evidence

Department for
Innovation, Universities and Skills

International comparative performance of the UK research base

July 2008

Using DIUS PSA target metrics for Research or Private Study

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Contact details

The reporting organisation is

Evidence Ltd 103 Clarendon Road, Leeds, UK LS2 9DF

t/ +44 (0) 113 384 5680

f/ +44 (0) 113 384 5874

e/ enquiries@evidence.co.uk

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Summary

This is our fifth report on the performance of the UK research base. This edition of the report has been restructured to enable a more ready focus on the UK's strong relative international performance in terms of sustainable achievement and productivity. The UK continues to support a more consistent performance than most countries across fields of research. It is strong overall in the natural sciences and, on indicators where it has been second to the USA, it has maintained a close challenge or moved into first place over the last few years. At the same time, the UK is itself under constant challenge in other areas and has a stimulating and competitive interface with key partners within Europe. The wider global benchmarks are affected by massive and rapid investment and growth in China and significant research development in smaller countries, notably Iran.

Theme 1 – Bibliometrics

- Output has been maintained at 9% of world papers despite growing competition.

UK produces just under 9% of world papers and is maintaining its position respective to G8 competitors while the USA is down from 35% to 32% since 1998 in response to the four-fold growth of China and other countries. Iran has a ten-fold increase to almost 7,000 papers; Brazil, Singapore, S Korea and Taiwan have also substantially increased their share. The UK's relative research output is strong in the biomedical and environmental sciences, ranking 2nd to the USA with broadly maintained share (around 10%). In mathematics, physical sciences and engineering, the UK has a similar or slightly lower output than main EU partners and its share is around 7% of world. The UK is publication-productive: 1st in the G8 with 1.5 times as many papers per researcher as the DIUS comparator group average.

- Citations have risen to 12% share of world.

The UK's share of world citations is rising and it has 12% of world citations moving ahead of G8 competitors. China's citation count is rising fast (from 1.5% in 1998 to 5.5% now). The UK's relative citation share is 2nd only to the USA in all subject areas except mathematics, physical sciences and engineering (Germany, Japan and China). Even so, the UK is improving its share in these areas. The UK is also citation-productive, 1st in the G8 with 2.5 times as many citations per researcher as the comparator group average. Counting frequency of occurrence among the top three by citation share in any subject area, the UK is 2nd to the USA with 7 or 8 places in each year.

- Impact has been maintained and is competitive with the USA in many areas. The UK has 13% of top 1% most highly-cited papers.

The UK's average citation impact has risen steadily over the last ten years and is now close to the USA. It has been overtaken by Germany, however, and also lies behind Switzerland, Denmark and the Netherlands in the DIUS comparator group. The UK sustains high impact across subject areas. It remains ahead of the USA in health, biology and environment and, on a smaller volume, the UK has passed the USA in physical sciences. China is now performing at a similar level to the G8 in physical science and engineering. UK impact is balanced by consistency and improves between early (1998-2002) and late (2003-2007) periods at a slight cost to diversity: performance gains are offset by specialisation.

The UK has 13% of the world's top 1% of highly-cited papers compared to 9% of total papers and 12% of total citations. The UK's 2,300 highly-cited papers cover about one-third of the EU's total with an average impact that places it 2nd in the G8.

The research impact of leading research nations appears to be converging, possibly because of an increase in collaboration. Co-authored papers are often high impact, so nations may be distinguished in the future more on their lower-impact domestic papers.

Theme 2 – Collaboration

- Collaboration is expanding and benefit-gains are shifting from the USA to the EU

Collaboration is increasing globally and co-authored papers have greater impact. UK internationally co-authored papers have risen from 22,500 (32% of total) to 37,000 (45%). The relative frequencies of co-authored papers with all key partners are rising. The fastest increase is with China but EU partners are rising faster than the USA. Both France and Germany now add greater impact to UK co-authored papers than does the USA.

