Defining R&D

Industrial R&D (Research & Development) is a key component of sustainable innovation-led growth since it helps to create the higher value added products, processes and services on which the future of UK companies increasingly depends. In the UK, R&D is defined in SSAP 13 (Standard Statement of Accounting Practice) and, for international companies, IAS 38 (International Accounting Standard); both are based on the OECD 'Frascati' manual.

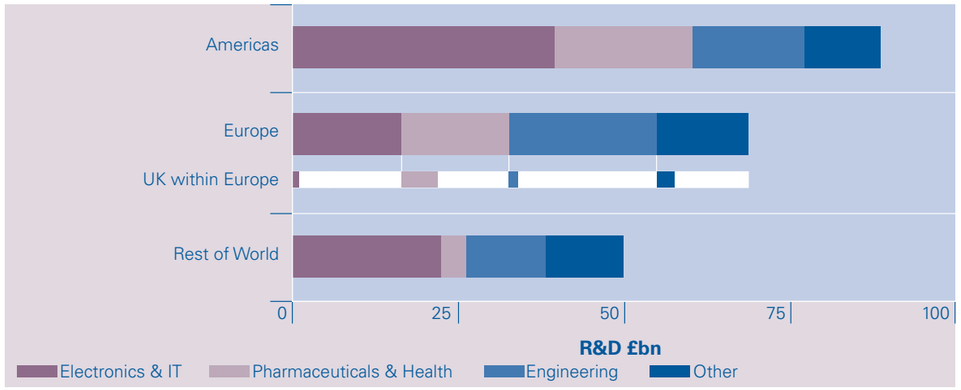
Contents – Part One – Commentaries and Analysis

Contents - Part Two - Company Data

Key points from the Scoreboard

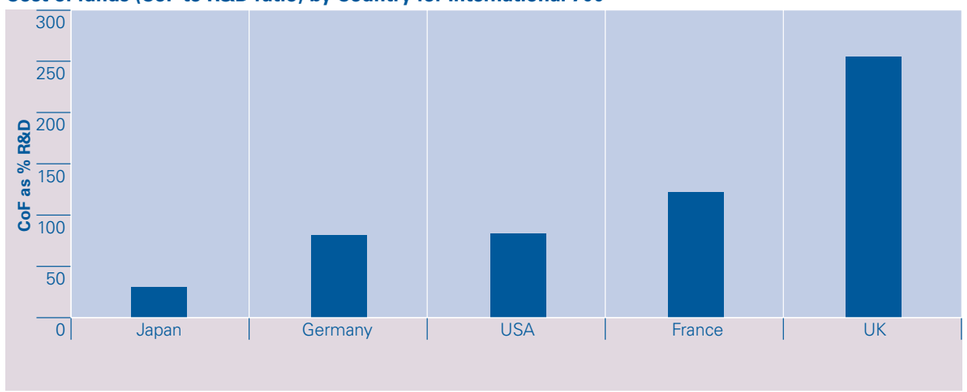
1. The 2003 R&D Scoreboard has been expanded to include the top 700 international companies (companies with R&D over £34m) and the top 700 UK companies. It also includes new data on cost of funds and on 2001 and 2002 US patents granted to companies in nine R&D intensive sectors.
2. The business environment was difficult for companies during the 2002/2003 financial year with both profits and employee numbers down. Despite this, R&D intensities (R&D as % sales) are unchanged from 2002 for Japan at 4.3% and have increased slightly both for the USA to 5.2% and for Europe (but only to 3.7%). The UK 700 R&D intensity is the same as in 2002 but 23 more companies now have R&D of £260k or more.
3. The Americas (primarily USA) lead in total R&D for pharmaceuticals & health and electronics & IT while Europe leads in overall engineering and in 'all other sectors'. Comparing the main European countries, UK companies in the international 700 have much higher total R&D in pharmaceuticals & health than Germany and France but much lower total R&D in both electronics & IT and in the broad engineering sector (where the UK is under 12% of Germany).

Total R&D Investment by Region



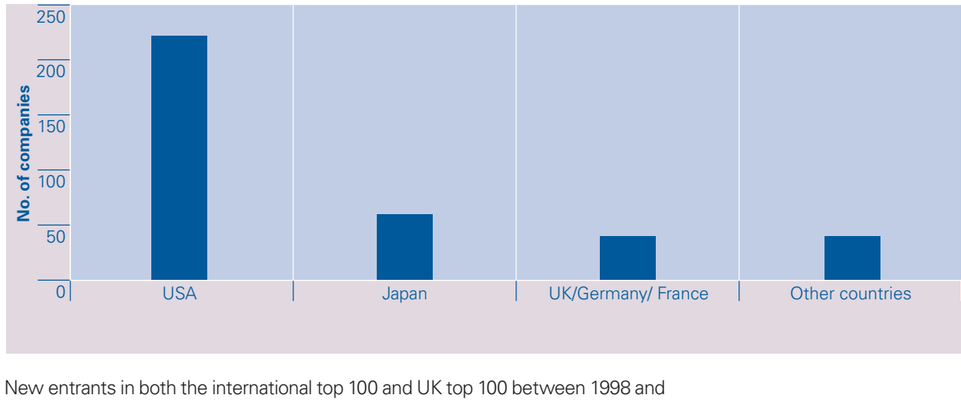
4. The financial environment for UK companies differs from that in the other major countries in two ways. Firstly, UK companies have a higher cost of funds relative to both sales and R&D than the US, Germany, France or Japan. This is driven by higher UK dividends. Secondly, acquisition spend relative to R&D plus Capex investment is much higher in the UK, even than in the USA, (the UK is typically larger than the USA by a factor of over three).

Cost of funds (CoF to R&D ratio) by Country for International 700



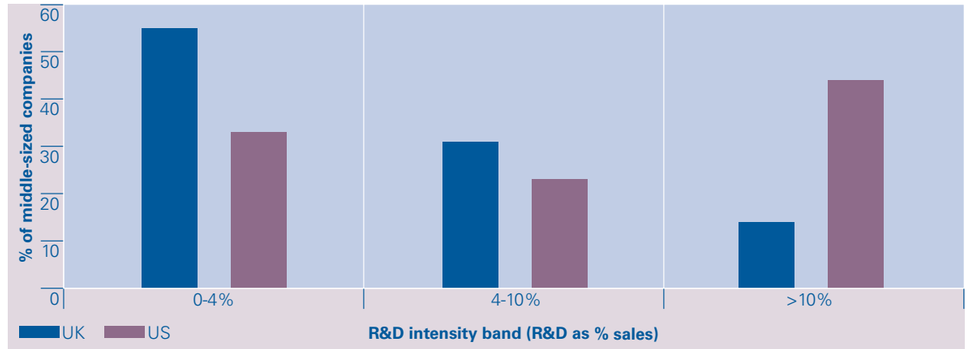
5. The UK has its highest proportions of R&D in pharmaceuticals & biotechnology (40%) and aerospace & defence (9%) whereas the international 700 has its highest proportions in IT hardware (22%), automotive (18%) and pharmaceuticals & biotechnology (17.5%). UK 700 R&D intensity is above international levels in pharmaceuticals, aerospace and health but below in most other sectors.
6. The five high R&D sectors of IT hardware, pharmaceuticals & biotechnology, electronic & electrical, software & IT services and health account for almost 60% of all R&D and are all dominated by the USA with the exception of electronic & electrical where Japan leads, Germany is second and the USA is in third place. The UK is in second place in both pharmaceuticals & biotechnology and health. A comparison of the US 1000 with directly comparable UK-owned companies in the UK 700 shows that the UK has 50% more companies with low R&D intensity (below 2%) but only just over one third the proportion of companies with high intensity of over 10% (mainly drawn from the high R&D sectors).

Number of Companies in the Five High R&D Sectors



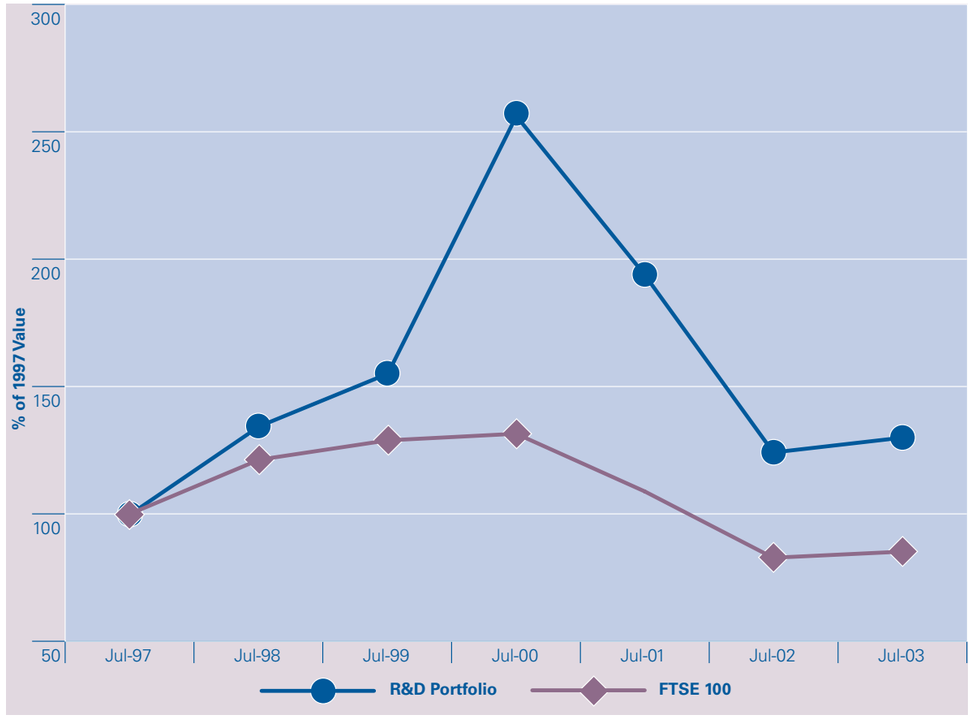
7. New entrants in both the international top 100 and UK top 100 between 1998 and 2003 are mainly in the IT hardware, pharmaceuticals & biotechnology, software & IT services, electronic & electrical sectors with, for the international 100, companies in automotive and aerospace & defence as well.
8. An examination of US patents for major companies in 2002 shows that companies are granted from 1 (pharmaceuticals) to 6 or 7 (Electronics or IT hardware) patents per year on average for every £10m of R&D although there are naturally sizeable variations between the companies in each sector. Europe just leads in this ratio for pharmaceuticals & biotechnology, but lags the USA and Japan for IT hardware and electronic & electrical.

R&D Intensity Distributions for US & UK Middle-sized Companies



9. A study of higher R&D intensity middle-sized companies (sales up to £500m) in the international 700 shows that the USA dominates with 80% of companies followed by Europe with 13% and Japan with 5%. These companies also have very high growth rates. A more detailed comparison of middle-sized companies in the US 1000 with comparable UK-owned ones from the UK 700 shows that the UK has less than one third of the US proportion of companies with R&D intensity above 10% but 60% more below 2%. However, the UK does have exemplar high growth middle-sized companies in all the five high R&D sectors – it is just that more are needed (and more capable of growth to larger sizes). For example, the US has almost 20 times as many companies with R&D intensity above 10% as does the UK.

Relative share price of R&D Portfolio of FTSE 100 Stocks vs FTSE 100 Index



10. R&D is related to company performance measures with R&D intensity linked to sales growth and labour productivity to R&D per employee. In the 2003 Scoreboard it is also shown that current sector market capitalisation-to-sales ratios are higher for pharmaceuticals & biotechnology, software & IT services and health (relative to R&D intensity) than for engineering-related sectors. Of companies in IT hardware, pharmaceuticals & biotechnology and software & IT services with above sector average market cap-to-sales ratios, 80-90% also have above average R&D plus Capex as % sales. Portfolios of UK high R&D intensity companies from both the FTSE 100 and FTSE 250 have shown share price growth from 1997 to 2003 of 30% and 50% respectively. The FTSE 100 has dropped 15% over this period whilst the FTSE 250 has increased by only 17%.

What the R&D Scoreboard contains:

- Details of R&D investment, Capex, sales, profits, employee numbers, growth of these quantities and market capitalisation for UK and international companies. All data is extracted directly from company annual reports & accounts and key ratios are calculated for each company and sector. Companies are classified by FTSE sector and by country.
- 700 UK-based companies (39 from the FTSE 100) are included with R&D investments totalling £16bn. The international section comprises the top 700 R&D investing companies (each with over £34m R&D) with R&D totalling £207bn.
- New data for 2003 includes 100 more international and UK companies together with new information on cost of funds, US patents and market cap to sales ratios. The data on stockturn and market breadth introduced last year is continued for 2003.
- These enhancements make the Scoreboard an even more useful sector-based international benchmarking tool for companies.

What the Scoreboard Analysis says:

Overall Perspective

- The 2002/3 financial year was difficult for many R&D intensive companies with little change in overall R&D or sales and reductions in both profits and employee numbers. However, 60% of international companies increased R&D over the previous year.
- The financial environment in the UK differs from that in other major countries in two respects. The cost of funds as a ratio of either sales or R&D is higher (higher dividends) and the ratio of acquisition spend to R&D plus Capex investment is much higher (higher even than for the USA).
- The R&D intensity (R&D as % sales) for the US (at 5.2%) and Europe (at 3.7%) have both increased slightly over 2002 with Japan the same at 4.3%. Within Europe, both Germany (4.6%) and Switzerland (6%) have increased their intensities significantly whereas the UK has changed only marginally. R&D intensity has increased over 2002 for 8 of the top 10 international sectors.
- New entrants to both the international and UK top 100 companies since 1998 have been concentrated in electronic & electrical, IT hardware, pharmaceuticals & biotechnology and software & IT services with, for international, more companies also in aerospace & defence and automotive.

R&D Sector Mix and Intensity

- R&D active UK companies are dominated by pharmaceuticals & biotechnology (40%) and aerospace & defence (9%) whereas internationally the largest sectors are IT hardware (22%), automotive (18%) and pharmaceuticals & biotechnology (17.5%). The UK is strong in food processing and oil & gas (9% compared to 2% internationally) but has lower proportions in electronic & electrical (4% vs 10%), automotive and IT hardware.
- Within world regions, the Americas have most R&D in both pharmaceuticals & biotechnology plus health and electronics plus IT while Europe leads in overall engineering and in the all-other-sectors category. Within Europe, UK companies perform more R&D in pharmaceuticals and health than other European countries but much less in electronics & IT and overall engineering than either Germany or France.

- UK company R&D intensity (and also Capex intensity) is above international levels in the strong sectors of pharmaceuticals & biotechnology, aerospace & health but well below international levels in electronic & electrical, software & IT services, chemicals and engineering which also account for smaller proportions of the UK total.
- The distribution of R&D intensity for the top 1000 US companies is very different to that of a strictly comparable set of UK-owned companies. The UK has a 50% higher proportion of companies in the lowest intensity band (up to 2%) while the US has almost three times the UK proportion in the highest intensity bands (above 10%). The UK's relative position, however, has improved over the last 4 years.

The Five High R&D Sectors and Middle-sized Companies

- The five high R&D sectors (electronic & electrical, health, IT hardware, pharmaceuticals & biotechnology, software & IT services) account for almost 60% of international 700 R&D and all are dominated by the USA except for electronic & electrical where Japan leads and the US is third behind Germany. The UK is in second place in both pharmaceuticals & biotechnology and health and in third place for software & IT services. These three sectors have the highest growth rates of the five.
- 94% of international middle-sized companies (sales from £50m to £500m) are in the five high R&D sectors and 82% of these are from the USA which leads in all five sectors. 87% of the middle-sized companies are in IT hardware, pharmaceuticals & biotechnology and software & IT services which have very high R&D intensities and R&D growth rates. Pharmaceuticals & biotechnology also has a high growth rate for sales.
- Middle-sized companies from the US 1000 are contrasted with comparable UK-owned companies from the UK 700 to show that the UK has many more in low intensity bands (0-2%, 2-4%) but less than one third of the US proportion with R&D intensity above 10%. The UK also has a larger proportion of its higher intensity middle-sized companies in the smaller size parts of the middle-sized range. However, there are successful UK companies in all five high R&D sectors – it is just that more are needed, and more capable of growing to larger sizes.

R&D and Company Performance

- A preliminary patent analysis shows a sevenfold difference between sectors in the ratio of US patents granted per £10m R&D investment. For a country, therefore, this ratio will be affected by sector mix. Europe leads the US and Japan in the ratio for pharmaceuticals & biotechnology, but lags for IT hardware and electronic & electrical.
- In addition to summarising the well-established links between R&D intensity and sales growth, R&D per employee and labour productivity, R&D plus Capex intensity and total shareholder return (for the broad engineering sector), the Scoreboard introduces new links between R&D and both market cap to sales ratios and share price growth.
- The market capitalisation to sales (MC/S) ratio for two groups of major sectors rises with R&D intensity. 80-90% of those companies in the highest R&D intensity sectors of IT hardware, pharmaceuticals & biotechnology and software & IT services with above average MC/S also have above average R&D plus Capex intensity for their sector.
- The share price of the group of all high R&D intensity companies in the FTSE 100 has been ahead of the FTSE 100 index in every year since 1997 and is now 130% of its 1997 value, the FTSE 100 having dropped by 15% in this period. The high R&D intensity FTSE 250 companies are also well ahead of the FTSE 250 index.

