slightly higher R&D to sales ratios in pharmaceuticals and health and slightly lower R&D to sales ratio in electronics and IT (Table 5).

**Table 5**
**R&D Intensity by sector**

| Group | US | Japan | Germany | France | UK | World |
|---|---|---|---|---|---|---|
| Pharmaceuticals and health | 13.9% | 13.2% | 10.3% | 15.5% | 14.5% | 13.6% |
| Electronics and IT | 10.0% | 5.8% | 8.7% | 7.9% | 7.7% | 8.2% |
| Engineering and chemicals | 3.1% | 4.2% | 4.4% | 3.8% | 4.8% | 3.8% |
| Low intensity | 1.3% | 2.2% | 1.1% | 0.8% | 1.4% | 1.5% |
| Very low intensity | 0.5% | 0.8% | 0.6% | 0.7% | 0.3% | 0.5% |

Source: DTI R&D Scoreboard 2004 (International 700)

We can extend this analysis to a wider set of firms. The R&D Scoreboard also provides sufficient information to compare firms in the UK 700 with an R&D Scoreboard containing the top 1000 US companies in terms of R&D expenditure. The UK data includes the activities of foreign owned subsidiaries; the US data includes foreign firms if they have a US listing.

The R&D intensities of firms within each sector are fairly similar between the UK and the US firms in the three low intensity groups. But the UK firms have a higher intensity in pharmaceuticals and health and a lower intensity in electronics and IT. The sales distribution of the UK firms is more heavily weighted towards the low intensity sectors compared to the sales distribution of the US firms. This, together with the fact that the group intensities are similar, suggests that the difference in overall intensities is largely due to differences in the industries they operate in. In particular, it appears that the strong US performance relative to the UK is largely attributable to its large weight of sales in electronics and IT and engineering and chemicals (Table 6).

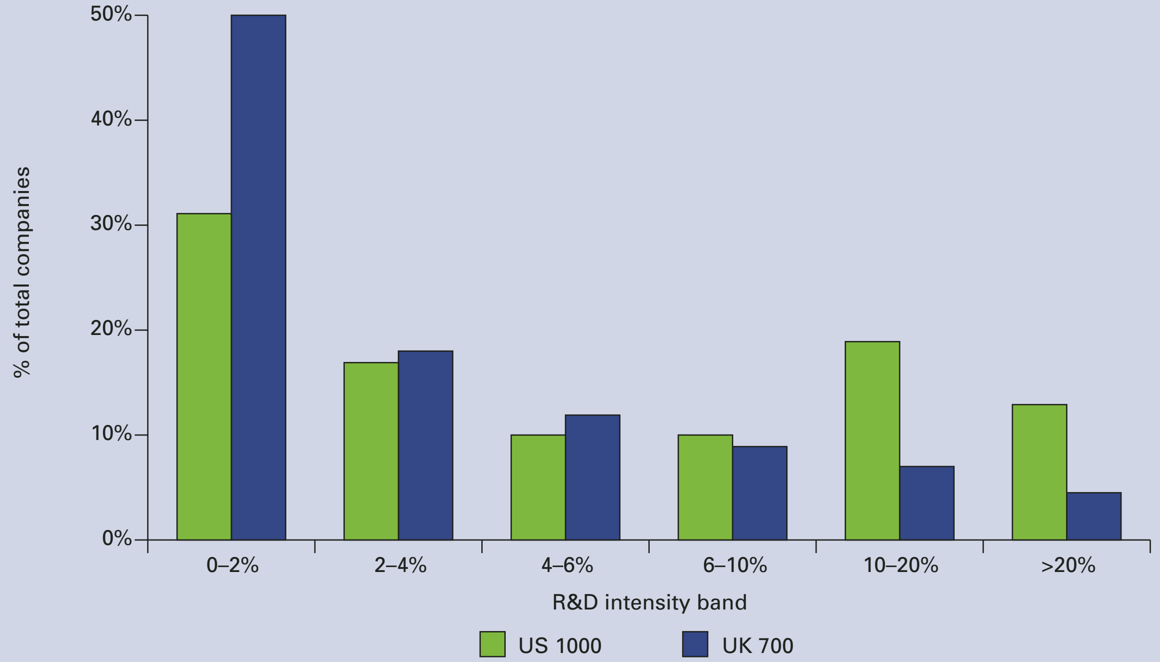
**Table 6**
**R&D intensity and share of sales by sector**

| | Group 1 Pharmaceuticals & biotechnology and Health | Group 2 Electronics & Electrical and IT Hardware | Group 3 Engineering & Chemicals | Group 4 Low intensity sectors | Group 5 Very low intensity sectors |
|---|---|---|---|---|---|
| **UK-700** ($I_T$ = 2.1%) | | | | | |
| Proportion of R&D expenditure | 41.3% | 13.7% | 28.1% | 11.8% | 5.1% |
| Proportion of Sales | 6.0% | 6.0% | 16.1% | 26.6% | 45.3% |
| Intensity | 14.5% | 4.9% | 3.7% | 0.9% | 0.2% |
| **US-1000** ($I_T$ = 4.5%) | | | | | |
| Proportion of R&D expenditure | 21.7% | 45.5% | 26.2% | 3.9% | 2.7% |
| Proportion of Sales | 9.0% | 21.3% | 34.7% | 14.6% | 20.3% |
| Intensity | 10.8% | 9.6% | 3.4% | 1.2% | 0.6% |

Source: DTI R&D Scoreboard 2004, US Industrial R&D Scoreboard

The R&D Scoreboard also groups UK and US businesses within particular R&D intensity bands. In this analysis, UK firms are only included in the comparison if their R&D spending exceeds $1million (around £560k) and their sales exceed $100 million (£56 million). This is the minimum cut off for entry into the US Scoreboard. The distribution of businesses largely reflects the different industrial mix of the two countries' R&D performing businesses. So we see that the UK, which has a less R&D intensive industrial mix, has a heavier concentration of firms in low R&D intensity bands (Figure 15).

**Figure 15**
**R&D intensity distributions for US and UK companies**

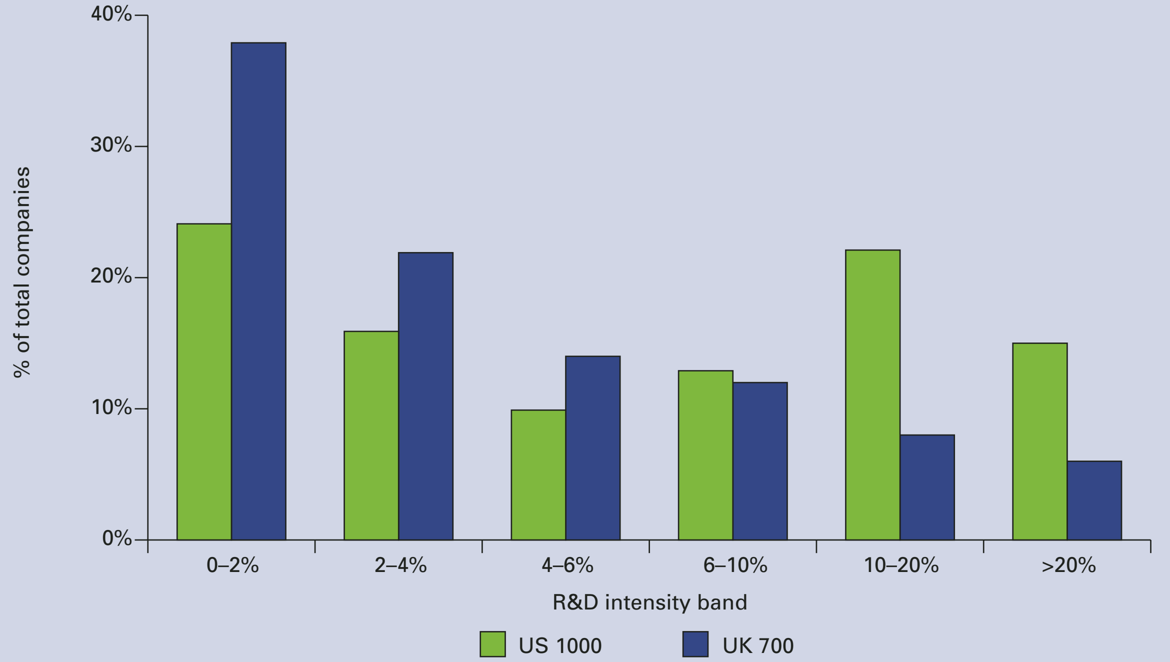



Note: Contains UK and US firms with R&D exceeding £560K and sales exceeding £56 million.