Theme 3 – Research postgraduate training

- The UK has a rising PhD output but its world share is falling and is below its output of papers

The UK has a rising output of PhD awards and is 3rd after the USA and Germany by volume, but its share of world PhDs has dropped from 9 to 8.5% which is less than its share of papers. However, the UK's share of PhDs in the natural sciences is above its general average. Relative to population size, it produces more PhDs than any G8 country except Germany though less than Finland, Sweden and Switzerland. Relative to the current researcher population, UK performance is on a par with Germany.

Theme 4 – Research workforce

- Workforce research capacity is below average using current data which show the UK lagging many competitors

The UK has fewer highly skilled people with research training than many of the DIUS comparator group countries but current shifts in researcher work patterns may not be adequately captured by OECD Frascati definitions for technology- rather than knowledge-based economies.

The UK has a rising frequency of researchers in the population and a similar relative capacity to its EU partners though it lags other G8 countries. UK R&D personnel are increasing in frequency within the workforce and population, and the UK's rank position within the group is improving. Its position within the G8 is largely unchanged, however, and it consistently lags all but Italy. Researchers are a lower proportion of R&D personnel for the UK than for most other countries in the comparator group.

Theme 5 – Output productivity

- UK productivity (papers and PhD awards per R&D spend) is 1st in the G8 and twice that of many competitors

The UK has consistently had an exceptionally high level of output productivity. It is ranked 1st in the G8 for papers per unit GDP, well ahead of most competitors. On citations per GDP, the UK has maintained its overall lead within the G8 and Germany's rising index is related to slower GDP growth. The UK's productivity on papers and citations relative to Gross Expenditure on R&D (GERD) is twice that of France, Germany and the USA, reflecting its increased impact (Theme 1). China's cites/GERD now exceeds that of Japan. Citations per HERD places the UK 1st in the G8 and it has risen from 4th to 3rd overall. Across subject areas, the UK's is 1st in the G8 in medical sciences, and natural sciences.

For PhD awards in relation to HERD, the UK is 2nd in the G8 to Germany and has moved further ahead of the USA and France. For the available data across subject areas, the UK has improved its position in medical sciences but declined in natural sciences although it is well ahead of the USA. In engineering, its productivity is again well ahead of the USA and better than Germany.

Introduction

This is a report about indicators of the UK's relative international research performance in science, engineering, the social sciences and the humanities and arts. It is the fifth report with these indicators and has undergone several changes. In 2005 we introduced data covering the Arts and Humanities. This year the information content, analysis, commentary and overall structure have continued to develop from previous cycles. There is a complete reshaping of the main themes better to reflect the areas which have been found to be most useful and of greatest interest to readers and users. To accompany this new format we have changed the tables and charts to simplify and make the indicators much clearer, with explicit links between numbers and statements about outcomes for the UK.

The Research Footprint® diagrams summarise the outcomes of analyses for six leading indicators, comparing the research profile of the UK, the G8 and a number of other leading research economies. The thematic commentary, following the Footprints, gives a broad overview of the UK's performance in terms of the selected indicators.

Background

The objective is to support a system for assessing outputs, outcomes and impacts related to the Public Service Agreement (PSA) target to 'improve the relative international performance of the UK research base'. This target is challenging. Many studies have indicated that successive advances in research become increasingly expensive (the "sophistication" factor, Advisory Board for the Research Councils (ABRC), 'Strategy for the Science Base', 1986) and the costs of improving relative performance rise in parallel.

The Atkinson Review of 'Measurement of Government Output' (2005) for the Office of National Statistics (ONS) affirmed that 'the measurement of quality is central to our concerns'. Sir Tony Atkinson recommended that all assessments of output and productivity should account for this. This is what DIUS sets out to do, capturing information not only on what the research base produces for the Science Budget investment but how its output is perceived internationally.