The Challenge for UK Companies

- The UK has a leading position in pharmaceuticals & biotechnology, health and aerospace & defence with R&D intensities above the international sector averages. It will be important to maintain this strong position.
- There are other sectors where the UK's R&D intensity is well below international levels and where the UK also has smaller proportions of its R&D than are found internationally.
- There are examples of UK middle-sized companies in all the high R&D sectors which have high R&D intensity, high growth rates of R&D and/or sales and where the market cap to sales ratio suggests above average prospects. A comparison with the USA suggests that the UK needs a higher proportion of such exemplars amongst its middle-sized companies and more with the ability to grow to larger sizes.
- A combination of good strategic choices (e.g. organic vs acquisition growth and high value added products & services), operational excellence, customer care and wise and balanced investment in the future will enable UK companies to sustain profitable growth and succeed in world markets.

What the Scoreboard doesn't say:

- That the R&D reported in companies' annual accounts is the only measure of innovation. Investments in capital equipment, market development, skills, new ways of working and other intangible assets are all methods of gaining competitive advantage.
- That it is simply a case of investing more. The Scoreboard is rather an international benchmarking tool to help companies decide if they are investing the right amount compared to competitors in their sector as part of their overall business strategy.
- That it is the only source of information. Companies and their shareholders are best placed to assess this and all the other information relevant to their technical strategies and business plans.
- That it covers all R&D activity funded by companies in the UK. While the Scoreboard seeks to be as comprehensive as possible, it does not, for example, include companies that undertake R&D but do not declare the amount invested in their accounts. It also excludes UK companies investing less than £30k per annum in R&D. As a Scoreboard for company funded R&D, it naturally excludes publicly funded R&D.

Ministerial Foreword

Lord Sainsbury of Turville, Parliamentary Under Secretary of State for Science and Innovation

For UK companies (globalisation) means increasing competition but also new markets for high value added goods and services.

Innovation-led Growth

Reductions in transport and communication costs, technological change and trade liberalisation have made global markets a reality. For UK companies this means increasing competitive pressures, but also new markets for high value added goods and services.

Surviving the challenge of increased competition and making the most of the opportunities offered by globalisation requires investment in new products, processes and services which are valued by customers. Industrial R&D is a key component of this sustainable, innovation-led growth; it helps create the high value added products, processes and services on which the future of UK companies increasingly depends. As the speed of technological change and market response continues to increase, innovation is becoming an urgent and continuous challenge for firms seeking future success and growth.

The 2003 R&D Scoreboard

The R&D Scoreboard provides a unique international benchmarking tool to enable UK companies to compare their R&D and Capex investments with the best international competitors in their sectors. The R&D Scoreboard has been published every year since 1991. This year we have expanded it to include details of the top 700 R&D-active international companies together with the top 700 UK companies by R&D investment.

Over half of the 700 international companies are in just five high R&D sectors:

- electronic & electrical,
- health,
- IT hardware,
- pharmaceuticals & biotechnology, and
- software & IT services.

The R&D Scoreboard has been published every year since 1991 and enables UK companies to benchmark their R&D and Capex investments against the best international competitors in their sectors.

After the US, Japan and Germany, there are more UK companies in the international top 700 than any other country.

The company commentary by Sir Tom McKillop of AstraZeneca, the second largest UK R&D investing company, emphasises the importance both of in-company R&D and of links with universities. He relates how R&D has transformed AstraZeneca from a company dependent on sales of mature medicines facing patent expiry to one with a range of high potential new medicines with strong patent protection. He also points to the importance of innovative procurement for the health of the European pharmaceutical industry.

Organic growth based on R&D and capital investment is a proven route to sustainable growth. Acquisition is sometimes seen as an alternative route which may be quicker and less risky. Brian Harding's commentary looks at acquisitions in eight R&D intensive sectors and finds that 70% of the larger acquisitions are associated with under-performance in shareholder returns. Furthermore, UK companies spend more than twice as much on acquisitions as they invest in R&D plus Capex. By contrast, US companies in the same sectors spend substantially less on acquisitions than they invest in R&D plus Capex.

What the Scoreboard shows

In two of the five high R&D sectors of the international Scoreboard, pharmaceuticals & biotechnology and health, UK companies have more R&D than any country apart from the USA, although we are less strong in the other three sectors. The UK also has R&D intensity (R&D investment as a proportion of sales) above the international average in pharmaceuticals & biotechnology and aerospace & defence – sectors which make up larger proportions of the UK economy than the international average – and health. And more UK companies are carrying out significant amounts of R&D. The UK Scoreboard for 2003 shows that an extra 23 UK companies now have R&D investment of £260k or more per year.

In two of the five high R&D sectors – pharmaceuticals & biotechnology and health – UK companies have more R&D than any other country except the USA although we are less strong in the other three sectors.

The R&D intensity of UK companies has increased over the last few years. The UK now has proportionally fewer low R&D intensity companies (intensity below 2%) and more high-intensity firms (over 10%) in the Scoreboard. However, there is no room for complacency. An in-depth comparison of the 1000 companies in the US R&D Scoreboard with the strictly comparable group of UK-owned companies from the UK 700 shows that the UK has proportionately more low R&D intensity firms than the US and many fewer with high intensities.

A similar study shows that the proportion of middle-sized US companies with high R&D intensity is more than three times that in the UK. However, there are high R&D intensity, high growth and profitable UK middle-sized companies in all the five high R&D sectors. It is just that we need more of these and more capable of growing to larger sizes.

The Role of Government

Government is creating a world-class business environment for R&D in the UK. The UK science base, an important source of new ideas and skilled researchers, is benefiting from an average 8% per year compound annual real terms increase in the science budget from 1997/8 to 2004/5. We have introduced R&D tax credits which are providing a stimulus to industrial R&D, including work commissioned from universities, and there are encouraging signs of increased industry/university collaboration.

Government is creating a world-class business environment for R&D in the UK. The UK science base... is benefitting from an 8% per year real terms increase... and we have introduced R&D tax credits... however, there is more to do (including) more innovative government procurement.

However, there is more to be done. The Innovation Review now in progress is identifying new ways to strengthen the UK's innovation performance. We are consulting on a revised definition of R&D to make our tax credits even simpler and more straightforward for business. In addition, the government intends to use more innovative approaches to procurement. All these measures will help UK companies to realise their full growth potential in world markets through innovation.

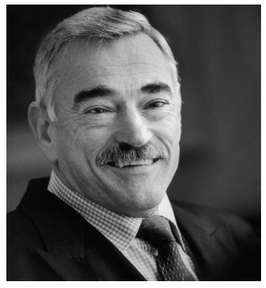
The Challenge for Business

The challenge for UK business is to use R&D, capital investment and a thorough understanding of global markets to create and exploit new opportunities. Early expansion into demanding overseas markets has helped successful UK companies raise their performance and grow. As well as wise and competitive investments in the future like R&D, successful companies make the right strategic choices and show operational excellence and attention to customers. With these strengths and sustained commitment, UK companies can grow and create more value in world markets.

The challenge for UK business is to use R&D, Capex and a thorough understanding of global markets to create and exploit new opportunities... with sustainable commitment UK companies can grow and create more value in world markets.

Commentary

Sir Tom McKillop, Chief Executive, AstraZeneca PLC



Innovation is the principal source of wealth creation and we need a good supply of well-trained scientists, passionate about research, if we are to compete successfully.

Pharmaceutical Innovation in Europe for Health and Economic Success

Pharmaceutical Research and Development is a major contributor to overall UK and European R&D activity and one in which we have been historically very successful.

AstraZeneca plays its full part in this. In the UK alone, we employ over 4,500 staff in R&D and spent over £700 million in 2002 out of a total R&D budget of over £1.9bn, an increase of 11% over 2001. In addition to this direct investment in R&D, we contribute through our relationships with universities, hospitals and smaller companies. We estimate that we have spent over £50 million over the last five years in grants and contracts with UK universities. Each year we directly fund over 100 post-doctoral students at a cost of approximately £100,000 each per annum, as well as contributing to many post-graduate research collaborations and providing student bursaries in selected topics. Indeed, we participate in research and the teaching of science at all levels and we do so with a sense of purpose and commitment. To us, innovation is the principal source of wealth creation and we need a good supply of well trained scientists, passionate about research, if we are to compete successfully.

We are particularly fortunate in pharmaceutical R&D that the products of our work can save and improve the quality of many people's lives, in addition to adding value to the local and national economies where the work is conducted. Direct and indirect employment flows from the investment programmes of companies like AstraZeneca and successful research leads to additional high-value manufacturing investment and exports. AstraZeneca pharmaceuticals are manufactured in the UK at Avonmouth and Macclesfield who in turn are customers for a large number of UK and Continental European suppliers. We set out to play an active part in the local communities in the 73 countries in which we operate, whether it be our employees giving their time to local projects or in helping many local good causes where we hope we can make an integral contribution to community life. In addition to the important contribution we make to the economy as a major employer, AstraZeneca spends over £1m each year in support of local communities, schools and charities within the UK.

Whilst we continue to increase our investment in R&D in both the UK and Europe, we are investing at an even faster rate in the USA.

Given such a virtuous circle, it is disappointing to observe that European based pharmaceutical companies are now locating less of their R&D within the EU, the level having declined from 73% of their worldwide R&D in 1990 to 59% in 1999. In the case of AstraZeneca, whilst we continue to increase our investment in R&D in both the UK and Europe in absolute terms, we are investing at an even faster rate in the US. Why is this happening?

70% of the worldwide sales of new medicines introduced between 1998 and 2002 were in the US and just 18% in the more populous European Union – a dramatic change from a decade ago.

The size of the US market and its premier position in biomedical research are of course important factors but so too is the US receptiveness to new medicines. 70% of the worldwide sales of new medicines introduced between 1998 and 2002 were in the US and just 18% in the more populous European Union – a dramatic change from a decade ago when the European market was larger than the USA.

As a result, European citizens are not getting as ready access to new medicines as their American counterparts and Europe is losing industrial and R&D competitiveness. Pressures on healthcare budgets are well understood as is the need for tough choices to be made, but Europe has been slow to deal with many structural and policy issues which have adversely affected the pharmaceutical industry to no economic gain, indeed to its significant economic loss. Overall the pharmaceutical industry is a huge net economic contributor to both the UK and European economies and is exactly the sort of high technology, high added value sort of industry in which we need to be successful.

The pharmaceutical industry is a huge net economic contributor to both the UK and European economies and is exactly the sort of high technology, high added value sort of industry in which we need to be successful.

Success is important not just to the large R&D based pharmaceutical companies but also to start-up companies and SME's who can only grow alongside established industry and a thriving academic research base. The UK Government has recognised this and the cycle of economic competitiveness driving further growth and R&D investment is being supported through Government policies, such as R&D tax credits and the development of clusters of world class bioscience companies in a number of regional strategies, including the work of Northwest Science (supported by the North West Regional Development Agency), in which I am involved . These moves combined with a 68 per cent real terms increase in the Government's total science budget from 1997/8 to 2004/5 are indeed welcome; but we must do even more to create an enabling climate for R&D discoveries to reach their full potential and to capture global investments in R&D capability.

Regulatory frameworks must become world class and that does not mean more regulation, but that it is fast, effective and responsive to innovation. More innovation is also needed in our approach to the public procurement of medicines which takes into account both their value to patients' health and the savings that medicines can and do make to healthcare budgets. Europe must seize the chance it now has to correct the distortions to the single market in pharmaceuticals, currently eroding so much value and driving away investment. The Commission, European governments and industry must deliver on the bold targets set for R&D and innovation in the Lisbon agenda. These are just a few of the improvements needed if we want to create the conditions for continuing success in pharmaceutical innovation for the UK and Europe.

Our scientists can compete with the best in the world. Within my own company they have played a vital role in the transformation of AstraZeneca from a company dependent on sales of mature medicines facing patent expiry to one with a range of high potential new medicines with strong patent protection. UK and European scientists can continue that success given the right conditions in which to compete and, in doing so, secure pharmaceutical innovation as one of the economic cornerstones of Europe, while bringing better health to its 450 million inhabitants.

Our scientists…..have played a vital role in the transformation of AstraZeneca from a company dependent on sales of mature medicines facing patent expiry to one with a range of high potential new medicines with strong patent protection.

Commentary

Brian Harding*, formerly of James Capel Stockbrokers

The share price effects of a growth strategy based largely on acquisitions are examined for a broad spectrum of manufacturing companies. The relationship between R&D plus Capex investment and acquisition spending is examined for both UK and US companies.

Acquisitions and Investment in Organic Growth in the UK and USA.

Introduction

As the 2002 R&D Scoreboard commentary showed, about 65% of all major acquisitions in the broad engineering sector were followed by long periods of share price under-performance. It was further demonstrated that UK companies in this sector spent between three and five times as much on acquisitions, per £ of sales, as their US counterparts.

In this article the share price effects of a growth strategy based largely on acquisitions, are examined for a broader spectrum of manufacturing companies including IT hardware, electronic & electrical, chemicals, pharmaceuticals & biotechnology and health in addition to the engineering, automotive and aerospace & defence sectors dealt with earlier. These sectors in total account for about 75% of all the R&D undertaken by UK companies. Most importantly, the relationship between investment, (Capex plus R&D), and acquisition spending is examined and UK and US practices in this area are compared.

The article is based on data relating to UK and US companies in the above eight sectors drawn from the US and UK R&D Scoreboards. There are 79 quoted UK companies, each of which meets a minimum turnover requirement of $100m in the year 2001. The US data is derived from 665 quoted companies in matched manufacturing sectors, with the same minimum turnover requirement. The article is divided into three sections:

Section 1 deals with the relative popularity of acquisition spend and organic investment in the UK over the period 1997-2001.

Section 2 examines the relative share price performance of high acquisition intensity companies.

Section 3 contrasts UK and US experience with respect to the use of acquisitions as a means of achieving corporate growth.

The 79 UK companies in 8 sectors made a total of 684 acquisitions over the period 1997-2001.

1. The Relative Popularity of Acquisition Spending and Organic Investment in the UK

Table 1 contains outline details of the total investment, (R&D plus Capex), and the total acquisition spend undertaken by the 79 UK companies over the five year period 1997-2001. It should be noted that this study has identified a total of 684 acquisitions where the consideration has been disclosed. A further 308 acquisitions were also completed in this period without disclosure of consideration and these are necessarily excluded from the analysis; they will not be material in financial terms or the consideration would have had to be disclosed.

Table 1: UK Investment and acquisition spending 1997-2001 £bn

Year	1997	1998	1999	2000	2001	Total
Acquisition spending (a)	11.1	13.3	47.8	60.5	7.5	140.2
Investment spending (b)	11.3	12.2	14.0	15.1	14.6	67.2
(a) as a % of (b)	98%	109%	341%	401%	51%	209%

1. Sources: The 2002 R&D Scoreboard. Thomson Financial.
2. The above figures on acquisitions include the purchase of Astra by Zeneca in 1999, and the purchase of SmithKlineBeecham by Glaxo in 2000.

* Brian Harding has a fellowship at Warwick Business School and was previously with James Capel for a period of some 20 years. Before this, he held senior management positions in UK engineering companies.

From table 1 it can be seen that, over the period, total acquisition spending was equivalent to 209% of total investment. The data on acquisition spending is, however, inherently very variable. Firstly, there is a strong cyclical element in the market for corporate control. Maximum expenditure tends to occur when the economy is buoyant and the price of making an acquisition is relatively high. Activity falls away in periods of economic difficulty when share prices and the cost of making an acquisition tend to be lower (see the data for 2001 above and The R&D Scoreboard 2002). This phenomenon relates to the desire of acquirers to use their own paper when their share prices are high, and the reluctance of sellers to deal when prices are low.

Over the period 1997-2001, a culture of growth by acquisition led to far more being spent by UK companies on acquisitions than on R&D and Capex combined.

Secondly, data on acquisition spending varies very sharply between companies. In particular, it is conceivable that the overall comparisons shown in table 1 above could be distorted by one or two exceptionally large deals. The two largest deals made over the period 1997 to 2001 are the acquisition of SmithKlineBeecham by Glaxo for $75.9bn in 2000, and the acquisition of Astra by Zeneca for $34.6bn in 1999. The arbitrary exclusion of Glaxo from the data shown in table 1 does result in a fall in the overall ratio of acquisition spend to investment spend, but only from 209% to 175%. If both Glaxo and Zeneca are excluded from table 1, there is a further but smaller fall in the ratio, from 175% to 153%. It appears that the data displayed in table 1 is not, therefore, unduly sensitive to the inclusion or exclusion of a small number of companies which have completed very large deals.

Lastly, acquisition intensity is examined by sector. The pharmaceutical and health sector was by far the most acquisitive with spend in this area almost equal to 56% of sales. (Even after the arbitrary removal of both GlaxoSmithKline and AstraZeneca, acquisition intensity in the sector was 35%). The other three sectors ranged from 8.5% to 19%. In any case acquisition spending exceeded investment in R&D plus capital spend in every sector group (see table 2).

Table 2: UK Investment and acquisition spending by sector (1997-2001)

	Acquisition Intensity	Investment Intensity
IT Hardware, electronic & electrical	19.0%	10.8%
Pharmaceuticals, health	55.8%	20.0%
Chemicals	8.5%	7.9%
Engineering, automotive, aerospace	11.9%	7.6%

The above figures on acquisition intensity include the purchases of Astra by Zeneca and SKB by Glaxo.