Source: DTI R&D Scoreboard 2004

The R&D Scoreboard also repeats the analysis for medium sized firms, defined to be those with sales between £56m and £500m. The difference, with US firms more concentrated in higher R&D intensity bands, again largely reflects differences in industrial mix (Figure 16). However a higher proportion of UK medium-sized firms are in the highest R&D intensity bands compared to the UK population as a whole (14% compared to 11%). This suggests that UK midsized firms that undertake R&D are concentrated in more R&D intensive industries than the larger UK companies in the UK 700. This reflects the UK's bias towards larger firms being in less R&D intensive sectors.

**Figure 16**
**R&D intensity distributions for US and UK: middle sized companies only**




Note: Middle sized companies are defined as having sales between £56m and £500m.

Source: DTI R&D Scoreboard 2004

The industrial scoreboards suggest that, within any sector, UK R&D performers have on average a similar R&D intensity to their competitors in the same sector. This average performance masks a relative UK strength in the pharmaceuticals and health sector and a relative weakness in electronics and IT.

## Within sectors does the UK have fewer R&D performers?

Fundamentally, market characteristics influence firms' R&D investment decisions.[18] If an industry consists of a series of niche markets, where the product is tailored to small group of users, then the incentive for any firm to increase R&D spending may be quite small. This is because the firm can only increase its market share within a small segment of the industry. If the firm can compete for a much larger segment of the market, served by many firms, then the incentive to spend on R&D will be much stronger, since a firm that increases its R&D can potentially capture market share from its competitors. Weaker firms in the industry are forced to exit, because they cannot recoup the costs of higher levels of R&D. In this case, we would expect to see the industry dominated by a few large, R&D intensive firms that produce a relatively narrow range of products.

Dominance of large firms can also occur if the technology has widespread application across a range of markets. A firm is more likely to do R&D if it can spread the results of its R&D across a wide range of markets, and thus sales.

18 Sutton (1998)

For example, advances in aero engines might also find applications in sea transport or power generation. In this case, the industry is likely to contain large firms, which deliver technologically related, but different products to a number of different markets.

One determinant of an economy's R&D intensity is therefore likely to be the activities of its large firms.[19] A relative lack of very large R&D intensive firms in the UK would indicate that UK businesses have not been able to succeed in markets where the returns to R&D are potentially high.

The Value Added Scoreboard sheds light on the activities of the largest UK firms compared to France and Germany.[20] This should give some insight into whether UK firms are well represented in markets likely to be characterised by high levels of R&D spending. Unfortunately, because of differences in accounting requirements value added cannot be calculated for US or Japanese companies and so they do not appear in the Scoreboard. In addition to this limitation, the UK owned firms in the Scoreboard also include foreign activities in their accounts, so not all their output will be generated in the UK. Also, the French or German companies in these comparisons may have significant UK operations which, to avoid double counting, are attributed to the European parent. These results are therefore not necessarily an accurate reflection of the activities of the largest UK based firms. But they are a good indication of the relative specialisation of large UK owned businesses.

The Value Added Scoreboard shows that, outside of Pharmaceuticals and Aerospace and Defence, UK owned firms in the international 600 are more likely to be concentrated in sectors that tend to have lower R&D intensities, such as financial services or extractive industries (Table 7). Relative to France and Germany, it is also clear that the largest UK owned firms are less well represented in sectors such as automotive, IT and software and electronics. All these sectors tend to have high R&D intensities. A full account of the UK's industrial performance is beyond the scope of this paper, but a common feature of all these industries is that UK firms struggled to retain a competitive edge in the past. As a result, the UK firms that operated in these markets either left the market or were taken over by foreign rivals.[21]

19 Cohen W (1995). The relationship between R&D and firm size is a contested one but the consensus appears to be that R&D spending rises proportionately with firm size within industries, whilst the number of innovations tends to increase less than proportionately with firm size and hence R&D productivity tends to decline with firm size. Although R&D productivity – in terms of numbers of innovations per unit of R&D – falls with firm size it is quite possible for the returns to R&D to increase. For example, larger firms can spread the costs and risks of R&D across more output, or large firms may be more able to appropriate more of the rents from R&D.

20 See footnote 15.

21 Owen (1999) provides a comprehensive picture of the troubles that befell these industries after WW II.

**Table 7**
**Distribution of value added in the top 600 European companies by nationality and sector**

| | | R&D Intensity of Industry | UK | France | Germany |
|---|---|---|---|---|---|
| 1 | Pharmaceuticals and Health | 13.6 | 5.9 | 1.9 | 4.5 |
| 2 | Software and Computer Services | 10.3 | 0.5 | 2.0 | 1.1 |
| 3 | IT Hardware | 9.5 | 0.0 | 1.2 | 0.7 |
| 4 | Electronic and Electrical | 6.0 | 0.6 | 2.8 | 7.7 |
| 5 | Aerospace and Defence | 4.6 | 2.1 | 2.6 | 0.0 |
| 6 | Automobile and Parts | 4.3 | 0.5 | 9.6 | 23.8 |
| 7 | Chemicals | 4.1 | 1.4 | 1.7 | 6.5 |
| 8 | Engineering | 2.7 | 1.0 | 0.6 | 7.8 |
| 9 | Media and Entertainment | 2.7 | 4.2 | 7.3 | 1.8 |
| 10 | Diversified Industrials | 2.5 | 0.7 | 1.5 | 2.9 |
| 11 | Other (Real Estate, Personal Care, Household, Textiles, Forestry & Paper) | 2.4 | 0.9 | 3.3 | 1.7 |
| 12 | Telecommunications | 1.6 | 8.9 | 3.0 | 7.0 |
| 13 | Support Services | 1.6 | 7.2 | 3.6 | 3.6 |
| 14 | Food, Beverages and Tobacco | 1.4 | 9.5 | 2.0 | 0.3 |
| 15 | Construction | 1.2 | 3.7 | 9.5 | 1.5 |
| 16 | Steel and Other Metals | 1.2 | 0.5 | 0.9 | 0.5 |
| 17 | Power and Water Production and Distribution | 0.8 | 5.0 | 9.3 | 8.3 |
| 18 | Transport | 0.6 | 5.0 | 5.5 | 4.6 |
| 19 | Extractive Industries | 0.4 | 14.8 | 8.9 | 0.0 |
| | *Leisure and Hotels | 6.1 | 2.0 | 1.1 | 1.1 |
| | *Financial Services | 1.7 | 17.4 | 14.3 | 10.3 |
| | *Retail | 0.8 | 8.3 | 7.6 | 4.2 |
| | ***Total** | **1.2** | **27.7** | **22.9** | **15.6** |
| **TOTAL** | | | **100** | **100** | **100** |
| Industries 1-5 | | | 9.1 | 10.5 | 14.1 |
| Industries 1-10 | | | 16.8 | 31.2 | 56.9 |
| Industries 15-19 | | | 29.0 | 34.0 | 14.9 |

Source: DTI estimates, DTI Value Added Scoreboard 2004, DTI R&D Scoreboard 2004
* These sectors contain a small number of R&D performers that are unlikely to be representative of the sector as a whole. As a result, the R&D intensities in these sectors are likely to be on the high side.