The UK is widely acknowledged to be an extremely effective research performer. It is therefore difficult to improve significantly on this relative level of achievement. Indeed, it will be difficult in some fields to maintain the UK's international status without, for example, additional investment that meets the growing competition from technologically the specialist research economies of China, Korea and Singapore. Once again, this year's report highlights the impact that China is having as its research base expands.

Until 2002, DIUS (then the Office of Science and Technology (OST)) employed a core set of indicators that demonstrated the position of the UK and reflected effectiveness in the use of research funding. This report describes an extended basket of indicators based on an original set first established in 2003. Plurality in an indicator system is a desirable feature, because over-dependency on any one indicator can be misleading. A balanced set can take account of differences in the pattern of performance between research disciplines, the interaction between inputs and outputs and possible measures of efficiency and effectiveness, and year on year fluctuations in any one indicator. They also help interpretation by providing a set of views across different aspects of a national research base.

Assessing excellence is as important as measuring system average. The peak of research excellence, however defined, includes those highly innovative outcomes that are most likely to impact on economic performance. The indicators in this report allow for disaggregation, to throw light on changing patterns of selectivity and concentration within the UK science base.

Other countries and communities – such as the EU, the NSF in the USA, CWTS in the Netherlands and the OST in Paris – already publish reports about national science and technology indicators on a regular basis. This report has taken note of the good practice established elsewhere.

Data and Indicators

Every piece of research data should have three attributes: subject area, time and location. Each attribute works at varying levels of detail and we need to identify the best level for analysis. Data about research usually measure something in one of three primary categories: input (usually financial), activity (or proxies such as staff numbers) and outputs. Secondary indicators describe the relationship between them. Sometimes, outputs can be followed through into outcomes and impacts. The UK indicators include both primary and secondary indicators and focus on impacts where possible. They are listed in the table (below) on the "Definition and description of indicators".

Bibliometric data play a key part in these indicators. Our work on this and other contracts has confirmed that there are sound reasons for being particularly cautious about such data with respect to social science and to humanities' and arts' research (see Background sections after the indicator pages). At the same time, for the natural sciences, there is also great value and applicability. Crucially, these data uniquely provide us with international comparisons of research quality for most countries and by subject area.

The Background sections that come after the indicator data describe the main data sources, list the range of the DIUS comparator group of countries, the level of subject disaggregation and the time frames used for comparisons. There is also a discussion about the significance and interpretation of bibliometric indicators and some cultural aspects of publication and citation behaviour in different countries and disciplines.

International comparisons are made across a DIUS comparator group of 25 countries. This includes the full G8 (UK, USA, Canada, France, Germany, Italy, Japan, Russia); a combination of selected OECD countries and larger nations from different continents with research bases both similar and contrasting in structure to the UK; as well as a spread of smaller nations with active and rapidly growing research bases with specific strengths. These are Belgium, Denmark, Finland, Netherlands, Poland, Spain, Sweden, Switzerland, Australia, Brazil, China, India, Iran, Israel, Singapore, South Africa, South Korea, and Taiwan. A separate line of analysis for a group of 27 EU countries is also included where feasible and appropriate.

The countries in the DIUS comparator group produce about five-sixths of the world's research papers catalogued by Thomson Reuters and a higher proportion of the most influential of these. A separate 'world' ranking is therefore normally omitted.

Many of the graphs that illustrate performance indicators use short codes for these countries, for clarity. These codes are linked to their countries in a table in the Background sections.

Subject disaggregations used in this report employ two systems of categorisation. First, there are five main OECD categories (medical sciences, natural sciences, engineering and technology, social sciences and humanities [which includes the arts]). Second, subjects based on 69 UK Units of Assessment (UoAs) are grouped by publication similarity into ten Super-UoAs (Clinical, Health & medically-related subjects, Biological sciences, Environmental sciences, Mathematics, Physical sciences, Engineering, Social sciences, Business, Humanities).