Whether or not the two major acquisitions in the pharmaceutical sector are included, it is clear that, over the period 1997-2001, a culture of growth by acquisition led to far more being spent in this area than on Capex and R&D combined. It is also clear that this culture, although most prominent in the pharmaceutical sector, is prevalent across a large part of UK manufacturing.

2. The Relative Share Price Performance of High Acquisition Intensity Companies in the UK

For each of the 79 UK companies in the study, an acquisition intensity figure was computed by summing acquisition expenditure over the period 1997-2001 inclusive and dividing this by the aggregate turnover recorded over the same period. These companies were then ranked by acquisition intensity. The top 30 companies accounted for 75% of all acquisition expenditure. For each of these top thirty companies the date of completion of the largest single acquisition was ascertained, and the share price performance from this date was compared with the FT All-share Index over the same period. On this basis 70% of all companies making a major acquisition under-performed the All-share Index*. The largest acquisition target had, in all cases, sales of more than 15% of those of the acquiring company.

The top 30 companies accounted for 75% of all acquisition expenditure and 70% of these companies under-performed the FTSE all-share index after making their largest acquisition.

* No more detailed statisticised analysis has been attempted because of the other factors causing share price variations.

For companies contemplating a large acquisition, the downside risks not only include the 70% chance of under-performance, but the scale of under-performance is larger, on average, than that of the out-performance of the remaining 30% of companies.

In many cases, the extent of the under-performance (following a large acquisition) was very severe with the share price dropping by up to 99%.

Table 3: UK Acquisition Intensity and Share Price Performance

Company	Acquisition Intensity	Change in Share Price from date of largest acquisition to March 2003	Change in FTSE All-share Index over the same period	Out-performance (+) or Under-performance (-)
Shire Pharmaceuticals	438%	-67%	-42%	-25%
Celltech	217%	-71%	-41%	-30%
Galen	162%	-52%	-42%	-10%
AstraZeneca	91%	-9%	-43%	+34%
GlaxoSmithKline	89%	-41%	-42%	+1%
First Technology	76%	-63%	-42%	-21%
Spirent	64%	-98%	-42%	-56%
Marconi	51%	-99%	-41%	-58%
Gardner	51%	-98%	-46%	-52%
BAE Systems	46%	-69%	-44%	-25%
Psion	43%	-94%	-43%	-51%
Smiths	41%	-21%	-42%	+21%
Bodycote	34%	-64%	-39%	-25%
Henlys	34%	-80%	-40%	-40%
AGA	32%	-20%	-38%	+18%
Meggitt	29%	-8%	-41%	+33%
Amersham	28%	-7%	-24%	+17%
Yule Catto	28%	-1%	-31%	+30%
Alvis	26%	+9%	-24%	+33%
Invensys	25%	-96%	-38%	-58%
Pressac	23%	-91%	-28%	-63%
ICI	23%	-89%	-24%	-65%
Yorkshire	22%	-93%	-46%	-47%
Enodis	22%	-86%	-41%	-45%
Filtronic	21%	-87%	-26%	-61%
BBA	21%	-65%	-38%	-27%
Mayflower	20%	-92%	-33%	-59%
FKI	19%	-76%	-41%	-35%
Firth RIxson	17%	-71%	-41%	-30%
Cobham	17%	+3%	-41%	+44%

Sources: Thomson Financial, Datastream.

It is worth noting that high acquisition intensity companies are well distributed across all four sector groups used in this analysis. Of the total of thirty, six are in the IT hardware, electronic & electrical sectors, six are in pharmaceuticals & biotechnology, three are in the small chemicals sector, and fifteen are in the large engineering, automotive and aerospace & defence sectors.

It is also worth noting that, in many cases, the extent of the under-performance was very severe with the share price dropping by as much as 99%. In fact, for companies contemplating a large acquisition, the downside risks not only include the 70% chance of under-performance but the scale of under-performance is, on average, larger than that of out-performance with an average decline against the All-share Index of 42%, compared to an average improvement against the All-share of 25% for the 30% of cases where there is out-performance. The under-performance of high acquisition intensity companies contrasts with the relative share price out-performance of high investment intensity companies, for which positive, statistically significant correlations have been discerned[1].

3. A Comparison of UK and US Investment Practice over the Period 1997-2001

The 79 UK companies completed 684 acquisitions over the period 1997-2001, an average of 9 per company, whereas the 665 US companies completed 1931 acquisitions, an average of only about 3 per company.

This comparison is based on data taken from the IT hardware, electronic & electrical, chemicals, health and pharmaceuticals, engineering, automotive and aerospace & defence sectors. The only requirement for inclusion was that the companies concerned should have minimum sales of $100m and a minimum R&D spend of $1m ($2m in 2001). The source documents were the R&D Scoreboard for the UK and the IRI Industrial R&D Scoreboard for the USA. There are 79 UK and 665 US companies which fulfil these size criteria. The analysis is effectively based on a complete enumeration of all the major companies operating in the above sectors. The 79 UK companies completed 684 acquisitions over the period 1997-2001[2], (an average of almost 9 per company). The 665 US companies completed 1931 acquisitions over the same period (an average of only about 3 per company).

There are substantial differences in investment culture between different sectors within both the UK and the USA. For example, the UK pharmaceutical industry spends about three times as much as the engineering sector, per £ of sales, on R&D and Capex. There are also substantial differences in the relative importance of various industrial sectors between the UK and the US. For example, of the 665 US companies in the study, 343 (about 52%) are in the IT hardware, electronic & electrical sectors. The corresponding figure in the UK is 25%. For these reasons the results have been analysed by sector and by year first, and only then aggregated so as to provide the clearest possible comparison between UK and US investment practice.

In table 4 below are set out the investment intensities, by sector and by year, for both US and UK companies:

Table 4: UK and US Investment Intensities* by Sector

Sector		1997	1998	1999	2000	2001	1997-2001
IT Hardware, Electronic & electrical	UK	10.3%	9.6%	10.8%	11.5%	12.1%	10.8%
	US	13.5%	14.1%	13.4%	14.2%	15.6%	14.1%
Pharmaceuticals, Health	UK	18.7%	19.5%	21.0%	20.3%	20.0%	20.0%
	US	16.8%	19.0%	17.2%	18.5%	18.4%	18.0%
Chemicals	UK	9.3%	9.3%	7.9%	6.3%	6.4%	7.9%
	US	9.4%	11.9%	11.9%	9.5%	8.9%	10.3%
Engineering Automotive and Aerospace	UK	6.3%	8.0%	8.2%	7.6%	7.7%	7.6%
	US	11.0%	10.6%	10.6%	10.5%	10.1%	10.5%

* Investment intensity: R&D plus capital spending as a percentage of sales.

In every year and in every sector (with the sole exception of pharmaceuticals) US companies invested more relative to sales than their UK counterparts.

It can be seen that, in every year and every sector, (with the sole exception of the pharmaceutical sector), US companies invested more relative to sales than their UK counterparts. US investment intensity (pharmaceuticals excluded), is equal to 132% of the average UK level. Whilst international comparisons are inevitably difficult, there is nevertheless, a substantial difference in cumulative investment intensity between the US and UK.

1. See DTI Capex Scoreboard 2001.
2. A further 308 acquisitions, almost certainly very small, were completed in the UK without disclosure of consideration. The corresponding figure for the US was 1824.

UK companies frequently spent more per £ of sales on acquisitions than their US counterparts. The position is effectively reversed vis a vis investment where US companies have generally higher investment intensities.

In table 5 below we set out acquisition intensities, by sector and by year for both US and UK companies.

Table 5: UK and US Acquisition Intensities by Sector

Sector		1997	1998	1999	2000	2001	1997 -2001
IT hardware, Electronic & electrical	UK	7.4%	19.4%	47.8%	17.2%	1.0%	19.0%
	US	4.6%	4.6%	4.4%	14.1%	15.0%	8.3%
Pharmaceuticals, Health	UK	5.1%	18.5%	71.6%	150.1%	10.0%	55.8%
	US	2.1%	3.3%	5.6%	47.2%	15.1%	16.3%
Chemicals	UK	24.2%	9.8%	1.2%	0.4%	2.1%	8.5%
	US	4.7%	8.2%	11.5%	13.4%	7.1%	9.0%
Engineering, Automotive and Aerospace	UK	6.7%	5.5%	33.4%	8.8%	6.1%	11.9%
	US	3.5%	4.3%	7.6%	4.8%	1.2%	4.3%

The data in this table includes the following major (over $10bn) acquisitions:

(i). In the UK: Zeneca bought Astra for $34.6bn in 1999; BAE Systems bought Marconi Electronic Systems for $12.8bn in 1999, Glaxo bought SmithKlineBeecham for $75.9bn in 2000

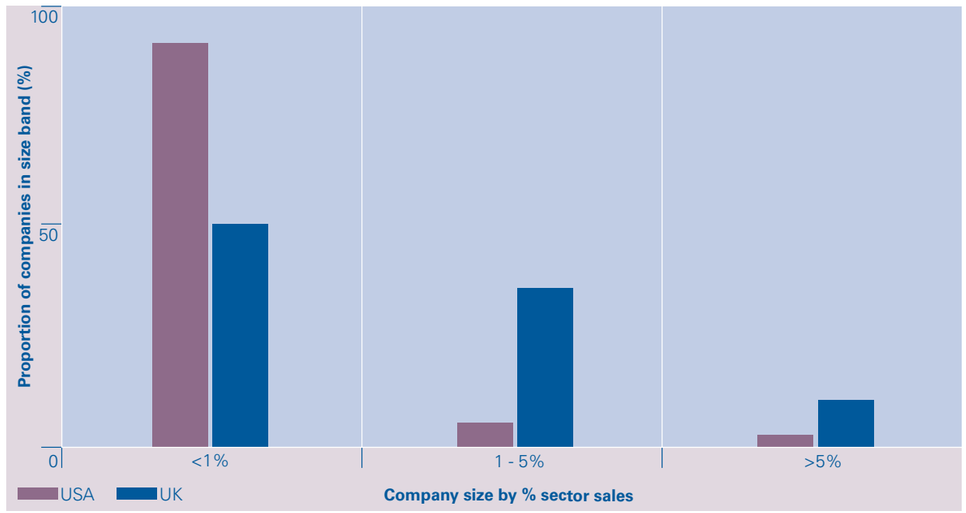
(ii). In the US: Boeing bought McDonnell Douglas for $13.4bn in 1997; JDS Uniphase bought E-Tek Dynamics for $15.4bn in 2000; Motorola bought General Instrument Corp for $10.9bn in 2000; Pfizer bought Warner Lambert for $94.4bn in 2002; Pfizer bought Pharmacia and Upjohn for $26.5bn in 2000; JDS Uniphase bought SDL for $41.4bn in 2001; Johnson and Johnson bought Alza for $11.1bn in 2001; and Dow Chemical bought Union Carbide for $11.7bn in 2001.

The UK is in a more advanced state of consolidation than the USA so that US manufacturing has the greater potential for acquisitions and might have been expected to show a higher rather than a lower propensity for acquisitions.

From the above table it can be seen that UK companies frequently spent more, per £ of sales, on acquisitions than their US counterparts. The position is effectively reversed vis a vis investment where US companies have generally higher investment intensities. This is an important point since, broadly speaking, growth by acquisition is associated with share price under-performance in two cases out of three, not only in the UK but also in the USA[3].

The idea that American companies are less inclined than their UK counterparts to pursue growth by acquisition is powerfully corroborated when the distribution of companies by size (sales) is examined. For both countries, and for the four sector groups which have been used throughout this study, companies were divided into three groups: those which accounted for less than 1% of their relevant sector sales, those which contributed between 1% and 5%, and those which accounted for more than 5% of relevant sector sales. The results of this analysis are set out in figure 1.

Figure 1: Company Size Distributions for US and UK



3. See M. L. Sirower, 'The Synergy Trap' 1997

It will be noted that, in 2001, 89% of US quoted companies each contributed less than 1% of their relevant sector sales. The corresponding figure for the UK is 50%. The position is wholly reversed when considering companies which accounted for more than 5% of sector sales. About 15% of British companies were in this position whereas only 3% of American companies contributed more than 5% of sector sales. If anything, the UK is in a more advanced state of consolidation than the USA, so that US manufacturing has the greater potential for acquisitions and might have been expected to show a higher, rather than a significantly lower, propensity to grow by acquisition. Further work is needed to understand why this should be so.

Conclusion

One key ratio for any comparison of UK and US investment practice is the acquisition spend per £($) of investment spending. Any difference in investment practices will show up most clearly in this ratio, despite the intensely variable nature of the acquisition component. We therefore tabulate below (table 6) the UK and US acquisition spend per £($) of investment spending over the period 1997-2001 inclusive.

Overall, UK companies spent three and a half times as much on acquisitions per £ of investment spending as their US counterparts.

Table 6: Acquisition Per £ ($) of Investment in the UK and US

	1997	1998	1999	2000	2001	1997 -2001
UK	0.98	1.09	3.41	4.0	0.51	2.09
US	0.32	0.37	0.54	1.05	0.61	0.59

Note: For major acquisitions included, see table 5

From the above table it will be seen that, in terms of acquisition spend per £($) of investment spend, UK companies exceeded US companies in four years out of five – and always by a large margin. In the last year, the UK spent slightly less than the US per £ of investment. Overall, UK companies spent three and a half times as much on acquisitions per £ of investment as their US counterparts. When the probability of under-performance attaching to a major acquisition is of the order of 70%, reliance on growth by acquisitions will, on average, produce disappointing results for shareholders. Even if the US data is adjusted to the same sector sales mix as the UK, the result is that UK companies still spent three times as much as US companies on acquisitions per £ of investment.

When the probability of under-performance attaching to a major acquisition is of the order of 70%, over-reliance on growth by acquisition will, on average, produce disappointing results for shareholders.

The above findings are broadly based in the sense that the UK and US companies, included in the study, account for about 75% of all R&D undertaken by quoted companies. The findings are also persistent.

Any suggestion that the nature of UK acquisitions is in some way broadly different from those undertaken by US companies is countered by the fact that acquisition under-performance rates (i.e. long run under-performance, in terms of total shareholder return after a major acquisition), are virtually identical between the two countries at around 66 – 70%.

No criticism is intended either of acquisitions per se, or of any particular acquisition. The importance of acquisitions is acknowledged as a means of removing poor management and in some other highly specific circumstances. Indeed, 30% of large acquisitions are associated with share price out-performance. It is a matter of degree and of risk. When the probability of under-performance attaching to a major acquisition is of the order of 70%, over-reliance on growth by acquisition will, on average, produce disappointing results for shareholders.

Over the period 1997 –2001, UK companies, unlike their US counterparts, chose to pursue growth predominantly via acquisitions with less emphasis on long-term investment in capital spending and research & development.

Analysis

By Dr Mike Tubbs, Senior Industrialist, DTI Business Finance & Investment Unit

The R&D Scoreboard is the only source of both input (investment) and output data for a substantial set of R&D-active companies from all regions of the globe.

1. The 2003 R&D Scoreboard

The R&D Scoreboard has been published every year since 1991 and is now acknowledged as the premier source for data on the world's top R&D-active companies together with those in the UK. It contains data both on company investment inputs such as R&D and Capex, outputs such as sales, profits and market capitalisation and key performance ratios.

Whilst value added (see reference 1) is the preferred output measure, US and Japanese companies do not give enough information in their accounts to allow value added to be calculated. The R&D Scoreboard is thus the only source of both input (investment) and output data for a substantial set of R&D-active companies from all regions of the globe.

The 2003 R&D Scoreboard contains three major improvements:

- The number of companies has been increased to 700 in both the international and UK lists, up from 600 in 2002. This means that the minimum R&D for inclusion in the international list has dropped from £42m in 2002 to under £35m in 2003. The minimum UK R&D has likewise dropped from £260k to £30k. However, there are 23 more companies this year with R&D of £260k or more which is a promising increase in the number of R&D-active UK companies.
- Data has also been collected on the cost of funds (CoF – the sum of interest and dividend payments) and on the proportion of CoF accounted for by dividends. While the company level data are not included for reasons of space, comparisons between countries are shown in figure 6 where big differences are evident in the CoF/R&D ratio.
- An initial set of patent data+ has also been included for some 150 international companies from nine of the more R&D intensive sectors. The data is based on US patents since any potentially important patent will be filed in the USA irrespective of the country of origin.

The emphasis of the 2003 Scoreboard is also on continuity of the main topics of analysis to ensure that significant trends in the data from year to year can be highlighted.

Of particular interest this year are:

- A comparison of R&D and R&D intensity for the three world regions.
- The different financial environments in the major R&D-active countries.
- A deeper analysis of sectors – sector mix, concentration and intensity.
- A comparison of the distribution of US and UK companies between the different bands of R&D intensity.
- Middle-sized companies – size distribution, intensity distribution and growth rates.
- Links between R&D intensity and market capitalisation/share price performance.

The 2003 R&D Scoreboard contains three major improvements but also emphasises continuity of the main topics of analysis so significant trends can be highlighted.

+ Provided by Innovaro Limited (reference 10) see pages 130-133 of part 2 of the Scoreboard

2. Overall Business Performance and R&D Intensity by Region & Country

2.1 Business Performance

The financial year 2002/2003 covered by this Scoreboard was a difficult one for most businesses and particularly for those in R&D-intensive sectors such as IT hardware and software & IT services. Some key results for the 700 international companies are shown in figure 1.