Further, the results may also indicate that lacking success in high R&D spending markets, many UK firms found themselves confined to relatively small niches in these markets or are dependent on R&D embodied in capital inputs purchased from other firms.

There are a number of positive signs that smaller UK based firms are developing a growing presence in markets for R&D intensive goods and services.[22] R&D amongst small and medium sized firms (0-249 employees) has risen strongly in the last few years, especially compared to total business R&D. Growth in R&D amongst independent small and medium sized businesses – who are most likely to be eligible for the R&D tax credit for small and medium companies (box four) – has been even stronger, with over a 100% increase between 1998 and 2003.

22 ONS (2004). Between 1998 and 2003, nominal R&D in small and medium sized firms increased by 45%. Over the same period, total business R&D increased by 35% and nominal GDP increased by 28.5%. As a result, the UK's ratio of business R&D to GDP rose from 1.17% to 1.23%.

## Box four
## R&D tax credits for small and medium companies

The latest monitoring data (including claims received on or before 12 October 2004) show that almost 13,000 claims have been made by SMEs since the scheme was introduced in April 2000. These claims are for around £709 million of support, based on almost £3.4 billion of R&D expenditure. In 2002-03, 4,490 claims were made and support of £255 million was claimed on an estimated £1.2 billion of R&D expenditure. The number of claims is very close to the estimate of 4,500 eligible SMEs made when the scheme was first introduced. For 2003-04 3,200 claims have so far been made, although this should increase as more claims are received.

*Source: Inland Revenue*

The R&D Scoreboard also provides signs of R&D dynamism in smaller UK owned firms. There are 276 UK companies with sales up to £50 million in the UK 700 R&D Scoreboard. The average R&D intensity of these companies is over 18% and over 200 have an R&D intensity exceeding 4% (Table 8).

**Table 8. Sectoral split for R&D intensive UK companies with sales up to £50m**

| Sector | Number of companies with sales up to £50m | Number of companies with R&D intensity over 4% |
|---|---|---|
| Software | 72 | 68 |
| Pharmaceuticals | 56 | 43 |
| IT hardware | 21 | 20 |
| Health | 22 | 20 |
| Electronic & electrical | 19 | 10 |
| Others | 86 | 39 |
| **Totals** | **276** | **200** |

Source: DTI R&D Scoreboard 2004

Analysis of the UK 700 R&D performing firms in the Scoreboard also shows that there are significant differences in the R&D to sales ratio and industrial mix by company size band. The sales of the largest R&D performers tend to be concentrated in less R&D intensive sectors. Smaller firms have larger R&D intensities, which is due to higher shares of activity taking place in more R&D intensive sectors. The smallest companies have a very high R&D intensity: this is due to a number of companies who invest heavily in R&D, but have little or no sales (e.g. high technology start ups) (Table 9).

**Table 9**
**Intensities and sales distributions by size band**

| Sizeband (£m sales) | | 5000 + | 2500 – 4999 | 1000 – 2499 | 500 – 999 | 250 – 499 | 50 – 249 | 0 – 50 |
|---|---|---|---|---|---|---|---|---|
| R&D Intensity | | 1.8% | 1.2% | 2.2% | 4.0% | 3.5% | 4.7% | 18.1% |
| Proportion of sales in each group | Group 1 | 6.1% | 0.0% | 4.9% | 14.3% | 6.0% | 10.3% | 18.0% |
| | Group 2 | 1.0% | 8.5% | 18.0% | 18.3% | 14.3% | 25.6% | 41.2% |
| | Group 3 | 5.8% | 44.5% | 24.9% | 37.1% | 46.6% | 42.5% | 30.4% |
| | Group 4 | 25.5% | 38.9% | 28.6% | 19.4% | 27.4% | 17.2% | 9.4% |
| | Group 5 | 61.5% | 8.1% | 23.7% | 10.9% | 5.6% | 4.3% | 1.0% |
| | | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

Source: DTI estimates, DTI R&D Scoreboard 2004 (UK 700)

The issue is whether some of these firms will eventually turn into the large R&D intensive firms that the UK currently appears to lack. Much will depend on the nature of the markets they serve. If firms are catering for a relatively narrow need and the technologies they use have relatively few applications, then it is likely that they will remain small. Attainment of large size is likely to depend either on finding multiple applications for the technologies developed through the firm's R&D effort; or the development of a specific product with significant global market potential. However, growth will be much more difficult to achieve if the market they serve is relatively mature and dominated by well-established incumbent firms.

## Are large foreign owned firms more likely to get their R&D from abroad?

In one of the sectors in the ten-year framework analysis where the UK performs less well – the motor vehicles industry – all the main car manufacturers are based overseas but many have large production centres in the UK. Typically, these global companies perform most of their R&D at their headquarters. Their home base will have a very large R&D expenditure compared to their output in that country and therefore a very high R&D intensity. The UK production centre will have a large amount of sales in the UK but do very little R&D and therefore have a very low intensity.

The propensity for foreign owned manufacturers to rely on R&D facilities overseas is also shown in a recent survey of EEF members. This showed that over a quarter of other EU owned companies and a fifth of US companies either have not established any R&D facilities in the UK in the first place or have withdrawn all their R&D capacity from the UK. The comparable figure for UK owned firms was around 5%.[23]

23 EEF (2004)

We can try to assess the likely impact of multi-national activities by identifying the firms, listed in the value added scoreboard, that operate in the sectors where the ten-year framework analysis suggests that the UK is relatively weak.[24] Foreign owned firms can be identified and using the R&D Scoreboard, we can identify whether these firms do R&D in the UK. There are clear limitations to this approach. Some major UK based, but foreign owned subsidiaries might be excluded because their foreign parent does not provide enough information in their accounts to calculate value added. Also, foreign parents may not report R&D in the accounts of their UK subsidiary. Hence, it is perfectly possible for a firm in the value added scoreboard to be excluded from the R&D scoreboard even though they have an R&D facility in the UK.[25] Nevertheless, this data provides interesting results (Table 10):

- Foreign owned manufacturers dominate the top 10 businesses by value added in those sectors where the ten-year framework shows that the UK has a relatively weak R&D performance i.e. motor vehicles, ICT and electronics.
- Several major foreign owned manufacturers report doing R&D in the Scoreboard, but the R&D intensity is relatively low compared to UK owned companies in the same sector. Hewlett Packard and several electronics companies fall into this category.
- It also appears that several major manufacturers carry out some R&D in the UK as part of their global R&D effort. But their R&D is not recorded in the UK R&D Scoreboard. Nissan, Honda and IBM fall into this category. However, it is likely, judging by the publicly available information on websites and in company accounts, that the UK operations are relatively small compared to their parent's global R&D effort.
- Several foreign-owned companies fund major R&D investments in these sectors, e.g. Ford and Phillips.

24 DTI/Company Reporting (2004b)

25 See in particular p126 in the Company data section of the Value Added Scoreboard (2004). Where a firm in the value added scoreboard did not appear in the R&D scoreboard we carried out internet searches of company websites and examined publicly available company reports to see if we could identify an R&D facility in the UK.