International R&D databases have historically focussed on science and technology and therefore have some deficits in social science and humanities data. This does affect some analyses, and this is discussed further in the Background sections.

It should be borne in mind that not all the research indicators used in the natural sciences are well suited to analysing research performance in the humanities and arts.

Details of the countries and subjects are given in the relevant part of the Background section after the indicators.

Definition and description of indicators

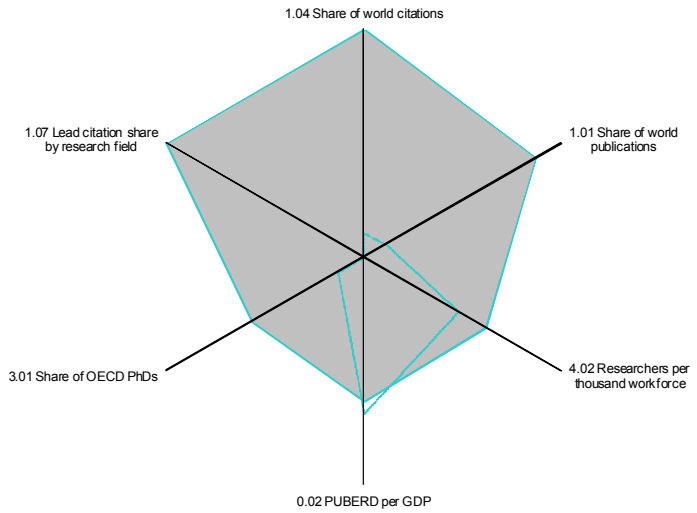
Indicator number	Description of performance indicator	Level of disaggregation	Primary data sources
THEME 1	Bibliometric outputs		
1.01	Number and share of world papers	System	Thomson Reuters NSI 2007
1.02	Number and share of world papers in ten main research areas	SUoA	Thomson Reuters NSI 2007
1.03	Papers relative to researchers	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
1.04	Number and share of world citations	System	Thomson Reuters NSI 2007
1.05	Number and share of world citations in ten main research areas	SUoA	Thomson Reuters NSI 2007
1.06	Citations relative to researchers	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
1.07	Rank on citation volume in nine main research areas - frequency of occurrence in top 3 nations	System	Thomson Reuters NSI 2007
1.08	Proportion and share of uncited papers	System	Thomson Reuters NSI 2007
1.09	Citation impact (citations per paper) relative to world baselines	System	Thomson Reuters NSI 2007
1.10	Citation impact relative to world baselines in ten main research fields	SUoA	Thomson Reuters NSI 2007
1.11	Variation and consistency of research strength	System	Thomson Reuters NSI 2007
1.12	Papers in top 1% by citation count	System	Thomson Reuters NSI 2007
THEME 2	Collaboration		
2.01	UK co-authorship for select partner countries relative to total UK co-authorship	System	Thomson Reuters NSI 2007

Indicator number	Description of performance indicator	Level of disaggregation	Primary data sources
2.02	Impact gain from co-authorship for UK with select partner countries	System	Thomson Reuters NSI 2007
THEME 3	Postgraduate research training		
3.01	Number and share of OECD PhD awards	System	OECD MSTI 2008-1
3.02	Number and share of OECD PhD awards in five main research areas	OECD field of science	OECD RDS 2007-1
3.03	PhDs awarded relative to population	System	OECD MSTI 2008-1
3.04	PhDs awarded relative to researchers	System	OECD MSTI 2008-1
THEME 4	Research workforce		
4.01	Researchers relative to population	System	OECD MSTI 2008-1
4.02	Researchers relative to workforce	System	OECD MSTI 2008-1
4.03	R&D personnel relative to population	System	OECD MSTI 2008-1
4.04	R&D personnel relative to workforce	System	OECD MSTI 2008-1
4.05	Researchers relative to R&D personnel	System	OECD MSTI 2008-1
THEME 5	Output productivity		
5.01	Papers relative to GDP	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
5.02	Citations relative to GDP	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
5.03	Papers relative to GERD	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
5.04	Citations relative to GERD	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
5.05	Citations relative to PUBERD (GOVERD + HERD)	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1
5.06	Citations relative to HERD	System	Thomson Reuters NSI 2007; OECD MSTI 2008-1