The financial year 2002/03 was a difficult one with both sales and R&D stable overall for the international 700 but with both profits and employee numbers down.

Figure 1: Business Performance of International R&D Companies

	All 700 Companies	Americas	Europe	RoW
Change* in Sales	0%	-2%	0%	+3%
Change in Operating Profit	-16%	-21%	-20%	-2%
Change in Number of Employees	-3%	-1%	-5%	-4%
Change in R&D	+1%	0%	-1%	+5%
Sales per Employee	£186k	£189k	£182k	£186k

* Change means % change over previous year for international 700

While both sales and R&D are stable overall (and show only small changes by region with Asia the only region showing some growth), profits are down substantially in America and Europe while employee numbers are down everywhere but particularly in Europe and Asia. Reduced profits but not reduced employee numbers were also seen in the 2003 Value Added Scoreboard for European companies (reference 1). Despite the small overall change in R&D investment, over 60% of the international 700 companies increased their R&D over the previous year. Note that overall sales per employee are now similar for all three world regions at £186± 4k. The range in 2002 was £165-216k and the reduction in spread is largely associated with exchange rate movements. (European currencies strengthening against the US Dollar since the £216k was for the Americas, £165k for Europe).

Despite the small overall change in R&D investment, over 60% of the international 700 increased their R&D over that of the previous year and R&D intensity increased for 8 of the top 10 sectors.

2.2 Regional R&D Analysis

The total R&D investments and the R&D intensities for the three world regions are given in figure 2. The R&D intensities (R&D as % sales) are independent of exchange rates and show increases over 2002 with the USA rising from 5.1 to 5.2%, Europe from 3.6 to 3.7%, but the rest of the world (RoW) remaining at 4.1% (Japan 4.3%). The Americas account for almost one half of the 700 companies (332 of which 321 are from the USA).

Figure 2: R&D Investment and Intensity by Region

	Total	Americas	Europe	RoW
Number of Companies	700	332 **(USA 321)**	194	174 **(Japan 152)**
R&D Investment	£206.7bn	£88.8bn	£68.9bn	£49.1bn
R&D Intensity (R&D as % Sales)	4.3%	5.1% **(USA 5.2%)**	3.7% **(See fig.3)**	4.1% **(Japan 4.3%)**
R&D Intensity In 2002 Scoreboard	4.3%	5.1% **(US 5.1%)**	3.6% **(see fig.3)**	4.1% **(Japan 4.3%)**

The R&D intensities for world regions show increases over 2002 for the USA (rising from 5.1 to 5.2%) and Europe (from 3.6 to 3.7%) while RoW remains at 4.1%.

Larger companies account for a substantial fraction of total R&D. For example, the top 37 UK companies account for over 82% of the R&D of the top 540 UK-owned companies.

The increase in the total number of companies over 2002 means that comparisons between European countries have become statistically more reliable with 14 more companies from the top four countries – now 47 companies from Germany and 37 from the UK. These larger companies account for a substantial fraction of total R&D. For example, the top 37 UK companies account for over 82% of the R&D of the top 540 UK-owned companies in the Scoreboard. The individual European country intensities are shown in figure 3 for the top four European countries – Germany, UK, France and Switzerland.

Figure 3: R&D Intensities for European Countries

	Germany	UK	France	Switzerland	UK 700
Number of Companies	47	37	33	21	(700)
R&D intensity*	4.6% **(4.3%)**	2.5% **(2.6%)**	3.1% **(3.2%)**	6.0% **(5.8%)**	(2.2%) **(2.2%)**
Intensity for All sectors except oils & pharmaceuticals*	4.3% **(3.9%)**	2.9% **(2.9%)**	2.9% **(2.9%)**	3.0% **(3.0%)**	(2.1%) **(2.1%)**
Pharmaceuticals	14.2%	15.1%	16.5%	14.2%	(15.5%)

* Previous year figures in brackets in red.

The overall R&D intensity has increased over the previous year for Germany and Switzerland but not for the UK or France.

The overall intensity has increased over the previous year for Germany and Switzerland but not for the UK or France. However, it was pointed out last year that the intensity figure excluding oil & gas and pharmaceutical companies is also meaningful. This is because oil & gas companies have very large sales but low R&D intensities while pharmaceutical companies have high R&D intensities but relatively low sales. The two sectors pull the overall average intensity in opposite directions by significant amounts so that differences in the size and ratio of these two sectors between countries can have substantial effects on a country's average intensity.

The overall intensity calculated excluding oils and pharmaceuticals is seen from figure 3 to be similar for the UK, France and Switzerland at 2.9 to 3.0%, but much larger for Germany at 4.3% reflecting Germany's strength in engineering. The four countries have similar intensities in pharmaceuticals & biotechnology (14-16 1/2%) but different 'weights' for this sector.

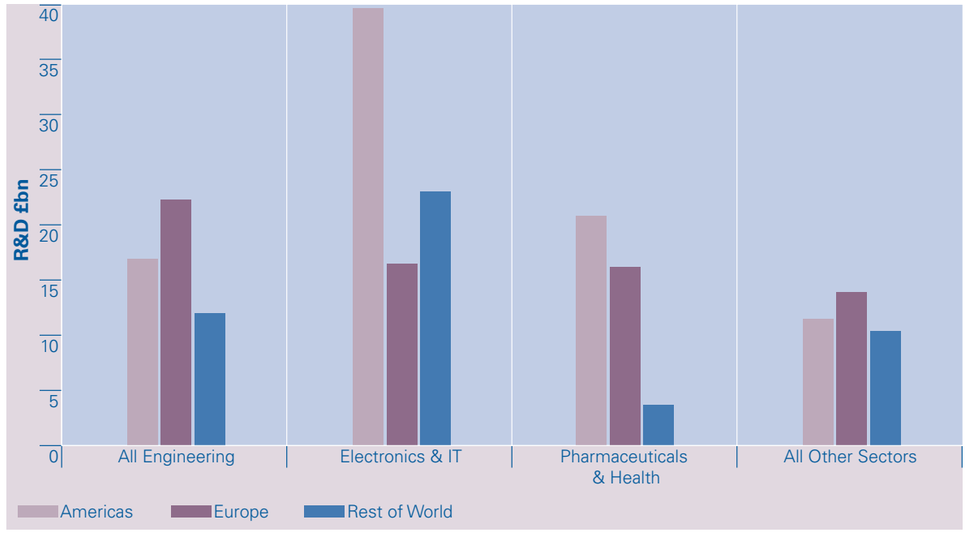
Whilst R&D intensity is a key measure, the quantity of R&D carried out by a country's companies in different sectors is also very important since this is related to the quantity of high value added activity. For example, a country derives limited benefit from high intensity R&D in a sector of small size that may even be subcritical. In other words, sector mix is very important as well as intensity within each sector. In judging the size of a country's R&D, by sector group, companies are grouped into four categories:

- Pharmaceuticals & biotechnology and health;
- Electronics and IT (IT hardware, software & IT services, electronic & electrical);
- Engineering (Aerospace & defence, automotive, engineering);
- All other sectors.

The Americas (primarily USA) have the largest total R&D and are first in pharmaceuticals & health and in electronics & IT. Europe leads in the engineering sectors and in the 'other sectors' category.

The distribution of R&D between these four groups of sectors is examined at three levels – between world regions, between the larger European countries and, for the UK, between large companies by R&D investment and others. Figure 4a shows total R&D by region for the four sector groups:

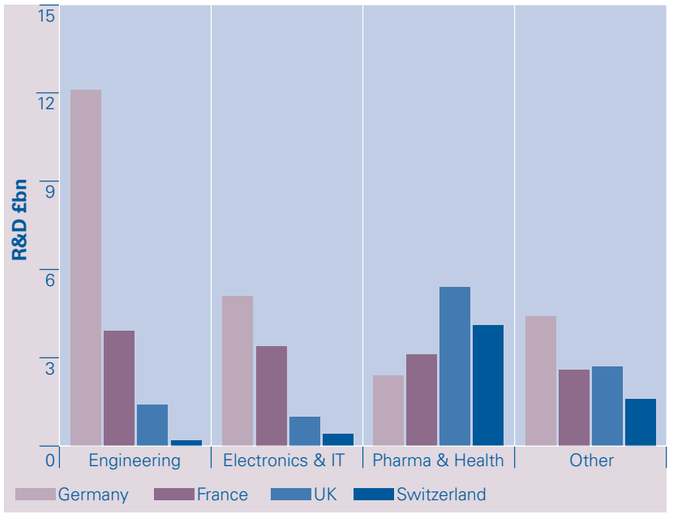
Figure 4a: Total R&D Investment by Sector Group for World Regions



The Americas (primarily USA) have the largest total R&D and are first in pharmaceuticals & health and electronics & IT. Europe leads in the engineering sectors and in others, and is a close second in pharmaceuticals & biotechnology plus health while the rest of the world (primarily Japan) is second in electronics & IT but has surprisingly little R&D in pharmaceuticals & health.

The Americas (primarily USA) have the largest total R&D and are first in electronics & IT and in pharmaceuticals & health. Europe leads in the engineering sectors and in 'others'.

Figure 4b: Total R&D Investment by Sector Group and Country for European Companies in the International 700



The international 700 data for the 4 main European R&D countries are shown in figure 4b which compares total R&D in the four sector groups. This figure illustrates the big differences in sector mix. The overall totals show that German companies in the international 700 have more than twice as much R&D as UK companies and almost twice as much as French companies. Switzerland, in the top 700 (with a much smaller population) has about half

Within Europe, Germany has a clear lead in engineering and in electronics & IT, but the UK is a clear leader in pharmaceuticals & health followed by Switzerland.

as much R&D as France, in the top 700*. However the total R&D for all the companies from Germany, France, UK and Switzerland is only 63% of the US total and 120% of Japan. For sector groups, Germany has a clear lead in engineering where its R&D is over three times that of France and eight times that of the UK; this reflects German companies' strength in automotive. Germany is also a clear leader in electronics and IT and in the 'other' category. The UK, on the other hand, is a clear leader in pharmaceuticals & health followed by Switzerland; the UK has more than twice Germany's level of R&D in these sectors. The UK is also second in the 'other' category.

Given that the 37 UK companies in the international 700 represent only about two-thirds of the UK 700 R&D, it is possible that the proportions of R&D in the four sector groups of fig 4b might be substantially different in the UK 700.

Figure 4c: R&D by Sector Group for UK 37 and UK 700

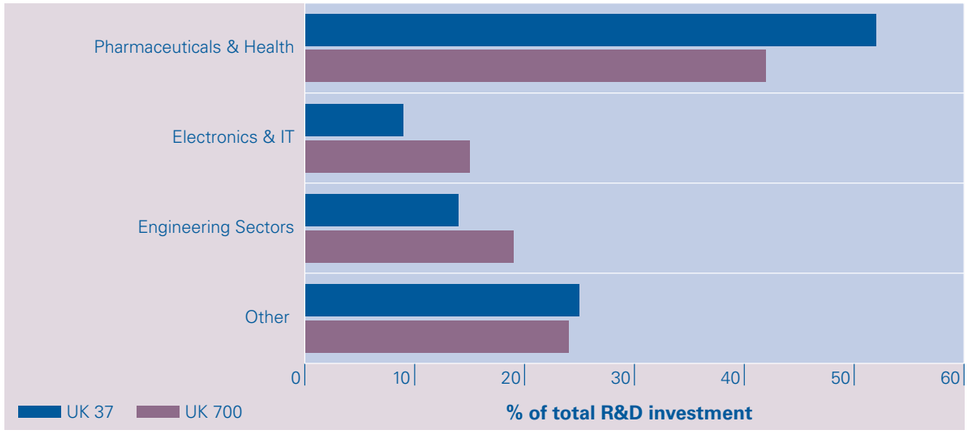


Figure 4c shows that this is not the case since pharmaceuticals & health still dominate the UK 700 with the 'other' category unchanged and both electronics/IT and engineering around one third and one half of pharmaceuticals & health. In Germany, the position is reversed with pharmaceuticals & health under half of electronics/IT and under one quarter of engineering. Further details of sector 'weights' are given in section 4.

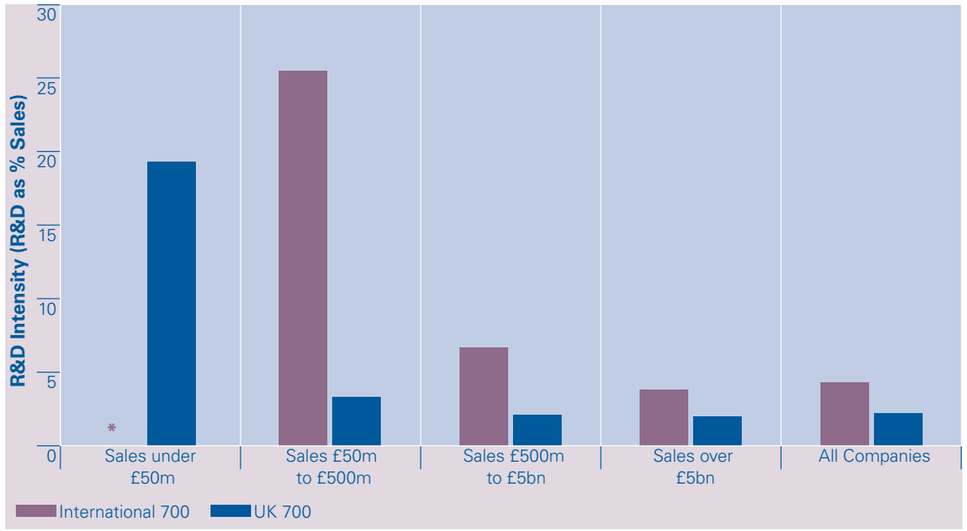
There is a significant inverse relationship between R&D intensity and company size with larger intensity on average for the smaller R&D-active companies. This is to be expected.

2.3 The Effects of Company Size and Ownership on R&D Intensity

There is a significant inverse relationship between company size and R&D intensity with larger intensity on average for the smaller R&D-active companies. This would be expected for sectors such as pharmaceuticals & biotechnology or software & IT services which contain many small companies since the costs of new product development are spread over smaller sales volumes for the smaller companies.

* See notes on p142 of part 2 Company Data.

Figure 5a: R&D Intensity and Company Size



* Figure omitted since only 15 companies have sales below £50m and all necessarily have R&D over the minimum of £34m.

The data are shown in figure 5a. International companies with sales over £5bn have an overall R&D intensity of 3.8% whereas companies with sales of £500m to £5bn have an intensity of 6.7% and those with sales of £50m to £500m have 25.5%. The trend in the UK is in the same direction but only for the smallest companies with sales up to £50m does the intensity rise above 4% (to 19.3% for the smallest). The low average R&D intensity for middle-sized UK companies will be discussed further in a later section which compares UK and US performance in this regard.

Figure 5b: R&D Intensity by Company Ownership

	International 700	UK 700
Listed Companies	4.3%	2.1%
Private Companies (including government owned)	6.3%	1.4%
Foreign owned companies	–	2.9%
All companies	4.3%	2.2%

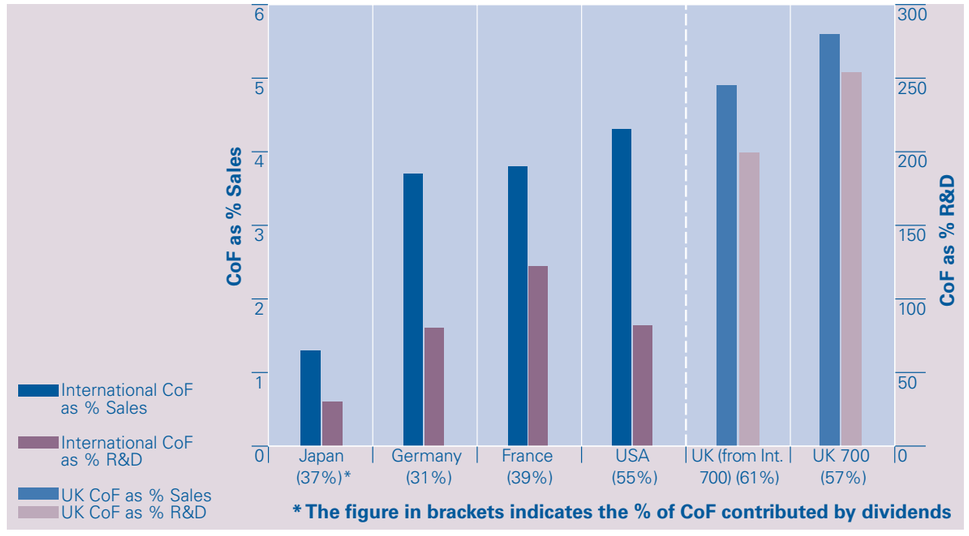
Intensity also varies with ownership as shown in figure 5b. In the international list there are only some 25 private companies but these have a higher than average intensity. The UK private companies have a much lower intensity due to a few companies with large sales but low R&D (e.g. Royal Mail, Wittington Investments). Foreign owned companies, on the other hand, have a higher than average R&D intensity driven by a few large R&D investors (e.g. Ford, Pfizer). Foreign owned UK companies, however, invest at a lower intensity than UK companies in several sectors (e.g. software & IT services, electronic & electrical). Overall, foreign-owned companies account for 21% of UK 700 R&D.