**Table 10.**
**Foreign investors in Motor vehicles, IT and Electronics**

| Sector and company (Top ten firms in each sector identified in VA Scoreboard 2004, UK 800; italics indicates foreign ownership) | R&D in 2004 R&D Scoreboard (£m) | R&D intensity in 2004 R&D Scoreboard |
|---|---|---|
| **Motor Vehicles and Parts** | | |
| *Ford* | 867 | 8.2 |
| GKN | 81 | 2.4 |
| *Land Rover* | Part of Ford UK. | |
| *General Motors* | Not listed, but owns Vauxhall which has an Engineering centre at Millbrook. | |
| *Honda Motor* | R&D reported at group level. Main centres described as being in US, Japan and Germany. UK facility to support independent European planning. | |
| Inchape | Luxury car dealer. No R&D reported. | |
| *Nissan Motor* | R&D reported at group level. Major facilities in Japan and US. UK is a base for designing European models. | |
| *BMW Manufacturing* | 4.85 | 0.3 |
| UGC | Not listed | Not Listed |
| Mayflower | 7.30 | 1.2 |
| **IT Hardware** | | |
| *IBM North region* | Major research centres in the US, Israel and Switzerland. More modest centres in Japan, India and China. IBM Hursley labs in UK involved in software development. | |
| Marconi | 197 | 12.6 |
| *Motorola* | 71.6 | 4.0 |
| *Hewlett Packard* | 25.3 | 1.2 |
| *Compaq Computer* | Merged with Hewlett Packard. | |
| *Nortel Networks* | 133 | 14.3 |
| *Nokia UK* | 122.63 | 6.3 |
| *Cisco Systems* | 19.39 | 6.8 |
| Spirent | 66 | 14.2 |
| Ericsson | No reference to UK R&D activities in accounts. | |
| **Electronics and Electrical** | | |
| Invensys | 165 | 4.2 |
| *Flextronics* | No sign of any R&D activities. | |
| Spectris | 34.10 | 6.0 |
| *NRG* | Part of Ricoh, which carries out R&D in US, Germany, China and Japan. | |
| ABB | 3.7 | 0.8 |
| TT Electronics | 8.6 | 1.6 |
| *Matsushita Electric Europe* | 13.36 | 0.3 |
| *Phillips Electronics* | 62.50 | 8.0 |
| *Raychem* | 0.37 | 0.1 |
| Laird | 6.0 | 1.4 |

Source: DTI R&D Scoreboard 2004, DTI Value Added Scoreboard 2004

The UK has been relatively successful at attracting manufacturing investment from abroad, particularly in sectors where UK owned firms struggled to remain competitive. But as a consequence of this, it is likely that at least part of the reason for the low business R&D intensities in these sectors is that many foreign owned manufacturers in the UK largely depend on R&D inputs from facilities based overseas.

Despite this, foreign owned companies make a significant contribution to UK business R&D. However this R&D is concentrated in relatively few firms. The top two companies (Ford & Pfizer) account for 36% of the foreign-owned companies R&D in the R&D Scoreboard, the top five for over 50% and the top ten contribute 62%. The top ten foreign owned companies have a higher R&D intensity (2.7%) than UK listed (2.0%) and UK private (2.2%) companies (Table 11). Foreign companies outside this group have an average R&D intensity of 1.2%.

**Table 11**
**The top ten foreign-owned UK companies by R&D**

| | | R&D £m | Change | Sales £m | R&D intensity |
|---|---|---|---|---|---|
| 1. | Ford UK | 867 | -10% | 10586 | 8.2% |
| 2. | Pfizer | 552 | +10% | 948 | 58.2% |
| 3. | Airbus UK | 349 | +40% | 1638 | 21.3% |
| 4. | Nortel Networks UK | 133 | -48% | 928 | 14.3% |
| 5. | Nokia UK | 123 | -23% | 1935 | 6.3% |
| 6. | Eli Lilly | 121 | +7% | 1518 | 7.9% |
| 7. | Syngenta | 98 | -13% | 358 | 27.4% |
| 8. | Merck Sharp & Dohme | 79 | +10% | 407 | 19.5% |
| 9. | Agilent Technologies UK | 76 | -9% | 390 | 19.5% |
| 10. | Roche UK | 74 | -10% | 461 | 16.1% |

Source: DTI R&D Scoreboard 2004

# IV. Internationalisation of business R&D: An opportunity for the UK?

Whilst most available evidence suggests that R&D still remains within the same country as the corporate headquarters,[26] a number of studies have shown that the share of R&D carried out abroad is increasing as multi-national enterprises (MNEs) increasingly conduct research and development activities abroad.[27] A recent survey by the European Roundtable of Industrialists (ERT) indicates that member companies (42 of the largest firms in Europe) invest almost 40% of their R&D outside of Europe. These firms plan to increase their R&D in future years, but the bulk of that increase will be spent outside Europe.[28]

The involvement of MNEs in overseas R&D is in part a reflection of demand related forces – to be closer to lead markets. And increased investment overseas can also follow a period of intense merger and acquisition activity. But investments in overseas R&D are also related to gaining access to specialised sources of knowledge.[29] Access to the best knowledge sources worldwide can clearly provide these businesses with a competitive advantage. This last factor may be becoming more important as the costs and complexity of technology development increase and the pace of innovation quickens. Both factors would lead firms to expand their networks of knowledge sources to take into account different countries' or regions' comparative advantage in knowledge production.

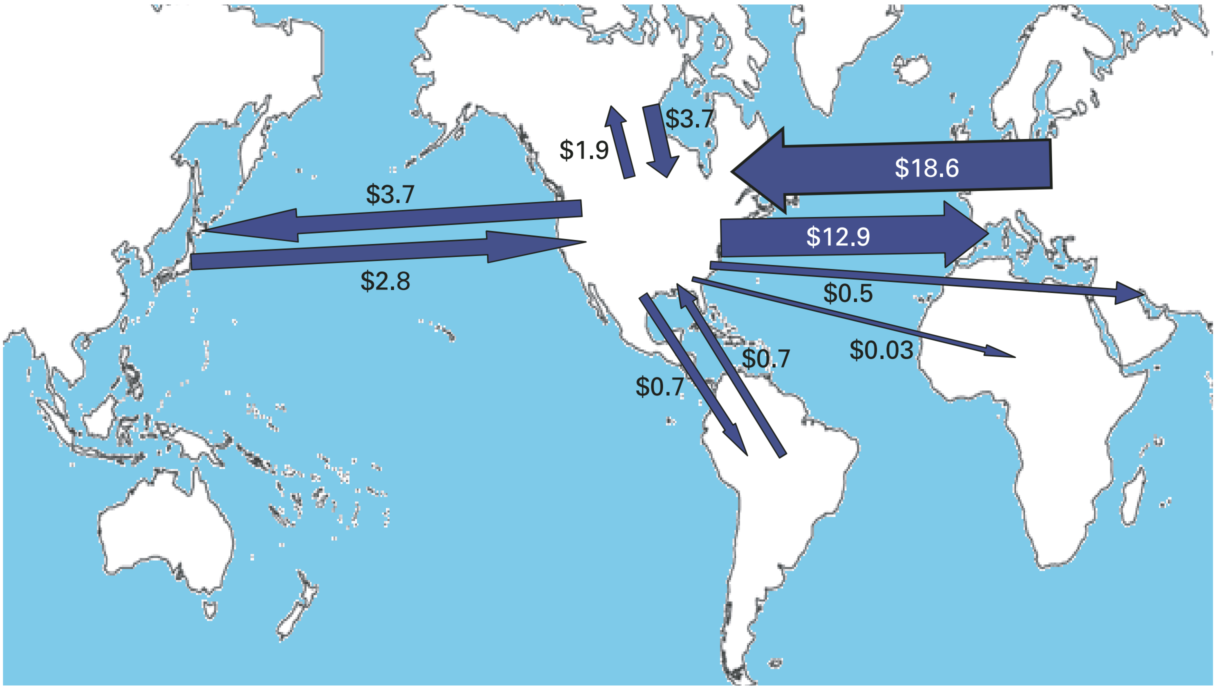
26 OECD (2004b).

27 McGuckin RH (2004); HMT (2003)

28 OECD (2003).

29 Both types of strategy can co-exist of course at the firm level: Narula and Zanfi (2004).

**Figure 17**
**Foreign owned R&D in the United States and US owned R&D overseas, by investing/host region: 2000**
(Billions of current U.S. dollars)




Sources: U.S. Bureau of Economics Analysis, *Foreign Direct Investment in the United States*, annual series and U.S. Bureau of Econonic Analysis, *U.S. Direct Investment Abroad*, annual series.