Indicator number	Description of performance indicator	Level of disaggregation	Primary data sources
5.07	Citations relative to HERD in five main research areas	OECD field of science	OECD RDS 2007-1
5.08	PhDs awarded relative to HERD	System	OECD MSTI 2008-1
5.09	PhDs awarded relative to HERD in five main research areas	OECD field of science	OECD RDS 2007-1

Research Footprints®

There are over 30 research indicators grouped under five themes. This complex body of data provides an informative and comprehensive view of many aspects of the comparative international performance of the research base, but it is not readily absorbed. We have illustrated key data via each country's distinctive Research Footprint® of international research competitiveness. The figure uses six key indicators and provides a direct graphical comparison of the performance of select comparator countries with the DIUS comparator group average. The shaded area - the 'footprint' - can be compared directly with the dotted line that marks the average footprint for the group. Each axis measures a specific indicator, with the lowest level of performance (low rank or zero activity) at the origin near the centre and the maximum value at the outer end of the axis. Footprint area has no statistical significance.



0.02 PUBERD per GDP
Theme: Not included in indicators
Full title: Publicly performed R&D (PUBERD) as proportion of GDP
Description: Volume of publicly funded R&D relative to general economy

1.01 Share of world papers
Theme: Bibliometric outputs
Full title: Number and share of world papers
Description: Relative output volume

1.04 Share of world citations
Theme: Bibliometric outputs
Full title: Number and share of world citations
Description: Esteem measured by share of world citations

1.07 Lead citation share by research field
Theme: Bibliometric outputs
Full title: Frequency in top three for citation share by main research fields
Description: Breadth of research strength

3.01 Share of OECD PhDs
Theme: Postgraduate research training
Full title: Number and share of OECD PhD awards
Description: Highly skilled people: research degree awards

4.02 Researchers per thousand workforce
Theme: Research workforce
Full title: Workforce research capacity
Description: Skilled R&D capacity within national workforce

Research Footprint® of comparative UK research performance

The Research Footprint® for the UK is compared in the next two pages, first with other G8 nations and with the pattern for the EU27 as a whole and second with a set of other leading research nations in the DIUS comparator group.

The display uses absolute values, not ranked position. The data coverage – for countries, years and fields – has improved again since last year. This has identified a number of exceptional performers for particular indicators, some of which appear to behave inconsistently and may be amended in later reports. There are also some anomalous values (e.g. those involving researchers for Italy, various data for Russia).

The dominant position of the USA is reaffirmed in the latest annual analysis, though its footprint area is shrinking somewhat through declining values for researchers per thousand workforce and PUBERD per GDP (which falls below average for the first time this year). It continues to be a strong performer across the board, however, and because of its sheer size achieves maximum performance in two indicators (share of world citations, and lead citation share by field) and comes close 2nd to the EU in share of world papers. Efficiency is rather less impressive and other nations continue to challenge it in terms of effectiveness, though it never falls below 50% of maximal performance. Its weakest performance is in public expenditure on R&D as a proportion of GDP where it ranks only 12th of 22 countries (just in front of the UK) – France, Germany and the Nordic countries all spend relatively more.

The EU has no calculated value on indicator 1.07 [which would be a summation of specific countries rather than an integrated figure] but it would score as highly as the USA. It has more PhDs than the USA (indicator 3.01). There is a decline in average PUBERD per GDP (indicator 1.02) and researchers per workforce (indicator 4.02, where data are occasionally patchy) because the EU expands eastwards into less research-intensive economies.