Foreign-owned UK companies have a higher than average R&D intensity driven by a few big R&D investors. However, they invest at a lower intensity than UK companies in several sectors (e.g. software & IT services, electronic & electrical).

2.4 The Cost of Funds

The cost of funds (CoF = interest on debt plus equity dividends) for R&D-active companies in the five major countries is shown in figure 6.

Figure 6: Cost of Funds by Country



There are big differences between these countries which all have reasonable numbers of companies in the international 700. The UK has a CoF at 4.9% of sales (and 5.6% for the UK 700) followed by the USA at 4.3%, France and Germany at 3.8/3.7% and Japan at 1.3%. It can be seen from figure 6 that the differences in CoF as % sales are largely driven by differences in dividends which account for 61% of UK* CoF, 55% in the USA but only 30-40% in France, Germany and Japan. These are the actual ratios of dividends to CoF and no judgement is implied on what the ratio should be. A pension fund may value dividends to meet pension commitments and may thus take a different view to an investor interested mainly in share price growth.

The figures for the USA and UK may be underestimates since a company wishing to distribute earnings to shareholders can also use share buybacks which avoid the double taxation levied on dividends in many countries (i.e. corporation tax on earnings and tax on the dividend). There is an issue as to whether share buybacks should, in formal accounting terms, be regarded as part of CoF. However, in practice companies do regard share buybacks as alternatives to dividends, particularly in the USA, for returning cash to shareholders. The USA has recently implemented a cut in the tax on dividends (in May 2003) and this may well lead to higher dividends in future financial years. Indeed, the number of US companies increasing dividends (or starting to pay them this year) is already (August) above the number for the whole of 2002. The scale of share buybacks can be estimated from Lombard Street Research (reference 2) which gave total UK share buybacks as 35% of dividends in the first quarter of 2003. A sample of R&D Scoreboard FTSE 100 companies gives a comparable ratio.

The UK has a cost of funds (CoF) of 4.9% of sales followed by the USA at 4.3%, France and Germany at 3.8/3.7% and Japan at 1.3%. The ratio of CoF to R&D is over 200% for the UK compared to the international average of 90%.

* A high overall UK market payout ratio of 55%, higher than all other major European countries was also reported by UBS Warburg ('European Strategy' 16 April 2003).

The ratios of CoF to R&D given in figure 6 show even larger differences with the UK at 200% or more compared to the international average of under 90% (Germany, France and the USA range from 80-120%). The US ratio would undoubtedly be larger if share buybacks were included. However, since this would also increase the UK figure significantly, the US/UK gap would arguably remain. The meaning of the CoF to R&D ratio is best seen by taking a model in which UK dividends are reduced to 35% of CoF (a level between Germany and Japan) and the balance of CoF transferred to R&D. UK large company R&D intensity would then rise from 2.5 to 3.8% (above the current European level). This example simply illustrates the size of the differences in CoF and R&D.

The scale of the difference is illustrated by noting that, if UK dividends were reduced to 35% of CoF (a level between Germany and Japan) and the balance of CoF transferred to R&D, UK large company R&D intensity would rise from 2.5 to 3.8% (above the European average).

If a notional increase of this size in R&D were to be implemented in practice, the sector mix issues raised in figure 4 would need to be taken into account. This would mean that, for an increase in R&D of this size to be fully effective, increases in R&D intensity would need to be accompanied by increases in the number of companies in high R&D sectors and by the expansion of existing companies into higher value added product/market areas. Figure 4 shows that this could either be in sectors where the UK has a small total of R&D or by expanding those sectors where the UK is already demonstrating success (or a mixture of the two).

2.5 Acquisitions and Organic Growth

The cost of funds and level of dividends is not the only difference in the financial environment for companies based in different countries. The other is the propensity of companies to grow by acquisition as opposed to organic growth (based on innovation, R&D and Capex). The 2003 Value Added Scoreboard (reference 1) showed that the UK spends a larger proportion of value added on both dividends and acquisitions (seen as higher amortisation of goodwill) than do other European countries. The second commentary in this Scoreboard (reference 3) shows that UK companies across several R&D-active sectors for a 5 year period spent on average more than twice as much on acquisitions as they invested in R&D plus Capex. This ratio is less than 0.6 across the same US sectors for the same period and much lower for other countries such as Germany and Japan. The US sectors are also less consolidated than the corresponding UK sectors so the opportunities for acquisitions are greater in the USA. Further work is needed to understand why US companies have a lower propensity for acquisitions than do UK companies when the corresponding US sectors are less consolidated. It might, for example, be that barriers to entry are different on the two sides of the Atlantic or that the difference in market sizes discussed on page 43 are important. The explanation is certainly not that major acquisitions have different chances of success in the US and UK since about two-thirds are associated with share price under-performance in both cases.

UK companies across several R&D-active sectors and for a 5 year period spent on average more than twice as much on acquisitions as they invested in R&D plus Capex. This ratio is less than 0.6 for US companies across the same sectors and for the same period.

It is also well established (references 4, 5, 6) that shareholder returns are lower for around two-thirds of companies that make major acquisitions (where the target company has sales of at least 15% of those of the acquirer). There are several ways in which major acquisitions can adversely affect organic growth. These include the large amount of management time needed to integrate a major acquisition and the financial pressures generated by paying the acquisition premium which is often not recovered through synergies (which can be the subject of optimistic estimates). It is in any case important that the quality of an acquisition target's R&D programme and patent portfolio is evaluated well before a final decision to acquire is made; anecdotal evidence from both the US and UK suggests that this is unfortunately not always a priority.

It is well established that shareholder returns are lower for about two-thirds of companies that make major acquisitions both in the UK and USA.

Five new companies have joined the international top 12 since 1998 – two each in pharmaceuticals and IT and one in automotive.

3. The Top R&D Investing Companies

The top 12 R&D investing companies both internationally and in the UK are listed in figure 7 which also gives their positions in the 1998 Scoreboard (reference 7). Internationally, several pharmaceutical & biotechnology, and IT hardware and software & IT services companies have risen over 20 places and joined the top 12. Amersham is the highest riser in the UK list (by 22 places).

Figure 7: The Top 12 R&D Investors 2003

International	UK-Owned
1. Ford (£4.8bn) (2)	1. GlaxoSmithKline (£2.9bn) (1)
2. DaimlerChrysler (8)	2. AstraZeneca (3)
3. Siemens (3)	3. BAE Systems (9)
4. General Motors (1)	4. Unilever (4)
5. Pfizer (31)	5. BT (10)
6. Toyota Motor (6)	6. Marconi (5 as GEC)
7. IBM (4)	7. Rolls-Royce (13)
8. GlaxoSmithKline (34)	8. Shell (6)
9. Matsushita Electric (7)	9. BP (17)
10. Volkswagen (20)	10. Invensys (14 as Siebe)
11. Microsoft (32)	11. Reuters (11)
12. Intel (£2.5bn) (21)	12. Amersham (£184m) (34)

Note: figures in brackets denote a company's position in the 1998 Scoreboard.

Over 20 companies have joined the international top 100 since 1998. Several companies have climbed by many places (e.g. Nokia by 52 places and Cisco by 39) while other companies have dropped out.

A fuller picture of the companies and sectors that have increased their relative positions in the Scoreboard can be obtained by identifying new entrants to the top 100 companies in each case. The results of this comparison are shown in figures 8a and 8b. There is some ambiguity in constructing figure 8 because of merger, acquisition and demerger activity. However, where companies in the 2003 and 1998 Scoreboards are clearly closely related, they are treated as the same company including the case of a simple demerger. Others formed from the merger of parts of two existing companies (e.g. Aventis or Syngenta) are treated as new companies. Some companies have remained in the international top 100 but have climbed by many places (examples are Nokia by 52 places and Cisco by 39 places). Other companies have dropped out of the international top 100 (e.g. ABB, France Telecom, Apple Computer and Shell).

Figure 8a: New Entrants to International Top 100 Since 1998

Aerospace & defence:	BAE Systems Finmeccanica Honeywell International
Automotive:	BMW, Nissan, Hyundai, Mazda, Michelin
Chemicals:	Syngenta
Electronic & electrical:	Agilent, Ricoh, Samsung
Food Processing:	Nestle
IT Hardware:	AMD, Broadcom, EMC, ST Microelectronics
Pharmaceuticals & biotechnology:	Aventis, Sanofi-Synthelabo, Wyeth
Software & IT Services:	Computer Associates, SAP

All but two of the new entrant international companies in figure 8a are from six sectors – aerospace & defence, automotive, electronic & electrical, IT hardware, pharmaceuticals & biotechnology and software & IT Services which are, with chemicals, in the top seven sectors by percentage of total R&D.

Figure 8b: New Entrants to UK Top 100 Since 1998

Sector	UK-owned	Foreign-owned
Chemicals	Aveciа†	Lubrizol Syngenta†
Electronic & electrical	Pace Micro Technology*	Agilent Alstom Philips
Food Processing	–	Effem
IT Hardware	ARM Bookham Dialog Semiconductor Filtronic TTP Communications	Matsushita Motorola ST Microelectronics
Pharmaceuticals & Biotechnology	Cambridge Antibody Merial Oxford Glycosciences Powderject+ Shire Pharmaceuticals	AHP Bristol Myers Squibb Eli Lilly Merck Sharp & Dohme Novartis
Software & IT Services	Amdocs LogicaCMG Merant NSB	
Other Sectors	7 companies	7 companies

* Classified as household now but as electronics up to 2002
† Both companies had origins in Zeneca
+ Now foreign-owned

Nearly 40 Companies have joined the UK top 100 since 1998 and some companies have risen by many places (Celltech from 77 to 22, Vodafone 48 to 15 and Sage 87 to 40). There are most new entrants in pharmaceuticals & biotechnology (10).

The new entrants to the UK top 100 between 1998 and 2003 are larger in number since only £17m of R&D in 2003 is needed to enter the UK top 100 (as opposed to £432m for the international top 100) so faster growing middle-sized companies can be and are included in the UK case. Several companies in the UK 1998 top 100 have risen substantially (Celltech from 77 to 22, Vodafone 48 to 15 and Sage 87 to 40). The new entrants are listed in figure 8b and comprise somewhat more UK-owned than foreign-owned companies. There are most new entrants in pharmaceuticals & biotechnology (10) – a strong sector in the UK – followed by IT hardware (8) and then software & IT services and electronic & electrical (both with 4).

90% of international 700 R&D is in the top 10 sectors and 57% in the top 3 sectors (IT hardware, automotive and pharmaceuticals).

The UK 700 has 40% of its total R&D in pharmaceuticals & biotechnology followed by aerospace & defence at 9%. The UK is also strong in food processing compared to the international level.

4. Industrial Sector Mix

Whilst there are companies from 27 sectors in the international list (and from 32 sectors in the UK list), 90% of the R&D is in the top 10 sectors and 57% in the top 3 sectors. The aim of this section is to provide an overview of the weight, concentration and intensity of R&D in the top 10 sectors and then to analyse the five high R&D sectors in more detail.

4.1 The top 10 Sectors by Proportion of Total R&D

Figure 9 shows the top 10 international sectors by proportion of R&D in the top 700 companies.

Figure 9: Sector Mix and Concentration UK & International

International Top 10 Sectors	% International 700 R&D (2002 in brackets)	% of Sector R&D in top 2 companies	% UK 700 R&D (2002 in brackets)	% Sector R&D in top 2 Companies
IT Hardware	21.7% (25.1)	11%	6.2% (8.2)	47%
Automotive	18.0% (16.5)	23%	7.3% (6.4)	89%
Pharmaceuticals & biotechnology	17.5% (16.3)	17%	40.0% (36.7)	76%
Electronic & electrical	10.4% (10.4)	31%	3.7% (4.5)	51%
Software & IT services	6.3% (6.7)	43%	5.0% (5.1)	21%
Chemicals	4.8% (4.9)	25%	3.5% (3.8)	46%
Aerospace & defence	3.9% (3.9)	30%	8.8% (9.8)	85%
Engineering	2.9% (3.0)	20%	**2.7% (2.6)+**	16%
Telecomms	2.2% (2.2)	59%	3.5% (3.0)	98%
Health	2.2% (2.0)	31%	**(2.1% (1.9)+**	75%
Food Processing	**0.9% (0.8)***	68%	5.5% (5.1)*	89%
Oil & gas	**1.4% (1.4)***	28%	3.6% (3.8)*	91%
Others	7.7%	–	8.1%	–

* In UK top 10 but not international top 10 + Not in UK top 10

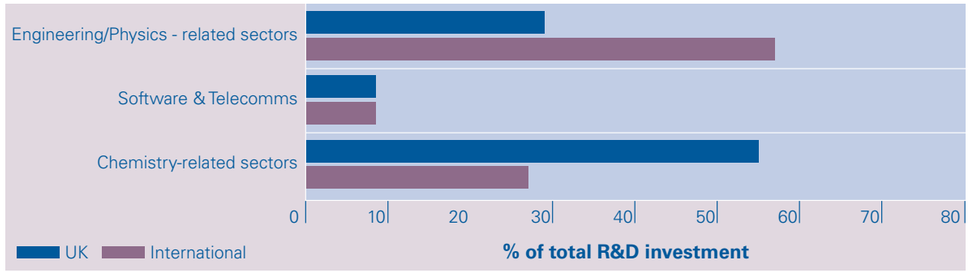
Given the absence of any very large UK software or engineering companies, these are the only two sectors where the top two UK companies account for a lower % of sector R&D than do the top two internationally.

The order is identical to last year although the proportion of IT hardware has decreased from 25.1% to 21.7% of the total. For the UK 700, the top 10 sectors include food processing and oil & gas in place of engineering and health. The major differences between the UK and international proportions are:

- The UK has 40% (up from 36.7% last year) of total R&D in pharmaceuticals & biotechnology compared to 17.5% internationally (up from 16.3%) with the second largest sector being aerospace & defence at 8.8% compared to 3.9% internationally. The UK is also strong in food processing (5.5% vs 0.9% internationally).
- The UK has much smaller proportions of R&D in IT hardware (6.2% vs 21.7%, both down from last year) automotive (7.3% vs 18%) and electronic & electrical (3.7% vs 10.4%). This reflects the differences seen in figure 4.

Figure 9 also shows the sector concentrations – the percentage of each sector's R&D contributed by the top 2 companies. Most of the international top 10 sectors have 20-30% of sector R&D in the top 2 companies, the exceptions being IT hardware (11%), software & IT services (43%) and telecomms (59%). The UK has percentages of 45% to 90% with exceptions being software & IT services and engineering (much lower) and telecomms (98%). The software & IT services and engineering sectors are the only ones in figure 9 where a smaller percentage of sector R&D is contributed by the top 2 companies in the UK compared to the international case. This reflects the absence of any very large R&D companies in the UK although both sectors have a long list of mostly small UK companies (78 in engineering and 111 in software & IT services). Indeed, no UK engineering companies are large enough to make the international 700. The comparable numbers in the international list are 47 in engineering and 68 in software & IT services. However, if only UK companies with R&D over £1m are counted, the UK figures become 50 in engineering and 79 in software & IT services.

Figure 10: Comparison of UK and International Sector Groups



There is a clear difference between the UK and international sector weights and this is illustrated by figure 10 which recasts the data of figure 9 into three groups of sectors. The conclusion from figure 10 is that, while the total proportions of software plus telecomms is identical in the two cases:

- The chemistry-related sectors account for 27% of international R&D but fully 55% of UK R&D;
- The physics/engineering based sectors account for 57% of international R&D, but only 29% of UK R&D.

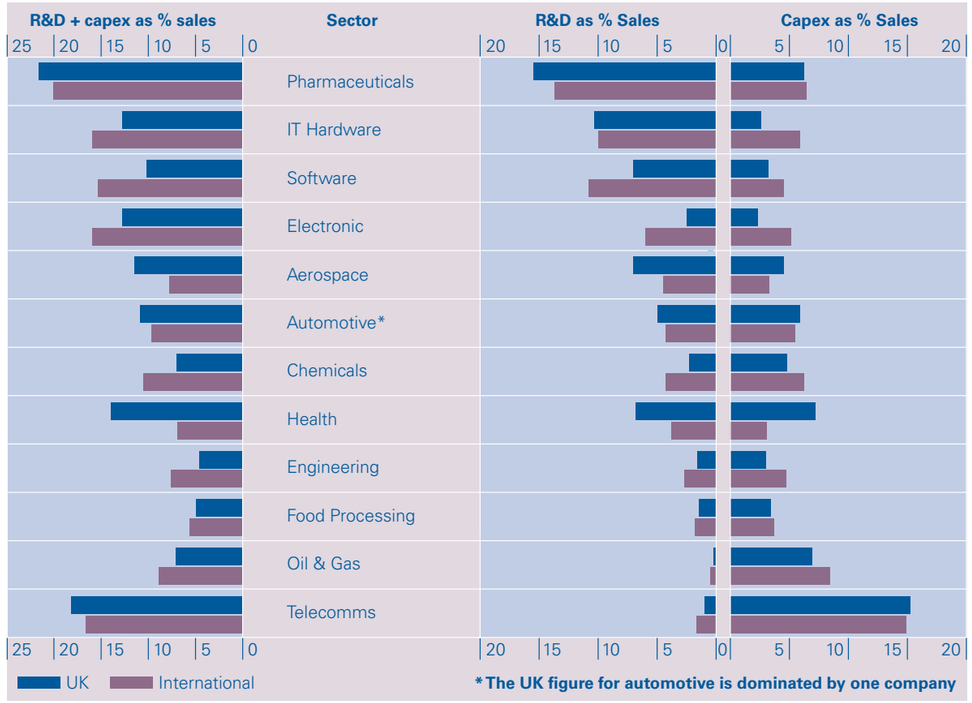
The chemistry-based sectors account for twice as large a percentage of UK R&D as they do for international R&D. The position is reversed for physics/engineering-based sectors which are twice as large internationally (as a proportion of total R&D) as they are in the UK.