In the same way that investment largely flows between Europe, Japan and the US, most international flows of R&D tend to be between these trading blocks (reflecting the fact that these three regions account for the bulk of global business R&D[30]) (Figure 17). Although MNEs have made considerable business investments in China, these have not yet involved large investments in R&D (box five).

30 In 2002 total business R&D in the OECD area amounted to $390.6 billion, of which $351.6 billion was accounted for by the US, Japan and EU-15.

**Box five**
**R&D by foreign firms with investments in China**

A recent OECD review of China's R&D performance found that:

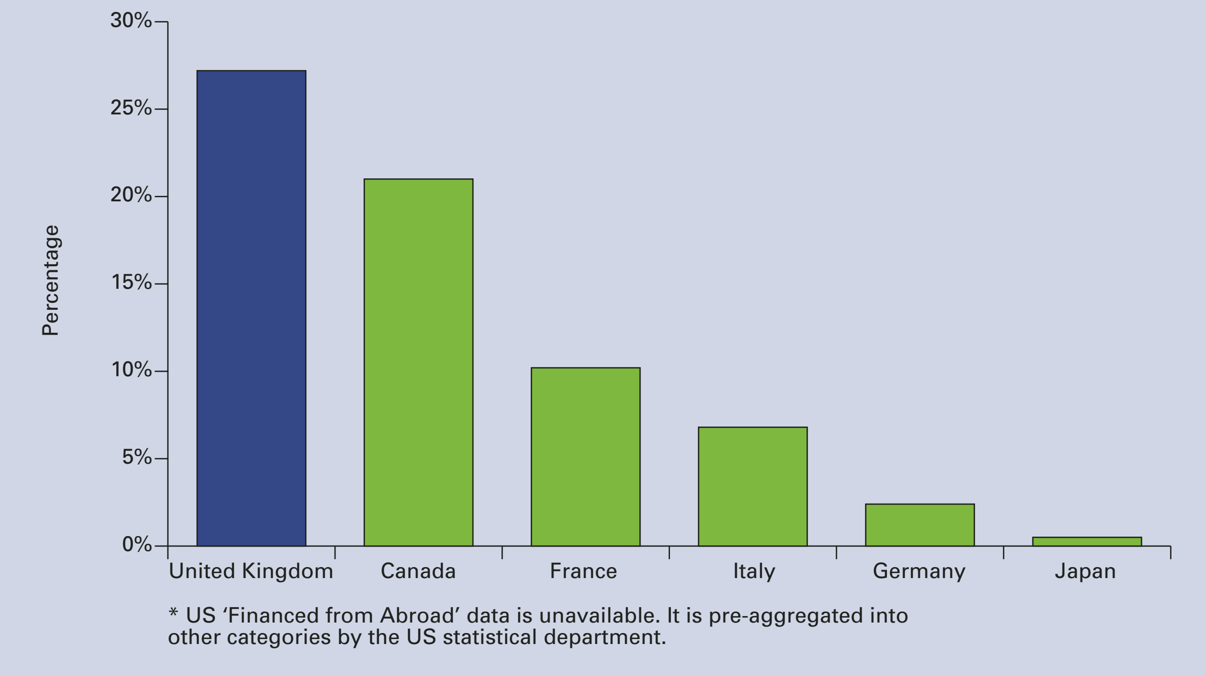
'Foreign firms that invest in China appear to have engaged in only limited levels of R&D activity, and their role in the innovation process seems even more limited. Foreign companies appeared to treat their joint ventures in China as production bases for their global business strategies. Only 1% of foreign companies had R&D departments, and half of these did not receive stable funding, one third did not perform R&D regularly, and nearly 40% lacked the necessary experimentation and testing equipment. Furthermore, when foreign companies acquired control of joint ventures, they often closed down the R&D facilities of the Chinese partner companies. This was especially common in joint ventures in light manufacturing, industries where FDI tended to concentrate, and may have resulted in China's increased technological dependence on foreign technology. In particular, foreign companies investing in traditional Chinese industries seem to have contributed little to improving the innovation capability of Chinese firms.

In recent years, foreign companies have shown greater interest in investing in R&D-intensive industries and in forming R&D joint ventures. Investments tend to concentrate in high technology industries such as software, telecommunications, biotechnology and chemicals. Two factors appear to explain this change: i) foreign companies are convinced of the long-term potential of the Chinese market and have turned towards longer-term investment; and ii) some foreign companies have recognised the value and cost advantage of the Chinese R&D workforce. In addition, the need for major adaptation of products for Chinese markets has led to joint R&D and production development in certain industries, such as software. Since such R&D investments are limited to certain high-technology sectors, the situation of traditional Chinese industries is unchanged.'

*Source: OECD, Science, Technology and Industry Outlook (2002)*

The UK is well placed to gain from an increase in international flows of R&D. It is already an attractive place for foreign owned firms to do R&D. Compared to other countries, a relatively high share of UK business R&D is funded from abroad (Figure 18).

**Figure 18**
**Percentage of business R&D funded from abroad, for G7* Countries, 2002**




Source: DTI estimates, OECD MSTI

According to the R&D Scoreboard, there are over 200 foreign-owned R&D-active companies in the UK accounting for 24% of the R&D reported by the UK 700. The Business Enterprise R&D survey reports a higher proportion of UK R&D carried out by foreign owned affiliates – around 40%. It is possible that this discrepancy is due to one of the limitations of the R&D Scoreboard in that it will not include the R&D of foreign owned firms if they do not disclose R&D expenditure in the accounts of the UK based subsidiary.

In most outsourcing decisions labour costs and skills are key factors when firms decide upon location.[31] Here, the UK is well placed. It is competitive as a place to do R&D – costs are low relative to the US, Japan and Germany (Table 12).

**Table 12**
**Cost of R&D internationally relative to the US**

| Price level (PPP/exch. rate)(%) | 1987 | 1995 | 1997 | 1999 |
|---|---|---|---|---|
| France | 108 | 108 | 91 | 85 |
| Germany | 108 | 134 | 108 | 101 |
| Japan | 100 | 145 | 108 | 110 |
| Netherlands | 107 | 104 | 85 | 80 |
| United Kingdom | 78 | 83 | 88 | 89 |
| United States | 100 | 100 | 100 | 100 |

Source: McGuckin (2004)

31 EEF (2004)

And the numbers of scientists and engineers in the UK have expanded strongly over the last few years as a result of a large expansion in higher education (Table 13). Some disciplines have been favoured more than others. In absolute terms, growth in those holding science and engineering first degrees has been particularly strong in medical related subjects – largely reflecting growth in nursing degrees – biological sciences, mathematics and computing, agricultural sciences and architecture. However, the Roberts Review found that uncompetitive salaries were deterring many talented students from pursuing careers in science, engineering and technology.[32]

**Table 13**
**Holders of first degrees by subject group, GB population of working age**

| Subject group | 1997 | 2000 | 2004 | % increase 1997-2004 |
|---|---|---|---|---|
| Medicine | 105,429 | 156,392 | 133,081 | 26.2% |
| Medical Related Subjects | 149,084 | 206,670 | 295,450 | 98.2% |
| Biological Sciences | 170,478 | 198,608 | 358,577 | 110.3% |
| Agricultural Sciences | 28,286 | 34,223 | 48,330 | 70.9% |
| Physical/Environmental Sciences | 238,818 | 276,895 | 337,585 | 41.4% |
| Mathematical Sciences & Computing | 183,808 | 237,977 | 345,026 | 87.7% |
| Engineering | 335,214 | 379,062 | 406,830 | 21.4% |
| Technology | 42,568 | 47,339 | 38,422 | -9.7% |
| Architecture and related studies | 96,712 | 131,338 | 160,029 | 65.5% |
| **All Science and Engineering subjects** | 1,350,397 | 1,668,504 | 2,123,330 | **57.2%** |
| **All subjects** | 3,138,821 | 3,857,045 | 4,792,867 | **52.7%** |

Source: Labour Force Survey, Autumn data.