Although UK share of world papers (indicator 1.01) and citations (indicator 1.04) are under pressure from growing nations including China, the UK's performance continues to be excellent, particularly given its modest public expenditure on R&D, where it ranks 13th. Because it ranks second on average to the USA, it has a very good position on average ranking by major research area (indicator 1.07). The UK's share of OECD PhD awards (indicator 3.01) closely matches its share of papers, and its concentration of researchers within its workforce (indicator 6.02) though rising, continues to be low by comparison with many other countries.

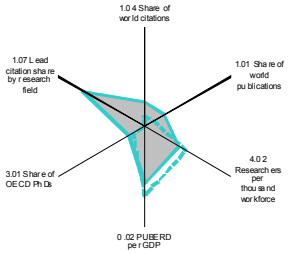
Germany, with its substantial research base, continues to display a well-balanced overall performance – strong PhD output with good share of papers and citations. This year though its footprint is diminished due to a fall in lead citation share by field (indicator 1.07) and proportion of research workers (indicator 4.02) where it, like the USA, falls below average this year. Each of our reports has confirmed that Germany is the major research competitor for the UK in Europe. These two are forming a lead sub-group with the USA, which is likely to be joined by China within five years.

Japan's value for researchers per thousand workforce (indicator 4.02) – where it had previously been significantly above average – has declined since last year, but its public expenditure on R&D as a proportion of GDP has increased and now comfortably exceeds average. This is in contrast to Italy, whose footprint continues to shrink, Australia, the Netherlands and Switzerland. France's performance once again tracks group average values closely. While Switzerland has a strong average bibliometric performance in many fields, in the Research Footprint® presentation its relatively small research base and capacity becomes clear.

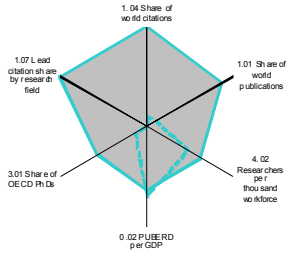
China's Research Footprint® is beginning to reflect the exceptional growth in its research base, with increasing share of papers and citations, and stronger performance in lead citation share by field (indicator 1.07), where it is now outperforming Japan.