It has been suggested that UK companies may, on average, be more successful in sectors where there is a closer link between science, research and commercial success such as pharmaceuticals & biotechnology and less effective in sectors which require the management of large scale manufacturing activities (e.g. lean production on a large scale).

4.2 R&D and Capex Intensity by Sector

The successful company maintains a balance between its investments in the future such as R&D, marketing and Capex. This balance differs for different sectors and figure 11 illustrates this for the larger R&D and Capex sectors in the Scoreboards. The figure shows R&D and Capex intensities (both investments are expressed as % sales) for the sectors of figure 9.

Figure 11: R&D and Capex Intensities, UK vs International



The key features of figure 11 are:

Sectors which have larger R&D intensity in the UK compared to the international level also tend to have larger Capex intensities (examples are health, pharmaceuticals, aerospace).

- Some sectors require very large R&D but smaller Capex (e.g. Pharmaceuticals) while others require large Capex intensities but little R&D (oil & gas and telecomms).
- Sectors which have larger R&D intensity in the UK (such as pharmaceuticals, aerospace and health) tend to have larger Capex intensities (similar for pharmaceuticals). Conversely, sectors which have smaller R&D intensity in the UK (engineering, electronics, chemicals) tend to have lower Capex intensities.
- Total investment intensity (R&D plus Capex) has higher values for all international sectors except health, pharmaceuticals, aerospace and automotive (where one company dominates the UK figure). Pharmaceuticals and aerospace are sectors with heavier R&D 'weights' in the UK while health is similar. The sectors where total investment is comparable (telecomms, food processing) are also those where the UK sector has heavier R&D weight (the UK is strong in mobile telecomms).

4.3 The Five High R&D Sectors

The five international high R&D sectors were introduced in the 2002 R&D Scoreboard (reference 8) and are electronic & electrical, health, IT hardware, pharmaceuticals & biotechnology and software & IT services. They all have average sector R&D intensity of over 5% (except international health which, however, has an intensity of 5.3% if one company with a very low R&D intensity and large sales is excluded). These five sectors account for 58% of total International 700 R&D. Four of the five sectors (all except electronic & electrical) also have R&D intensity over 6% in the UK 700.

Figure 12: Number of Companies in each of the 5 High R&D Sectors by Major Country

	USA	Japan	UK	Germany	France	Others
IT Hardware (131+ companies)	**91 (55.3%)***	16 (21.7%)*	3 (1%)*	1 (1.4%)*	3 (4.9%)*	17
Pharmaceuticals & biotechnology (82 companies)	**42 (47.2%)**	17 (9.8%)	6 (14.3%)	5 (6.1%)	2 (8.4%)	10
Electronic & electrical (52 companies)	14 (8.6%)	**25 (50.1%)**	1 (1%)	2 (18%)	3 (4.5%)	7
Software & IT Services (66 companies)	**55 (88.5%)**	1 (0.7%)	4 (2.1%)	2 (4.9%)	2 (1.7%)	2
Health (31 companies)	**20 (82.7%)**	1 (1.2%)	2 (5.5%)	3 (4.6%)	1 (1.3%)	3
TOTALS	222	60	16	13	11	39

+Total companies in the sector from all countries e.g. Taiwan has 5 in IT hardware and 2 in electronic & electrical.

•The figures in brackets are the % of total sector R&D contributed by companies from that country.

The USA is a clear leader in four of the five high-R&D sectors with the US third behind Japan, and Germany in the fifth sector. The UK is in second place in both health and pharmaceuticals & biotechnology.

There are big differences in the number of companies contributed to each of the five high R&D sectors by the major countries. Figure 12 shows that the USA is a clear leader in four of the five sectors with Japan in first place for electronic & electrical, the US being third (behind Germany by % R&D). Japan is in second place in IT hardware with Germany a clear second in software & IT services because of SAP. The UK is in second place in both health and pharmaceuticals & biotechnology by percentage of R&D despite the larger number of Japanese companies in pharmaceuticals & biotechnology. The percentage of total R&D in each sector is shown in brackets for each country in each sector.

Since the five high R&D sectors account for nearly 60% of total R&D, it is important to ascertain whether, in difficult business conditions, their high R&D intensities are being maintained.

Figure 13a: CAGR's for the 5 High R&D Sectors

	CAGR R&D	CAGR SALES	R&D Intensity Change over 4 years
IT Hardware	+5%	+1%	Increase
Pharmaceuticals & biotechnology	+12%	+10%	Increase
Electronic & electrical	+3%	+4%	Small decrease
Software & IT Services	+10%	+5%	Increase
Health	+10%	+16%	Decrease

This query is answered by figure 13a which shows the CAGR's (compound annual growth rates averaged over 4 years) for both R&D and sales for the 5 sectors. Clearly, if the CAGR for R&D is larger than that for sales, the R&D intensity has increased over the period. There are two conclusions from figure 13a:

- Pharmaceuticals & biotechnology and health have seen double digit annual average increases in both R&D and sales whereas those in software & IT services are lower and those in electronic & electrical and IT hardware are in small single digits.

The average R&D intensity has increased over the last four years for software & IT services, pharmaceuticals & biotechnology and IT hardware, has changed little for electronic & electrical and decreased for health where, although R&D has increased at 10% p.a., sales have increased even faster.

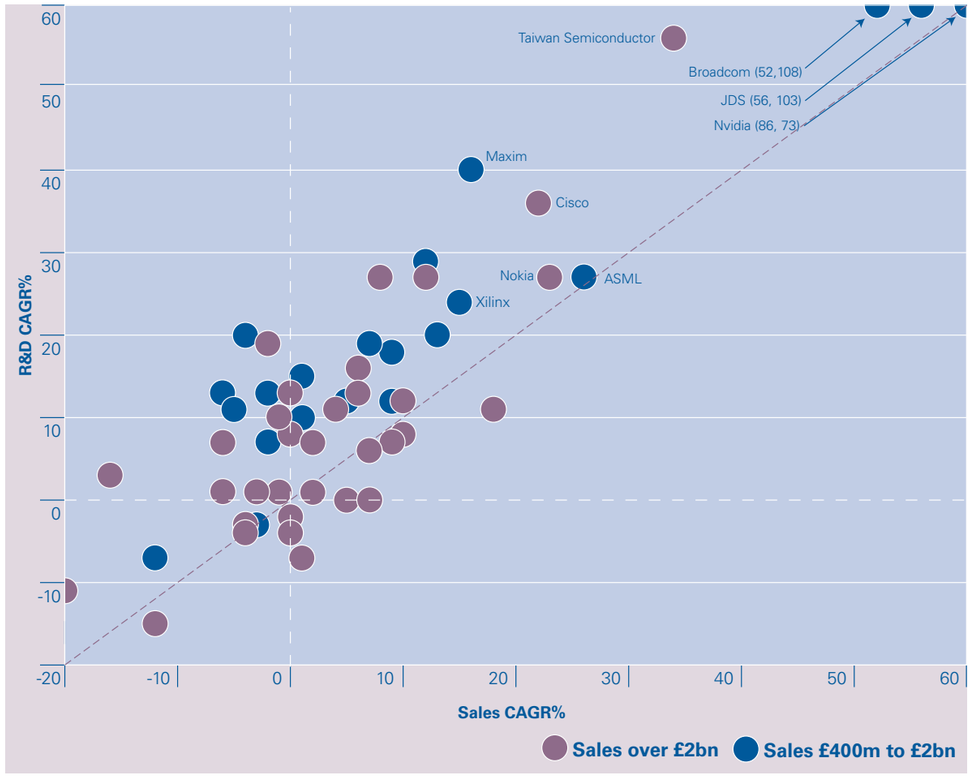
Analysis

R&D intensity has increased for most IT hardware companies over the last 4 years. Some companies (such as Nokia, Cisco, Taiwan Semiconductor) have increased both R&D and sales by over 20% p.a.

- The R&D intensity has increased over 4 years for software & IT services, pharmaceuticals & biotechnology and IT hardware, has changed little for electronic & electrical and decreased for health where, despite a 10% per annum increase in R&D, sales have increased even faster.

A plot of R&D CAGR vs Sales CAGR for nearly 60 of the largest international IT hardware companies is shown in figure 13b. A comparison of this figure with the same plot in the 2002 R&D Scoreboard (figure 13 of reference 8) shows similar numbers of companies above and below the line in both years so that, despite the continuing difficulties for this sector, the vast majority of companies have positive R&D CAGR's and R&D intensity has increased for most companies over both 4 year periods. A number of companies have increased both R&D and Sales by large amounts and a few of these (all in the top right hand quadrant) are labelled.

Figure 13b: IT Hardware - R&D Growth vs Sales Growth over 4 years

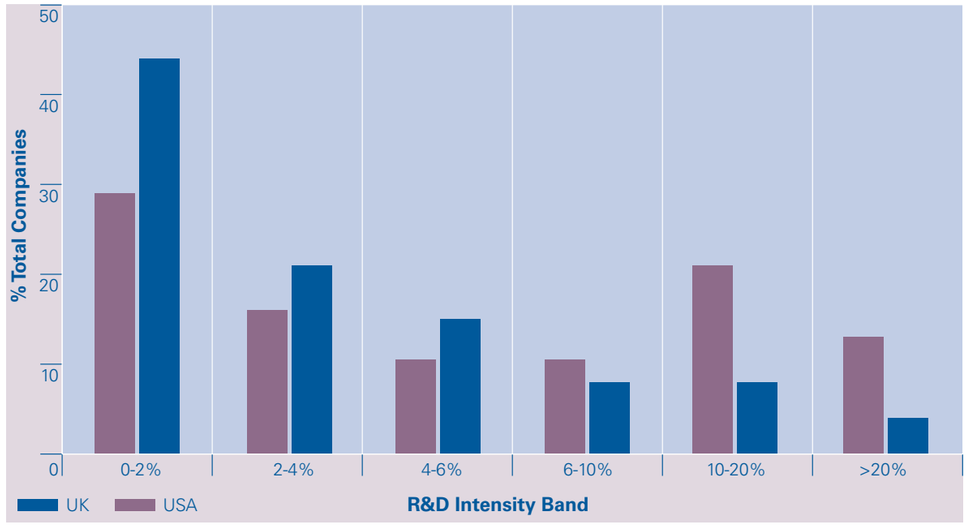


The UK is strongly represented as the second largest country in both pharmaceuticals & biotechnology and health. Since this strength goes back several years, the UK has competitive advantage in these sectors but needs to ensure that the business environment for them is as supportive as possible so that the sources of past advantage are maintained and enhanced.

4.4 The Distributions of R&D Intensity UK vs USA

Whilst average R&D intensity is significant, it is also important to understand what proportion of a country's companies are investing at both lower and higher levels of R&D intensity since this will determine the range

Figure 14: Distributions of R&D Intensity for comparable sets of US and UK-owned companies



of new products and services they can offer. The proportion of companies investing at high R&D intensities will depend both on a country's representation in the five high R&D sectors and on the propensity of its companies to adopt a high R&D strategy for growth within their sectors. R&D data for a large number of companies are only available for the UK (this Scoreboard) and the USA (reference 9).

The US Scoreboard includes only companies with R&D over $2m and sales over $100m and figure 14 therefore compares the 1000 US companies in the US Scoreboard with all UK-owned companies from the UK 700 that meet the US conditions on minimum R&D and sales (some 180). The key points from figure 14 are:

- The UK has a 50% larger proportion of companies in the lowest intensity band (0 to 2%) compared to the USA (44% vs 29%) and a larger proportion in the second lowest band (2-4%).
- The US has almost three times the UK's proportion of companies in the highest two R&D intensity bands (those above 10%) with 34% of companies vs 12% in the UK. The US also has a higher proportion in the 6-10% band.
- However, there are signs of improvement with the UK's proportion of companies in the lowest intensity band falling from over 50% last year to 44% this. The UK proportion in the highest two bands has also risen marginally as has the US proportion. Changes over the last 4 years reflect changes in both sector mix and intensity.

Whilst R&D intensity is significant, so also is the proportion of a country's companies investing at each band of R&D intensity. This depends both on its representation in the five high R&D sectors and on the propensity of its companies to adopt a high R&D strategy for growth.

The UK has a 50% larger proportion of companies than the USA in the lowest R&D intensity band, but only just over one third of the US proportion with intensity over 10%. However, there are signs for improvement for the UK.

4.5 Patents and R&D

The results of R&D are, in many sectors, protected by patents. Any important patent will be taken out in the USA as well as other jurisdictions since the USA is the leading market in the world for most R&D based products. A comparison of the number of US patents granted to R&D active companies compared to their R&D investment is thus of interest but is subject to some limitations:

- US companies may have some advantage since they are liable to take out all patents, not just the most important, in the USA (there is, however, little evidence of this in figure 15b).

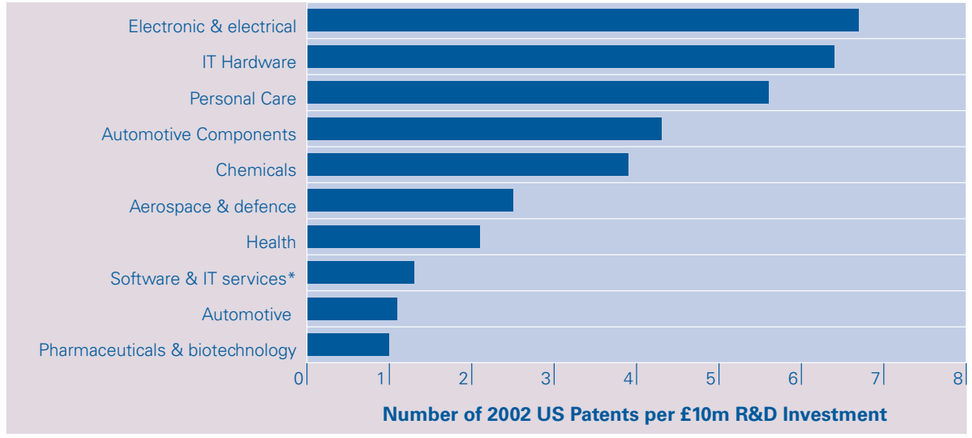
Analysis

Some patents are more important than others and patent citation analysis is one method of quantifying this.

- A comparison of the number of patents granted to current R&D investment may underestimate the ratio for a company whose R&D is growing rapidly since their patents will be the result of earlier, lower levels of R&D.
- Some patents will be more important than others. This issue can be addressed by using patent citations to identify those patents seen as important by other companies. There was insufficient time to complete such an analysis for this Scoreboard.
- Comparisons should not be made between companies in different sectors since sectors such as software & IT services have more instances where protection mechanisms other than patents (e.g. copyright and trademarks) may be more appropriate.

However, figure 15a shows the average number of patents granted in 2002 per £10m R&D investment for large R&D companies+ from 10 sectors (reference 10 and company details in part 2 of this Scoreboard).

Figure 15a: US Patent Activity of International Companies in R&D Active Sectors



* IBM excluded since it has both hardware & software R&D
Note: The numbers of patents for each company has been provided by Innovaro Limited.

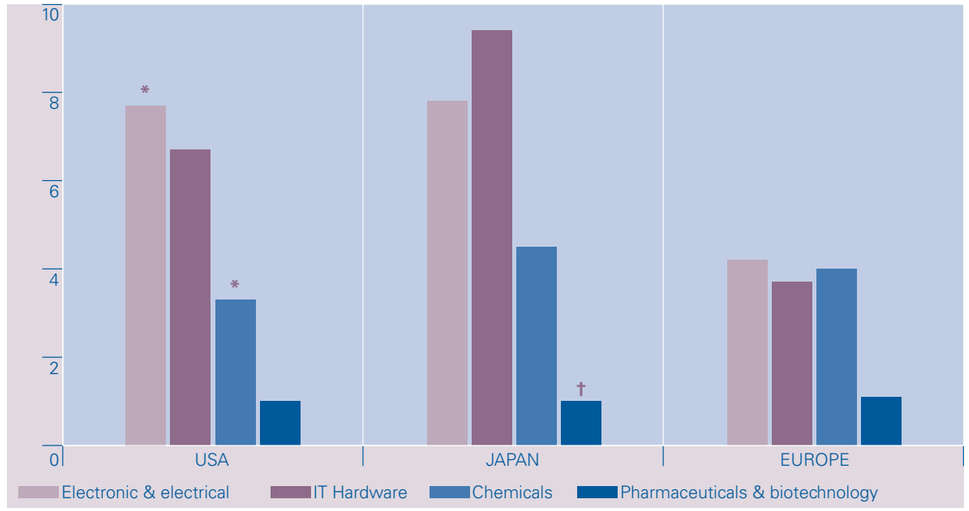
Given the large differences between sectors in the number of US patents per £10m R&D, comparisons between countries of numbers of patents granted are only meaningful if their sector mixes are similar.