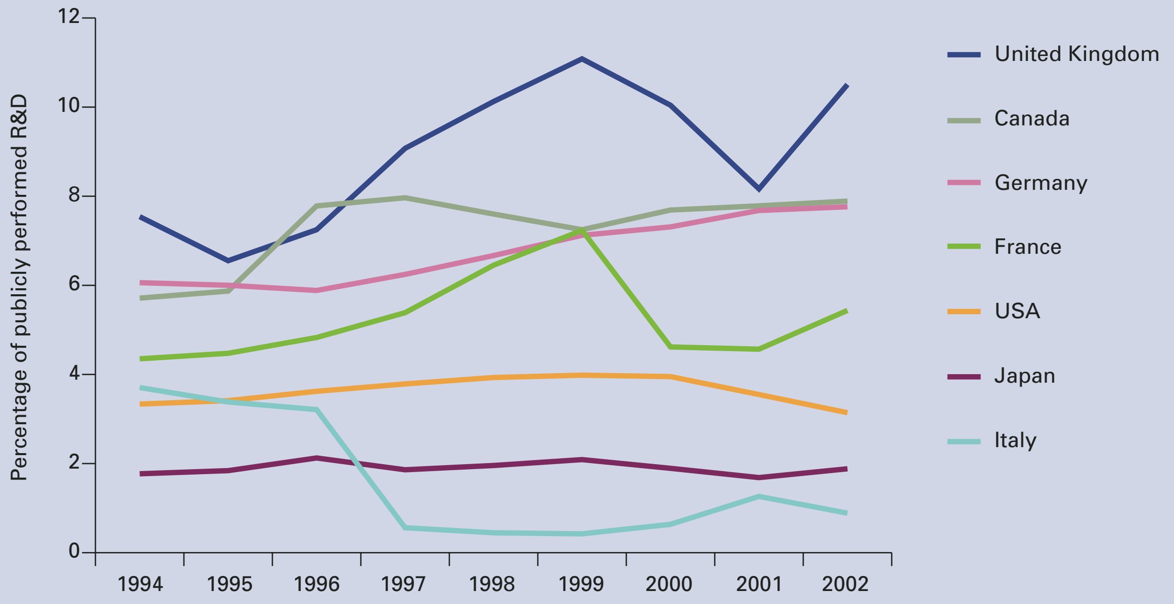
Importantly, the quality of research is also high (box six).[33] Furthermore, judged by several indicators, such as the share of public research funded by business, the UK Science and Engineering base is relatively open to collaboration[34] (Figure 19).

32 Roberts (2001)

33 Evidence Ltd (2004)

34 OECD (2002b) shows that over 10% of all UK HE funding for research comes from industry. DTI (2003) also noted that there has been an increase in industry-university collaboration between 1981 and 2000.

**Figure 19**
**Business sector funding of publicly performed R&D**




Source: OECD MSTI

The Lambert Review noted that: 'there has been a marked change of culture in the past decade, with many universities casting off their ivory tower image and playing a much more active role in the regional and national economy.'

**Box six**
**Quality of the UK science base**

A recent report concluded:

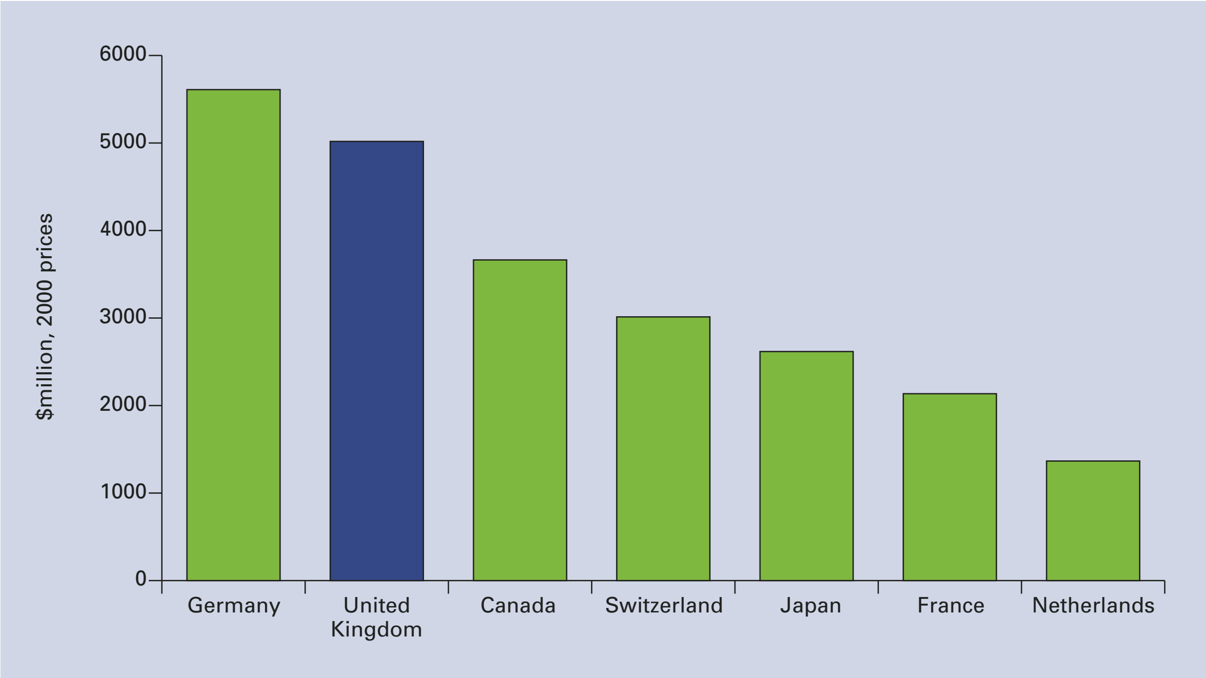
'This second report on the performance of the UK research base confirms the UK's strong relative international performance in terms of achievement, productivity and efficiency. The UK is strongest overall in the natural sciences, and on many indicators is second only to the USA. Although the UK has been overtaken by other nations in some areas, it sustains a more consistent performance across fields than those countries. The UK's strong international performance has been achieved with lower average investment compared to its competitors and with a relatively lower availability of people with research training and skills.'

*Source: Evidence Ltd (2004)*

In the same way that foreign businesses are looking to exploit sources of UK knowledge, UK businesses are also looking overseas. UK businesses are major investors in R&D overseas (Figure 20). They are, for example, the largest investors in the US after Germany.[35] This investment is mainly concentrated in the chemicals, including pharmaceuticals, sector.