Research Footprints® for UK, G8 countries (except Russia) and the EU25

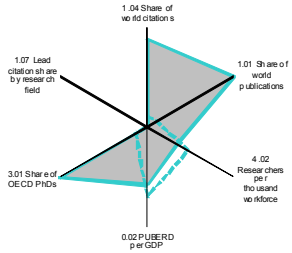
UK



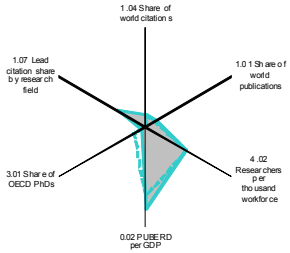
USA



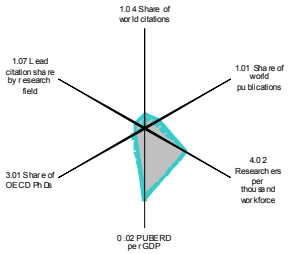
EUROPEAN UNION



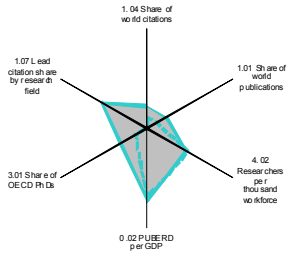
CANADA



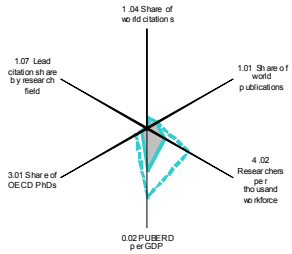
FRANCE



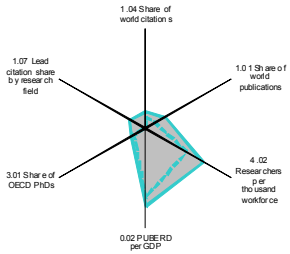
GERMANY



ITALY

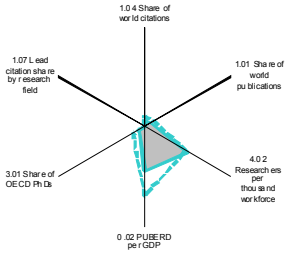


JAPAN

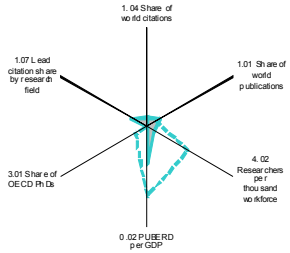


Research Footprints® for other leading comparator nations

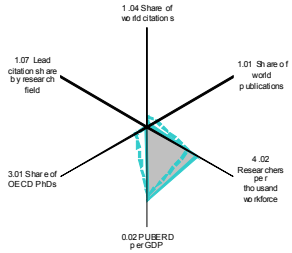
AUSTRALIA



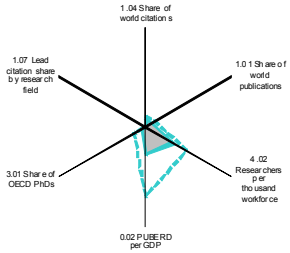
CHINA



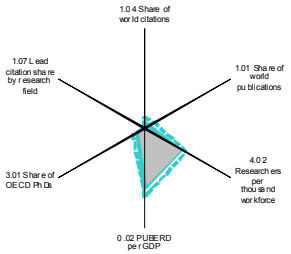
DENMARK



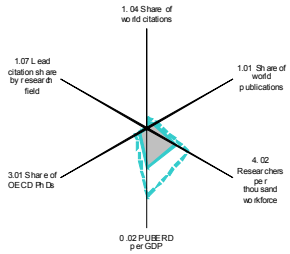
NETHERLANDS



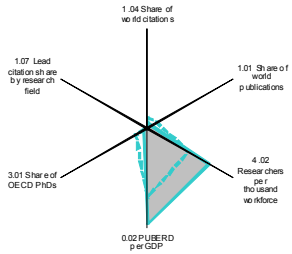
SOUTH KOREA



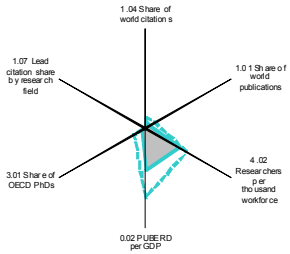
SPAIN



SWEDEN



SWITZERLAND



Thematic commentary

Theme 1 – Bibliometric outputs

The UK produces a growing total of about 80,000 indexed research papers per year, slightly less than 9% of world output and is maintaining its position respective to G8 competitors. For all established research economies, share of world total output is declining gradually: the USA is down from 35% to 32% since 1998. This is a response to rapid expansion of research output from China (up from 20,000 to 80,000 papers in ten years) and similar if lesser growth in other countries. The most rapid relative growth is that of Iran, a seven-fold increase in share and ten-fold increase in volume from 768 to almost 7,000 papers since 1998. Brazil, Singapore, S Korea and Taiwan have also substantially increased their share. India has shown marked growth in output in the last five years. Its volume is now comparable to Australia or Spain but remains well short of G8 comparisons and has not quite doubled since 1998. (Indicator 1.01)

Bibliometric data cover ten main subject areas. The UK's relative research output is strong in the biomedical sciences. In clinical sciences (10.6%), health (10.3%) and biology (8.6%) it ranks 2nd to the USA and has broadly maintained its share, as it has also done in environmental research (10%). In mathematics, physical sciences and engineering, the UK has a similar or slightly lower output than main EU partners and its share tends to be around 7% of world papers. China has moved well ahead of all but the USA in these areas with a four to five-fold growth on a very substantial volume base. In the social sciences, business and humanities the UK has maintained its relative position (12.5% or more). Countries with exceptional growth across fields from a relatively small base include Iran, which has expanded its output not just in technology areas but at a similar pace (ten-fold since 1998) in almost every subject area. Brazil and Singapore have typically doubled output in most fields, while India has a more mixed growth pattern. (Indicator 1.02)