The number of patents is large with over 20,000 in 2002 just for the 25 IT hardware companies. The range is also large with 6-7 patents per £10m for electronic & electrical and IT hardware but only 1 per £10m for pharmaceuticals & biotechnology where a substantial proportion of R&D is invested in ensuring that a patented compound is effective and acceptable to regulatory agencies with a low level of side effects. The variation between companies in number of patents per £10m R&D investment is also quite large except for pharmaceuticals & biotechnology where almost all the major companies lie in a fairly narrow band. In most sectors there are also one or two companies with large ratios well clear of other companies in the sector. Examples are Canon in electronic & electrical, Honda Motor in automotive, Micron Technology and Advanced Micro Devices in IT hardware. These differences between companies will be interesting to explore once citation data are available to 'weight' patents by potential impact.

The data of figure 15a is recast in figure 15b for 4 of the sectors which each have at least 20 companies to compare the data for the USA, Europe and Japan by sector. A key conclusion from figure 15b is that comparisons of total numbers of patents granted between countries will only be meaningful if their sector mixes are the same. Otherwise, comparisons should only be made by sector.

+ Some 150 companies are included in the list in part 2 of this Scoreboard.

Figure 15b: US Patents per £10m R&D by Sector for the Three Regions



* only 4 companies + only 3 companies

For pharmaceuticals & biotechnology, the three regions are almost the same but with Europe ahead by 10% at 1.1. Europe, by contrast, lags in electronic & electrical and IT hardware with only around 50% of Japanese levels and 55% of U.S. levels. These results are unsurprising since the international Scoreboard reveals a European strength in pharmaceuticals & biotechnology and modest presence in IT hardware. It will be interesting to repeat this analysis with patents weighted according to citations. This would remove the assumption inherent in figure 15b that the mix of important and less important patents is similar across the three regions. It should also allow some robust comparisons between companies within each sector.

For US patents per £10m R&D, Europe is ahead of the USA in pharmaceuticals & biotechnology but lags in electronic & electrical and IT Hardware.

5. R&D – Active Middle-sized Companies

R&D active middle-sized companies are important since they are both the potential large technology companies of the future and a mechanism with sufficient scale to enable emerging technologies to become part of the market and corporate landscape. A healthy middle-sized company sector has four characteristics:

- An adequate total size (by value added, sales, R&D);
- A reasonable size distribution (companies spread throughout the range £50m to £500m sales);
- An R&D intensity distribution biased towards the higher intensities (e.g. figure 18);
- An adequate growth rate for both sales and R&D.

A healthy middle-sized company sector has an adequate total size, a reasonable size distribution, an R&D intensity distribution biased towards higher intensities and reasonably high growth rates for both sales and R&D.

Middle-sized companies are defined as those having sales of between £50m and £500m. Given that a company needs nearly £35m of R&D to be included in the international 700, a middle-sized company in the international Scoreboard must have an R&D intensity of at least 7% if it has sales of £500m, 14% at £250m and 35% at £100m. The analysis of middle-sized companies from the international 700 is thus naturally biased towards high intensity sectors. This limitation does not apply to comparisons of US 1000 companies with UK owned companies from the UK 700 that meet the entry conditions for the US 1000 (which imply a minimum intensity of only 2% for companies with sales of only $100m and lower minimum intensities for larger companies).

Almost 80% of middle-sized companies in the international 700 are from the USA with 13% from Europe and 5% from Japan.

5.1 Size and Size Distribution

Figure 16 displays the numbers of middle-sized companies from the international 700 from each region and shows:

- Almost 80% of middle-sized companies in the international 700 are from the USA with 13% from Europe and 5% from Japan.
- Over 87% of all these higher intensity middle-sized companies come from just 3 sectors – IT hardware, software & IT services and pharmaceuticals & biotechnology.

This shows how successful the USA has been in starting and growing new companies in the three key R&D-based sectors. The UK has 4 of the 14 European companies of figure 16.

Figure 16: Middle-sized Companies in the International 700 by Sector and by Region

	Region			
Sector	Americas	Europe	RoW	Totals
IT Hardware	37	4	2	43
Software & IT Services	26	3 (UK1)	1	30
Pharmaceuticals & biotechnology	16	3 (UK 2)	3	22
Electronic & electrical	4	1	1	6
Health	2	–	–	2
All other Sectors	3	3 (UK 1)	–	6
Totals (Country)	88 (US 86)	14 (UK 4)	7 (Japan 5)	109

The size distribution by sales of middle-sized companies from the US 1000 can be compared with the precisely comparable set of UK-owned companies from the UK 700 just as the R&D intensity distributions are compared in section 5.3. The distribution of sizes between £65m (the smallest company in the US 1000) and £500m sales is similar for companies with lower R&D intensities (below 4%) but, for companies with intensity above 4%, the US has 34% of companies in the £200-£500m size range compared to only 20% in the UK. There are thus fewer UK higher R&D intensity larger middle-sized companies but correspondingly more UK companies in the £65-200m size range. This suggests either than the process of generating higher technology UK middle-sized companies started later or that it is more difficult for the UK companies to grow to larger sizes. There is anecdotal evidence for both explanations.

For middle-sized companies with higher R&D intensity (R&D over 4% of sales), the US has 34% of companies in the £200-500m size range by sales compared with only 20% for the UK.

5.2 Growth Rates

The growth rates for middle-sized companies in the IT hardware, software & IT services and pharmaceutical & biotechnology sectors are given in figure 17.

Figure 17: Growth Rates for Middle-sized Companies in the Highest R&D Sectors

Sector	CAGR For R&D	CAGR For Sales	R&D Intensity
IT Hardware (45 companies)	+25%	+4%	+28.9%
Software & IT Services (29 companies)	+20%	+8%	+23.4%
Pharmaceuticals & biotechnology (29 companies)	+33%	+22%	47.6%

The CAGR's (compound annual growth rates over 4 years) for R&D are all high ranging from 20-33%, but the CAGR's for sales are 22% for pharmaceuticals & biotechnology but in single figures for the other two sectors where business conditions have been difficult over the last four years. The R&D intensities are very high, particularly for pharmaceuticals & biotechnology as middle-sized companies try to develop new products as quickly as possible.

The CAGR's for R&D are all high for middle-sized companies in the IT hardware, pharmaceuticals & biotechnology and software & IT services sectors.

Whilst there are only 4 UK companies included in figures 16 & 17, there are other middle-sized UK companies in the three key sectors of figure 17 with comparable growth rates. If we select UK-owned middle-sized companies with double digit CAGR's for R&D, a positive sales CAGR and R&D intensity over 10% we find:

- IT Hardware : 3 companies
- Pharmaceuticals & biotechnology : 4 companies
- Software & IT services : 5 companies

Of these 12 companies, those that exceed the average CAGR for both R&D and sales and the average R&D intensity for their sector in figure 17 are ARM and NSB. If the R&D intensity criteria are relaxed to one half of the levels in figure 17, the list grows from 2 to 7 companies. Note that many of these UK companies have made acquisitions which account for part of the sales growth although some (e.g. ARM) have grown almost entirely organically, based on R&D (ARM has an R&D intensity over 33%).

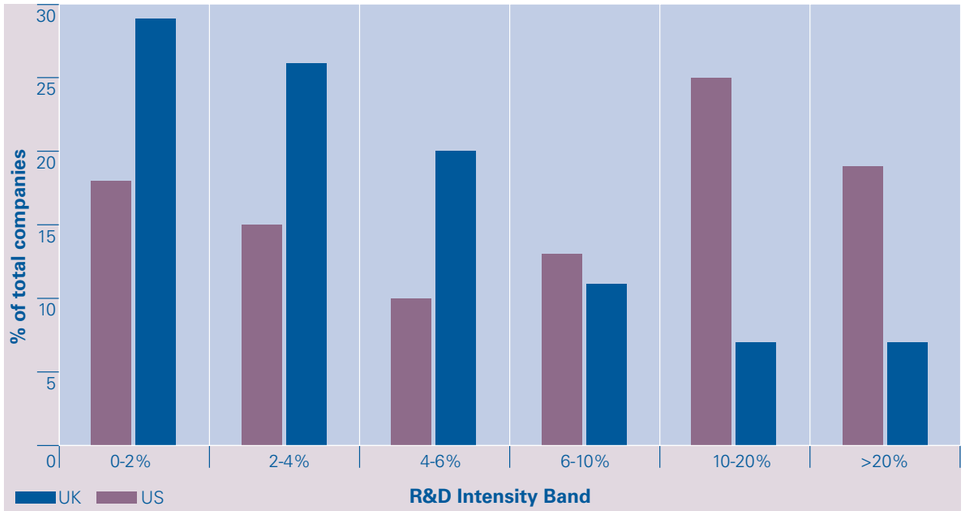
Since profitable growth is the aim of any company, it should be noted that only 6 of the 12 companies listed above are making a positive operating profit on sales. There are also many US companies that make losses in the early stages and the key is to reach profitability while funding for growth is still readily available.

The UK has a larger proportion than the USA of middle-sized companies in the lowest two R&D intensity bands but less than a third of the US proportion with R&D intensity over 10%.

5.3 US and UK Middle-sized Companies

The distributions of US and UK-owned middle-sized companies are compared in figure 18 which follows the format of figure 14.

Figure 18: Distribution of R&D Intensity for comparable US and UK Middle-sized Companies



More than one half of the US middle-sized companies are in the five high R&D sectors compared to less than one quarter of the UK total.

The US data is taken from reference 9* and UK data from this Scoreboard for a strictly comparable set of UK-owned companies. Since the minimum sales limit for US middle-sized companies is £65m for the US Scoreboard, the sales range is taken as £65m to £500m, a small difference from figure 16. The key points from figure 18 are:

- The UK again has a larger proportion of companies in the lowest two intensity ranges (55% vs 33% in the USA) and less than one third of the proportion with intensity above 10% (14% vs 44% for the USA). The number of UK companies with intensity above 10% is slightly down on 2002.
- Further analysis shows that more than one half of the large US group are in the three key high R&D sectors of IT hardware, pharmaceuticals & biotechnology and software & IT services. Less than one quarter of the UK total are in these sectors, indicating the importance of sector mix.

There are only 14 UK middle-sized companies with R&D intensity above 10% compared to nearly 20 times as many in the US group. These potential UK exemplar companies are summarised in figure 19.

Figure 19: High R&D Intensity UK Middle-sized Companies – Growth & Market Cap to sales ratio

	1 Total number of companies	2 Total with data	3 Number with double digit CAGR for R&D and/or sales	4 Number in 3 also with above sector average market cap/sales
R&D Intensity Above 10%	14	11	10	5
R&D Intensity 6-10%	13	11	8	4
Totals	27	22	18	9

There are UK middle-sized companies in all the five high R&D sectors with double digit CAGR's for R&D and/or sales and a market cap to sales ratio above the average. It is just that more such companies are needed in the UK and more capable of further growth.

Eleven of the 14 companies come from IT hardware, pharmaceuticals & biotechnology and software & IT services and three from other sectors. Both growth rates and market capitalisation-to-sales ratios are available for 11 of the 14 companies. In addition to these 14 there are 13 companies with R&D intensity of 6-10% and 11 of these have growth rates and market cap-to-sales ratios available. Of the total of 22 companies with full data, 18 have double digit CAGR's for R&D, sales or both and nine of these also have a market cap-to-sales ratio over unity and above the sector average.

The latter group of nine companies in figure 19 includes Renishaw, Gyrus, ARM, Acambis, SkyePharma, Galen, iSoft, First Technology and Spectris. They are drawn from the electronic & electrical, health, IT hardware, pharmaceutical & biotechnology and software & IT services sectors – the five high-R&D sectors of section 4. All 9 companies are profitable with 5 of the 9 having operating profit over 15% of sales and 8 of over 8% of sales. Unfortunately, the US Scoreboard does not give market caps or CAGR's so a similar analysis can not be done for US middle-sized companies from reference 9. However, the conclusion from figures 18 & 19 is that the UK needs to develop more higher growth, high R&D intensity companies with good prospects†. Figure 19 shows this can be and has been done for all the five high R&D sectors – it is just that more such companies are needed in the UK.

* Significantly more than half of the US 1000 companies are middle-sized

† The number of high R&D UK middle-sized companies is also reduced by foreign acquisitions in the UK

Figure 20: Size Distribution of Companies shown in figure 19

Total number of companies From fig. 19	SALES £65-100m	£100-250m	£250-400m	£400-500m
Column 1 (27)	13	11	3	0
Column 4 (9)	4	5	0	0

Growth from £50m sales to £500m or more may be quite demanding since figure 20 shows that the size distribution of the UK companies in figure 19 is biased towards the smaller sizes. Fully 24 of the 27 companies of figure 19 are below £250m sales and 13 below £100m. Only one of the nine higher performing companies of figure 19 has sales above £200m and none of them are above £250m.

A successful company will excel in the three key areas of strategic choice (of sub-sector & growth route), operational effectiveness (business processes & attention to customers) and wise and balanced investment in the future.

6. R&D and Company Performance

It has been pointed out (reference 1) that a successful company will excel in the three key facets of its business:

- Strategic choices of subsector and growth route:
  - the mix of organic growth and acquisitions.
  - the subsectors in which it competes (value added and/or commodity and the funding to develop new products, services & markets in the chosen subsectors).
- Operational excellence:
  - quality of business processes (e.g. lean production).
  - attention to customers (quality, value, on-time delivery, service).
- Wise and balanced investment in the future:
  - R&D, Capex, market development and the balance of these investments.

Since a successful company needs to excel in all three areas, there will be a statistical but not a one to one relationship between investment inputs such as R&D and Capex and outputs such as value added, wealth creation efficiency, profits or market capitalisation. For example, a company may have higher than average R&D and Capex but a poor acquisition or below average operational performance might blight performance for several years.

The R&D Scoreboard is primarily a benchmarking tool for company investments in R&D and Capex by sector. It also provides information on financial performance and on operational efficiency such as stockturn or percentage of sales in different world regions (there is evidence that sales to the more demanding customers, often in developed overseas markets sharpen a company's performance – see reference 11).

Previous R&D Scoreboards have summarised the links between investment (e.g. R&D intensity) and company performance (reference 8). The main links identified by several studies are:

- High R&D intensity is linked to higher sales growth.
- Labour productivity (e.g. sales or value added per employee) is linked to investment per employee.
- Higher R&D intensity companies in the FTSE 100 show higher share price growth than the FTSE 100 and total shareholder return over 10 years is higher for companies in the broad engineering sector with higher ratios of R&D plus Capex to sales.

There are links between R&D intensity and higher sales growth, labour productivity and investment per employee and between investment intensity and shareholder returns.

Business growth through innovation has been voted the top priority for US companies in 2002 and, indeed, for every year but one since 1997.

This section highlights recent work on three other aspects of the investment/performance link – organic vs acquisition growth, the implications of market cap-to-sales ratios and recent share price performance of high R&D investing companies.

6.1 Growth – Organic Growth and Acquisitions

The standard models for valuing companies are based on discounted cash flow and show that a faster growing company will be worth more than a slower growing company even if both are earning the same return on invested capital (reference 12). It is therefore not surprising that 'business growth through innovation' has been voted the top priority for 2002 facing technology leaders of industrial companies in the USA (reference 13). Indeed, it has been voted top priority every year since 1997 except for 2001 when it was second to 'accelerating innovation'.

The options for growth are organic growth, acquisitions or a mix of the two. It has been established that 60-70% of major acquisitions in the USA and UK lead to under-performance in shareholder returns, often for 4-5 years afterwards (references 3, 4, 5, 6). The 2003 Value Added Scoreboard (reference 1) showed that UK amortisation (largely related to acquisition goodwill) is larger than that in other European countries. In addition, the US ratio of acquisition spend to R&D plus Capex investment is substantially less than unity (much less for the broad engineering sector) whereas the UK ratio is of order 2x (reference 8 and the commentary by B.Harding in this Scoreboard). These comments are primarily on large acquisitions – interviews with CEO's suggest that small acquisitions for relevant technology or to add demanding customers can be much more effectively combined with organic growth.

The ratio of acquisition spend to R&D plus Capex investment is 0.6 for the USA but over 2x for the UK for the same 8 sectors.

A comparison of UK and international R&D plus Capex intensities was given in figure 11 on page 34. In figure 21, the ratio of international 700 to UK 700 investment intensity (R&D plus Capex as % sales) is given for 8 sectors together with the ratio of international to UK R&D-to-Cost of Funds.

Figure 21: A Comparison of UK and International Investment for 8 Sectors

	Ratio of International to UK investment intensity (Investment intensity = (R&D+ Capex)/Sales)	Ratio of International Z to UK Z (Z = R&D/CoF)
Aerospace & defence	0.7*	1.1*
Health	0.5	1.1
Pharmaceuticals & biotechnology	0.9	1.3
Chemicals	1.5	3.3
Engineering	1.7	2.6
Electronic & electrical	2.4	2.5
IT Hardware	1.2	2.6
Software & IT services	1.5	4.6

* In both cases, a low figure indicates that the UK has a higher propensity to invest in R&D (or R&D plus Capex).

Three UK sectors – aerospace & defence, health and pharmaceuticals & biotechnology – stand out as investing more heavily in both R&D and R&D plus Capex as % sales than do their international counterparts.