35 NSF (2004)

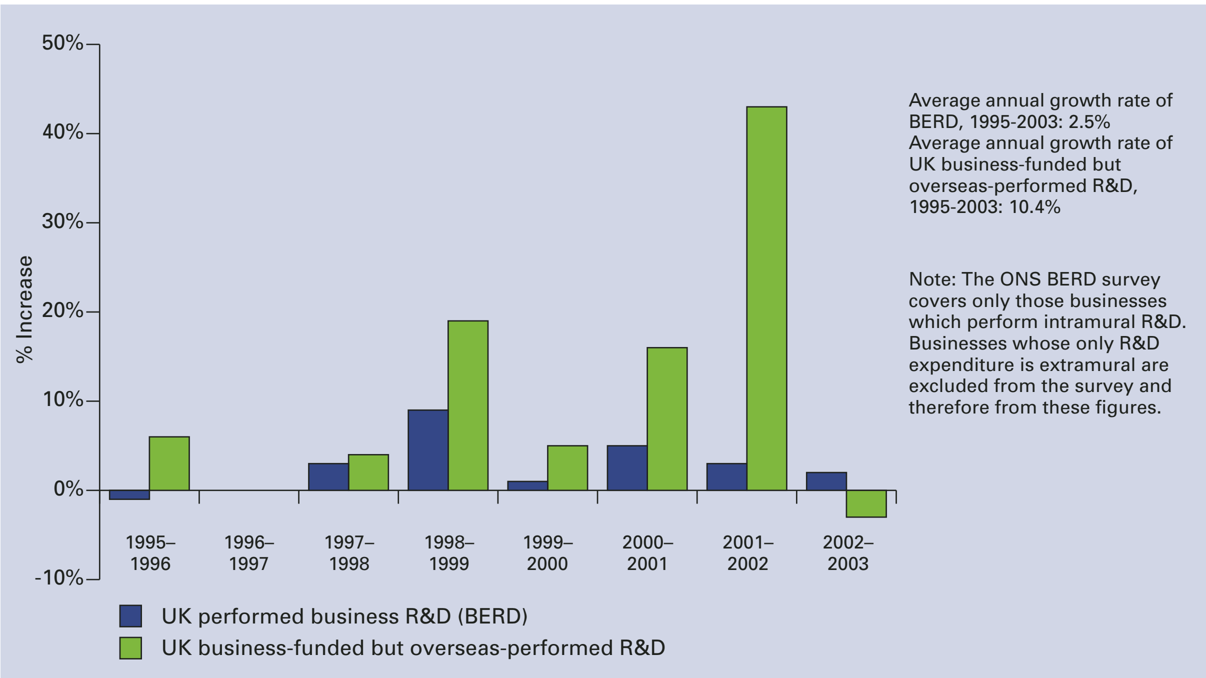
**Figure 20**
**R&D Performed by majority-owned affiliates of foreign companies in United States, by country, 2000**




Source: National Science Foundation, Science and Engineering Indicators, 2004.

There is evidence that UK firms are outsourcing more of their R&D abroad (Figure 21). Since 1995 UK business funded, but overseas performed R&D has increased at a faster rate than business R&D performed in the UK (10.4% compared to 2.5%).

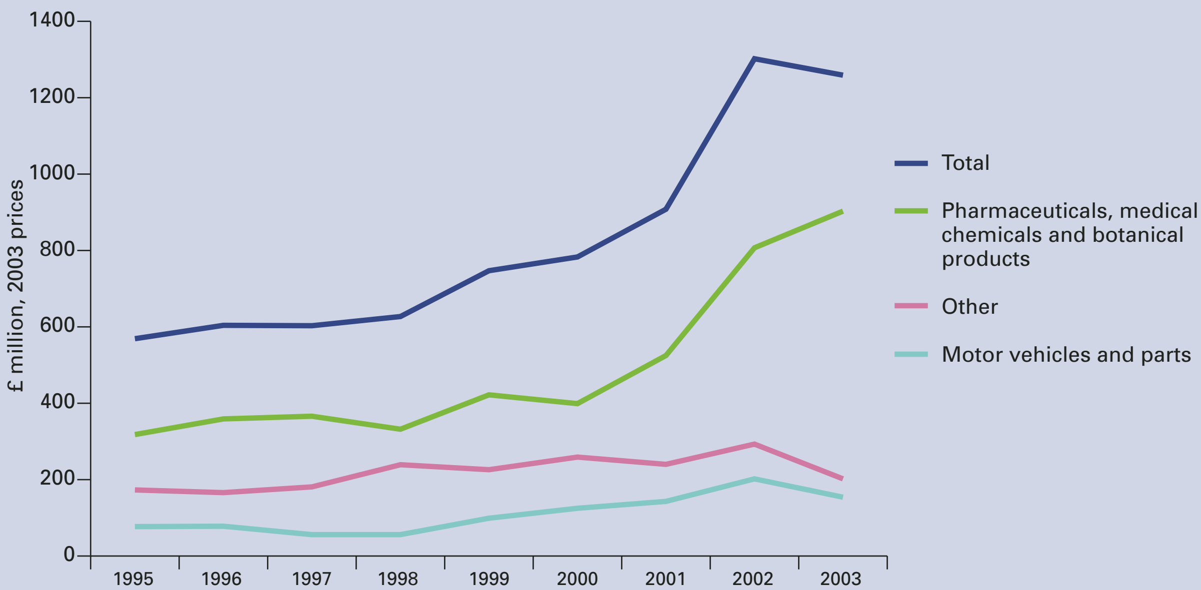
**Figure 21**
**UK business R&D and business funded but overseas performed R&D: real terms annual growth rates, 1995–2003**




Source: ONS BERD.

The most recent increases in offshoring – particularly between 2000 and 2002 – have been largely driven by the pharmaceuticals sector (Figure 22).

**Figure 22**
**UK business-funded but overseas-performed R&D: by product group, real terms, 1995–2003**




Note 1: 2001 product group breakdown estimated
Note 2: The ONS BERD survey covers only those businesses which perform intramural R&D. Businesses whose only R&D expenditure is extramural are excluded from the survey and therefore from these figures.

Source: DTI estimates, ONS.

For as long as the UK retains access to centres of science and technological excellence and is an attractive place to do business, it will remain an attractive place to do R&D for UK and foreign owned firms. A recent survey funded by the Engineering Employers Federation (EEF) suggests that, for smaller firms at least, this is the case. It found that most members had kept some or all of their R&D functions in the UK. And that around three quarters of EEF members plan to keep all their UK based R&D in the UK. A fifth expect to relocate some, but not all.[36] The survey did indicate, however, that those companies that moved all their manufacturing off-shore are less likely to have retained their R&D in the UK. This suggests that some indigenous manufacturing capability is required in order to anchor R&D capability in the UK.

36 EEF (2004). The EEF survey was based on a stratified random sample of 494 engineering and manufacturing companies drawn from EEF members.

# Annex A: R&D methodology

## The Frascati Manual – proposed standard practice for surveys on research and experimental development

Monitoring the R&D efforts of industry, governments and universities is an important aspect of successful economic policy making and analysis. The Frascati Manual (http://www1.oecd.org/publications/e-book/9202081E.pdf) is the internationally accepted methodology for collecting and using R&D statistics, and enables inter-governmental discussions on science and technology investment to take place based on reliable and comparable figures. It is the standard guide for surveys in all OECD member countries, and includes definitions of basic concepts, guidelines for collecting data and the classifications to be used in compiling statistics.

The Manual is agreed by a group of national experts on science, technology and innovation statistics under the auspices of the Organisation for Economic Co-operation and Development (OECD), and was last updated in 2002.

The Frascati Manual definition of R&D is as follows: "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, society, and the use of this stock of knowledge to devise new applications."

### CURRENT ISSUES REGARDING R&D ANALYSIS

While R&D data are collected using a common, harmonised methodology, there still exist some known difficulties with analysing results.

### SECTOR BREAKDOWNS

The OECD makes available detailed breakdowns of R&D expenditures by industry via its Research and Development Statistics publication and its "ANBERD" (Analytical Business Enterprise R&D) database. There are known problems in the comparability of these data across countries, since some countries report using an "SIC" approach, other countries use a "product group" approach, and others use a mixture of the two. The SIC (Standard Industrial Classification) approach is more straightforward – firms' total R&D is classified according to their principal industrial activity, usually as recorded in the business register. The product group approach requires firms to break down the R&D that they perform into the sectors for which it is carried out. The UK preference is to follow the product group approach, since in practice firms often perform R&D for a range of product groups. This is in line with what the Frascati Manual recommends, but other countries find it more difficult to collect product group data and present industrial breakdowns using the SIC approach; hence valid comparisons are limited. The problems are especially pronounced in the service sector, particularly in R&D services (SIC73). Here, a large proportion of the R&D that is carried out is aimed at manufacturing applications (roughly two thirds in the UK in 2002). Hence to imply that all R&D in SIC73 is "service sector R&D" would be potentially misleading. Some countries redistribute the R&D of large firms across product groups, while some do not and others only redistribute the R&D of firms in SIC73. Hence, making valid international comparisons is difficult.