Three UK sectors – aerospace & defence, health and pharmaceuticals & biotechnology stand out on both criteria as sectors where the UK invests heavily. The other five sectors have an R&D/CoF ratio $2^1/_2$ to $4^1/_2$ times for international compared to the UK. This may reflect both a lower UK propensity for R&D and a higher UK propensity for acquisitions since CoF will increase relative to R&D if an acquisition premium is funded by debt or by equity with a maintained dividend per share.

Several possible reasons have been advanced as to why companies might favour acquisitions over organic growth. However, the key question is rather that of why UK companies should favour acquisitions over organic growth much more than their US counterparts in the same sectors even though the US sectors are less consolidated (and hence offer more potential acquisition opportunities). Three explanations have been put forward. The first is connected to the sheer size of London's financial sector (and its M&A specialists) relative to the UK economy. The second invokes differences in the barriers to entry of new competitors to sectors in the US and UK. The third invokes the smaller size of the UK market relative to the USA meaning that growth beyond a certain point requires major expansion, often overseas expansion for a UK company well before it is needed for a similar US company. Acquisition often appears to be the solution for rapid overseas expansion. However, successful UK companies stress the importance of early organic overseas expansion into demanding markets as a competitive driver. This does not, of course, exclude later, smaller acquisitions to strengthen particular competences or market sectors.

The question is why UK companies should favour acquisition over organic growth much more than their US counterparts in the same sectors even though the US sectors are less consolidated (and hence offer more acquisition opportunities) and some two-thirds of major acquisitions in both countries are associated with under-performance in shareholder returns.

6.2 Market Capitalisation to Sales Ratio

The 2003 Value Added Scoreboard (reference 1) introduced the concept of a market cap to value added ratio (MC/VA) as a measure of the financial markets' valuation of the wealth created by a sector or company. It was shown that there are big differences in the MC/VA ratio between sectors and even for companies in the same sector with similar wealth creation efficiency since perceived prospects were different. US and Japanese companies do not give sufficient information in their accounts to allow value added to be calculated (employee costs are not given) but a market cap-to-sales ratio (MC/S) can be used instead.

Figure 22: Market Capitalisation and R&D Intensity for large international sectors

The MC/S ratio is shown in figure 22 for the 12 largest sectors from figure 9. There are two groups of sectors on this chart of MC/S vs R&D intensity indicated by the dotted lines (which do not necessarily imply a linear relationship):

The market at present values health, software & IT services and pharmaceuticals & biotechnology more highly relative to their R&D than the engineering-based sectors.

- The high MC/S sectors (given their R&D intensity) consisting of pharmaceuticals, software & IT services, health, food processing, telecomms and oil & gas.
- The lower MC/S (compared to R&D intensity) sectors based mainly in engineering which include IT hardware, electronic & electrical, aerospace & defence, chemicals, engineering and also automotive which has a much lower MC/S than would be expected from its R&D intensity. The low MC/S for automotive reflects current world market conditions (e.g. capacity).

The UK sectors of IT hardware and software & IT services would be well below the international ones were they included in figure 22 whereas both health and pharmaceuticals & biotechnology have higher UK R&D intensity and comparable MC/S to their international counterparts.

The overall conclusion is that, out of the higher R&D sectors, the market at present values health, software & IT services and pharmaceuticals & biotechnology more highly than the engineering-based sectors. The words 'at present' are stressed since both IT hardware and software & IT services enjoyed much higher valuations in 1999. The further question is to what extent the financial markets recognise the benefits of strong investment in the future.

Figure 23: The relationship between high Market Cap to Sales Ratio and High Investment Intensity

For those companies with above average market cap to sales ratios in their sectors, well over 80% of them also have above average investment intensity for IT hardware, pharmaceuticals & biotechnology and software & IT services.

	2	3
Sector	Number of companies with above average MC/S	% of column 2 with above average R&D plus Capex as % sales
Electronic & electrical	25	60%
IT Hardware	82	89%
Pharmaceuticals & biotechnology	36	83%
Software & IT Services	19	84%

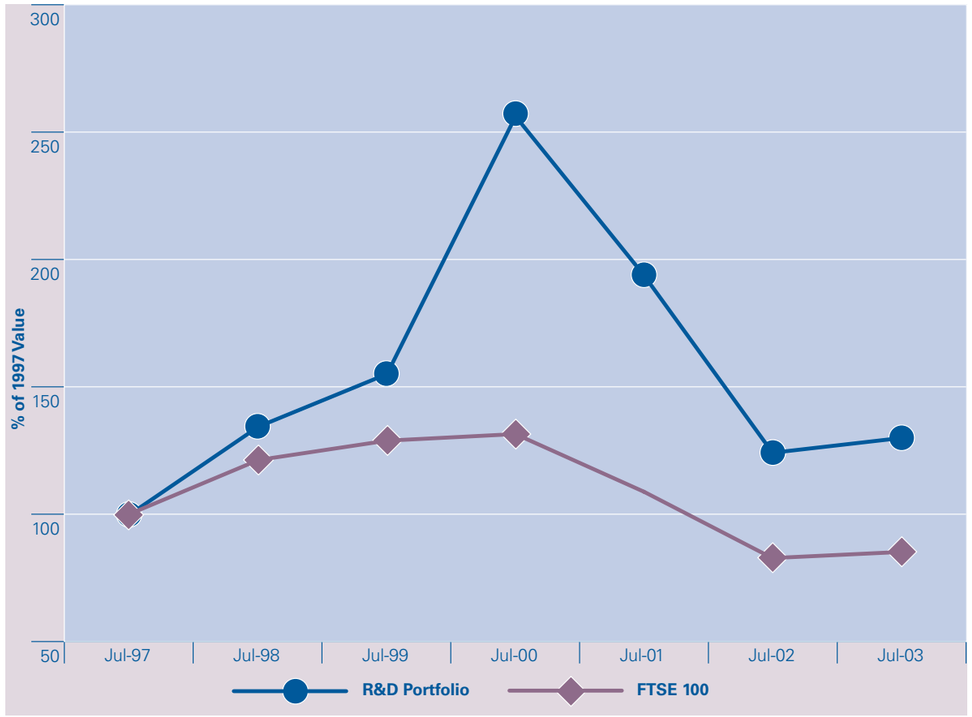
Figure 23 shows that, for those companies with above average MC/S within their sector, there are well over 80% also with above average investment intensity (R&D plus Capex as % sales) for IT hardware, pharmaceuticals & biotechnology and software & IT services. For electronic & electrical, the ratio is 60%. It is well known that a pharmaceutical company's valuation depends sensitively on its R&D pipeline but it is encouraging that the higher R&D IT hardware and software & IT services companies are also well represented amongst those valued by US markets (US since figure 12 shows that the USA dominates these two sectors).

The FTSE 100 R&D portfolio is now 130% of its 1997 value whereas the FTSE 100 index is 15% lower than its 1997 value.

6.3 Share Price Performance

Recent R&D Scoreboards have included a graph of the share price performance of all the FTSE 100 companies with R&D intensity over 4%. The companies for 2003 are the same as those used in 2002 (and include Johnson Matthey which has an intensity over 4% if sales are calculated less the cost of precious metals). Figure 24 shows that the share price of the R&D portfolio (equal investments in the 10 FTSE 100 companies with R&D intensity over 4%) has been ahead of the FTSE 100 index in every year since 1997. The absolute values of both the R&D portfolio and the FTSE 100 fell from 2000 to 2002 but are now rising. The key point is that the R&D portfolio is now 130% of its 1997 value whereas the FTSE 100 is 15% lower than its 1997 value.

Figure 24: Relative share price changes for R&D Portfolio of FTSE 100 Stocks vs FTSE 100 Index



A similar study has been carried out for the high R&D companies in the FTSE 250 with similar results. The FTSE 250 portfolio behaves in a similar way with the share price of the FTSE 250 R&D portfolio now 150% of its 1997 value whereas the FTSE 250 index has only risen to 117% of its 1997 value. It is clear from the discussion at the start of section 6 that high R&D intensity does not automatically guarantee performance since a company may not invest its R&D in the areas of highest potential, may not make the best strategic choices and may have less than excellent operational performance. However, in sectors where R&D is important for the generation of new products and services, a company that under-invests in R&D relative to its best competitors is very unlikely to succeed over the medium to long term.

The FTSE 250 R&D portfolio is now 150% of its 1997 value whereas the FTSE 250 index is now 117% of its 1997 value.

A company that under-invests in R&D relative to its best competitors is very unlikely to succeed over the medium to long-term.

7. Conclusions

The increased number of companies and additional data incorporated into the 2003 R&D Scoreboard provides all companies with a comprehensive sector-based international benchmarking tool. The foregoing analysis uses this extensive Scoreboard database to give insights into the R&D-active sectors of the UK and international economies and the way in which wise R&D investment can drive organic growth and improve company performance. The main conclusions are:

Overall R&D Investment and Business Environment

- The 2003 Scoreboard contains the top 700 UK and international companies (an increase over the 600/600 for 2002) and has a wealth of data on R&D, financial performance and key ratios for each company.
- Total R&D for the international 700 is £207bn and for the UK 700 is £16bn. The international 700 includes companies with R&D investment down to just under £35m.

- The business environment for international R&D companies was difficult in the 2002/03 financial year with no increase in sales over the year before and R&D up by only 1% (although 60% of companies increased their R&D over the previous year). Profits were down substantially and total employees are also down over the previous year.
- Within the international 700, the Americas show an R&D intensity of 5.1%, Europe 3.7% and the rest-of-the-world 4.1% (dominated by Japan at 4.3%). Within Europe, Germany has an intensity of 4.6% (up from 4.3%) with the UK at 2.5% and France at 3.1% and Switzerland at 6.0%. The UK intensity is close to that of France and Switzerland for the average of all sectors excluding pharmaceuticals & biotechnology and oil & gas but Germany is still some 30% higher in this case.
- Overall R&D intensity is shown, as expected, to be inversely related to broad company size band. Foreign-owned companies in the UK have a higher all-company average R&D intensity but a lower intensity than UK-owned companies in several sectors (e.g. software & IT services, electronic & electrical).
- The financial environment in the UK differs from that in other major countries in two respects. Firstly the cost of funds (CoF) as a ratio of either sales or R&D is higher for the UK than Japan, France, Germany or the USA since dividends are higher. For example, CoF as % R&D for the UK is over twice the international and US levels. Secondly, the ratio of acquisition spend to R&D plus Capex investment over a 5 year period is much larger for the UK than for the USA (209% vs 59%).

R&D Sector Mix and Intensity

- R&D-active UK companies are very strong in two sectors in the UK – pharmaceuticals & biotechnology (40%, up from 37% in 2002) and aerospace & defence (9%) whereas internationally the largest sectors are IT hardware (22%), automotive (18%) and pharmaceuticals & biotechnology (17.5%). The UK is also strong in food processing and oil & gas, but has lower proportions of total R&D in electronic & electrical (4% vs 10% internationally), automotive and IT hardware.
- The Americas (primarily USA) lead in total R&D for pharmaceuticals & health and electronics & IT while Europe leads in overall engineering and in the group of other sectors. Within Europe, UK companies in the international 700 have much higher total R&D in pharmaceuticals & health than Germany and France but much lower R&D in both electronics & IT and in the broad engineering sector (where the UK has under 12% of Germany's total).
- New entrants to both the international and UK top 100 companies lists since 1998 have been concentrated in electronic & electrical, IT hardware, pharmaceuticals & biotechnology and software & IT services with, for international, more companies also in automotive and aerospace & defence.
- UK company R&D intensity is above international levels in the strong sectors of pharmaceuticals & biotechnology, aerospace & defence and health but well below international levels in electronic & electrical, software & IT services, chemicals and engineering which also account for smaller proportions of the UK total. The same is true of Capex intensity for all these sectors.
- The distribution of R&D intensity for the top 1000 US companies is very different to that of a strictly comparable set of UK-owned companies from the UK 700. The UK has a 50% higher proportion of companies in the lowest intensity band (0 to 2%) while the USA has almost three times the UK's proportion in the highest intensity bands (above 10%). The UK's relative position has, however, improved over the last 4 years.

The Five High R&D Sectors and Middle-sized Companies

- The five high R&D sectors (electronic & electrical, health, IT hardware, pharmaceuticals & biotechnology, software & IT services) contribute nearly 60% of international 700 R&D. The USA is the country with the largest percentage of R&D in four of these sectors (47% for pharmaceuticals & biotechnology rising to 89% for software & IT services) while Japan is the largest in electronic & electrical with 50%, Germany being second and the USA third. The UK is second in both pharmaceuticals & biotechnology (with 14%) and health, the sectors with the highest growth rates.
- The CAGR's (compound annual growth rates over 4 years) for both R&D and sales are positive for all the five high R&D sectors. CAGR's for R&D are in double figures for pharmaceuticals & biotechnology, software & IT services and health and CAGR's for sales are in double figures for pharmaceuticals & biotechnology and health. R&D intensity increased for IT hardware, pharmaceuticals & biotechnology and software & IT services, showed a small decrease for electronic & electrical and decreased for health only because sales increased even faster than R&D (which had a high CAGR of 10%).
- 94% of middle-sized companies (sales £50m to £500m) in the international 700 are in the 5 high R&D sectors and 82% of these are from the USA with 13% from Europe and 5% from Japan. The US has been particularly successful in starting and growing such companies. Middle-sized companies in the IT hardware, pharmaceuticals & biotechnology and software & IT services sectors have very high CAGR's for R&D and very high R&D intensities.
- A comparison of middle-sized companies from the US 1000 with a strictly comparable set of UK-owned companies from the UK 700 shows firstly that, for companies with R&D intensity over 4%, the US has 34% of companies in the larger £200m - £500m size range compared to only 20% for the UK. Secondly, the UK has a larger proportion of companies in the low (0-4%) intensity range (55% vs 33% in the USA) and less than one third of the US proportion with intensity above 10% (14% vs 44% for the USA).
- There are, however, examples of UK middle-sized companies in all the 5 high R&D sectors which have high R&D intensity, double-digit CAGR's for R&D (and/or for sales) and above average market cap to sales ratios. It is just that more such companies are needed in the UK.

R&D and Company Performance

- A preliminary analysis of US patents for some 150 international companies in nine sectors shows a sevenfold difference between sectors in the ratio of the average number of patents granted per £10m R&D investment (from of order 1 for pharmaceuticals & biotechnology to 6-7 for IT hardware and electronic & electrical). Europe leads the US and Japan in this ratio for pharmaceuticals & biotechnology but lags for IT hardware and electronic & electrical. The sectoral variations in this ratio point to the importance of sector mix in comparisons of different countries' patent performance.
- Successful companies make good strategic choices (of subsector and growth route), show operational excellence (in business processes and attention to customers) and make wise and balanced investments in the future. The Scoreboard is primarily a benchmarking tool for R&D and Capex investments and points to links between these inputs and financial performance.

- R&D intensity is linked to sales growth, R&D per employee to labour productivity and R&D plus Capex intensity to total shareholder return (for the broad engineering sector). Given these links, it is of concern that, over a series of R&D active sectors, UK companies on average spend more than twice as much on acquisitions as on R&D plus Capex. This compares with the US where, although the same sectors are less consolidated, US companies on average spend on acquisitions under two-thirds of what they invest in R&D and Capex. Some two-thirds of larger acquisitions are associated with under-performance in shareholder returns in both the UK and USA.
- The market capitalisation to sales ratio (MC/S) indicates the prospects the financial markets assign to different sectors and companies. At present, the market values the health, software & IT services and pharmaceuticals & biotechnology sectors more highly, for a given R&D intensity, than the engineering-related sectors. For those companies with above average MC/S in the IT hardware, pharmaceuticals & biotechnology and software & IT services sectors, 80-90% of them also have above average investment intensity (R&D plus Capex as % sales).
- The share price of a portfolio of all the higher R&D intensity companies from the FTSE 100 has risen 30% since 1997 while the FTSE 100 has declined by 15%. A similar trend is seen for the FTSE 250 where the R&D portfolio has risen by 50%, the FTSE 250 index by only 17%.

The Challenge for the UK

- The UK has leading positions in pharmaceuticals & biotechnology, health and aerospace & defence where it has higher R&D intensity than the international averages and the sectors are larger as a proportion of total R&D (comparable for health). It will clearly be important to maintain this strong position in an increasingly competitive world. This will require both company effort and improvements to the UK's business environment to ensure it is amongst the most competitive of the developed economies.
- There are other sectors where the UK's R&D intensity is well below international levels and where the UK also has smaller proportions of its R&D than are found internationally. While there are companies in these sectors that would benefit from more investment and a move to higher value added products, there are some UK companies already demonstrating success in niches in these same sectors.
- There are examples of UK middle-sized companies in all the high R&D sectors which have high R&D intensity, high growth rates and where the above average market cap to sales ratio suggests good prospects. However, comparisons with the USA suggest that the UK needs more such exemplars amongst its middle-sized companies and more with the ability to grow rapidly to larger sizes. In particular, more UK middle-sized companies are needed with higher R&D intensities.
- A combination of good strategic choices (organic vs acquisition growth, higher value added subsectors), operational excellence, customer care and wise and balanced investment in the future are needed to ensure that UK companies can sustain profitable growth and succeed in world markets.

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* Copies of the R&D and Value Added Scoreboards for this and previous years are available from the DTI publications orderline Telephone: 0870-1502-500; also see www.innovation.gov.uk/finance.