In addition to the measurement issues highlighted above, in certain countries R&D statistics have shown rapid recent growth in the service sector. It is possible that this is an indirect result of manufacturing firms off-shoring their manufacturing activities overseas. It is quite possible that such firms would retain large sales and R&D facilities in their home base and, as a result, would be reclassified as service sector companies; yet much of their R&D is still directed towards the development of new manufacturing products and processes.

## DISCREPANCIES BETWEEN BERD AND GOVERD

There are known differences in some of the figures reported using the business R&D (BERD) and government R&D (GOVERD) returns, which has a knock-on effect when estimating GERD. In particular, the Government-funded R&D that business reports in BERD differs significantly from the business-based R&D that Government reports in GOVERD. When estimating GERD, the standard internationally recommended practice of the OECD is to use information from those performing R&D when this is available. These estimates are considered more reliable than those from surveys of R&D funders.

## BOUNDARIES OF R&D

Recent academic thinking suggests that there exist differences in what firms record as R&D, even within the same industry. Where R&D is distributed across an organisation, it is often difficult for firms to disaggregate their spend when it does not coincide with organisational boundaries. There is an argument to suggest that surveys should break down R&D data using distinct categories for research and development in order to assess the extent of differences between firms and industries.

## GLOBALISATION OF R&D

International R&D investments by multinational corporations, such as overseas R&D spending and R&D joint ventures and alliances, support long-term activities aimed at the development of new products and technological capabilities. Such investments are becoming more common, and measuring the extent of these technological linkages is becoming increasingly more complex. The OECD will discuss some of the resulting issues in its forthcoming Globalisation Handbook and will oversee further work to address the shortfalls in international data collection systems throughout 2005.

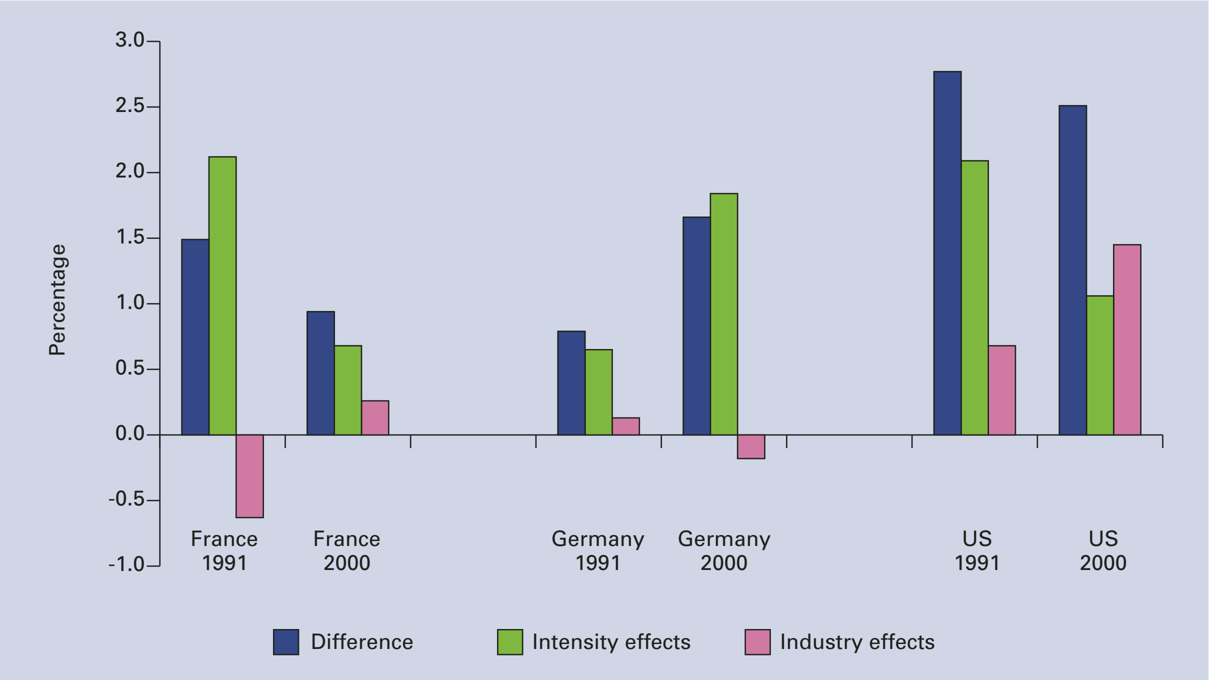
# Annex B: Differences between the R&D Scoreboard and the Business R&D survey

| Differences | R&D Scoreboard | Business R&D (BERD) survey |
|---|---|---|
| **Definition of R&D** | International accounting standard based on Frascati R&D definition | Frascati R&D definition |
| **Data collection method** | Data comes from audited company accounts. | Data comes from a survey. |
| **Economy coverage** | International comparisons based on the 700 largest firms worldwide in terms of R&D expenditure.<br><br>Also contains data on the top 700 UK R&D performers. | Survey covers all large firms and a stratified sample of small firms. It is therefore representative of all R&D performers. |
| **Calculation of intensity** | Intensity = R&D expenditure / sales | Intensity = R&D expenditure / GVA (Gross Value Added) |
| **Sectoral classifications** | Uses FTSE (Financial Times Stock Exchange index) classification | Uses NACE classification (the European statistical classification of economic sectors) |
| **Nationality** | In the international 700: All R&D for global companies is allocated to the country in which the HQ is located.<br><br>In the UK 700: R&D of foreign subsidiaries is included when it is recorded in accounts. | R&D for global companies is allocated to different countries according to where the R&D was performed. |
| **Financing** | Does not include R&D that has been funded by governments or other companies. | Includes all R&D expenditure regardless of the source of funding. |
| **Expenditure allocation** | All R&D expenditure is allocated to the main economic activity of the firm. | Firms can allocate their R&D expenditure between sectors according to the activities it relates to. |

# Annex C: Changes over time in the industry and intensity effects calculated using Business R&D survey data

The Business R&D survey analysis can be extended to consider how the industry mix effects and intensity effects have changed between two points in time. Comparing data for 1991 and 2000 shows that the difference in manufacturing R&D intensity between the UK and France and the UK and US has fallen. In both cases this was due to a relative increase in UK R&D intensities within sectors offset partly by a shift in the other countries towards a more R&D intensive sector mix. Differences in manufacturing R&D intensity between the UK and Germany widened as UK R&D intensities within sectors decreased relative to Germany, although this was partially offset by a relative shift in the UK towards a more R&D intensive sector mix (Figure 23).

**Figure 23**
**Country differences in manufacturing R&D intensity relative to the UK: industry and intensity effects, 1991 and 2000**




Source: DTI estimates, OECD

# Annex D: Scoreboard Sector groups

## Group 1

Pharmaceuticals & biotechnology

Health

## Group 2

Electronic & electrical

IT hardware

Software & computer services

## Group 3

Aerospace and defence

Automobiles and parts

Engineering & machinery

Chemicals

Personal care & household products

Diversified industrials

Household goods & textiles

Leisure & hotels

Media & entertainment

## Group 4

Beverages

Construction & building materials

Food producers & processors

General retailers

Steel and other metals

Support services

Telecommunication services

Banks

Food & drug retailers

Speciality & other finance

## Group 5

Electricity

Oil & gas

Transport

Utilities (ex-electricity)

Tobacco

Forestry & paper

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