The UK is very publication-productive, effectively 1st in the G8 (Italy has anomalous 'people' data) and 3rd globally with 1.5 times as many papers per researcher as the DIUS comparator group average. (Indicator 1.03)

The UK's share of world citations is rising and it has 12% of world citations, more than its share of papers (Indicator 1.01). While 2nd to the USA, the UK – with Germany close behind - is moving ahead of other G8 competitors. China's citation count is rising fast (from 1.5% in 1998 to 5.5% now) but still lags significantly on established research economies and tends to dip in the last year of any analysis. The smaller countries with exceptional output growth tend to see a slower rate of citation growth. In the 1-2% range, India, Singapore and S Korea have doubled their share of world citations but Brazil and Taiwan have not yet done so. Iran, however, has gone from less than 0.1% to 0.41% with a steady rise year on year. (Indicator 1.04)

The UK's relative citation share is 2nd only to the USA in all subject areas except mathematics, where it also lies behind China and France, physical sciences (Germany, Japan and China) and engineering (China, Germany, and Japan). Germany's relative strength in technology has been recognised in previous reports, but the UK is improving its share in these areas. In biomedical areas, the UK maintains its lead over Germany. In all subject areas, the UK has an excess share of several percentage points of citations over papers. The UK is also citation-productive, 1st in the G8 and 3rd globally with 2.5 times as many citations per researcher as the comparator group average. (Indicators 1.05, 1.06)

Counting frequency of occurrence among the top three by citation share in any subject area, the UK is 2nd to the USA with 7 or 8 places in each year. Germany lies 3rd with up to 6, but China has started to displace some other countries and lies 5th behind Canada and ahead of the rest of the G8. (Indicator 1.07)

Share of uncited papers has fallen slightly for the UK, but all countries show a clear downward trend on this indicator and at about the same rate. (Indicator 1.08)

Citation impact (average citations per paper normalised for year and subject area) is the most widely used index of research quality. The UK's citation impact has risen steadily over the last ten years and it is now very close to the USA. It has been overtaken by Germany, however, and within the

comparator group also lies behind Switzerland, Denmark and the Netherlands. China has a broadly rising trend but drops in citation counts for the most recent years reduce its current impact in all fields. (Indicator 1.09)

Across subject areas, the UK has sustained a high average impact. It passed the USA on performance in several areas in the previous report and it remains ahead in health, biology and environment. Biological sciences are clearly the UK's strongest area on quality as well as relative quantity. On a relatively smaller volume, however, the UK has now passed the USA in impact in physical sciences. It is moving progressively closer to the USA in all other areas. This year's data also show the UK being leap-frogged by France in some areas, but this outcome is against longer-term trends and may be revised next year. China is now performing at a similar level to the G8 In physical science and engineering.

In many subject areas there is a convergence of impact among leading research economies. This may be driven by greater collaboration, where co-authored papers are often of higher citation impact than domestic papers. This will make it increasingly difficult to distinguish differences in research performance in the future. (Indicator 1.10)

Long-term research performance involves a balance between niche strengths and a diversity of high-performance and capacity that allows shifts to address opportunities. We visualise this by looking across subject areas simultaneously at impact and variance. For the UK, high impact is matched with consistency, placing the country in the upper-right quadrant of performance. Impact improves between early (1998-2002) and late (2003-2007) periods at a slight cost to diversity, so performance gains are offset by specialisation. The USA has fallen back while France, Germany and the Netherlands are unchanged. China has moved up in research diversity as it spreads its investment. (Indicator 1.11)

Some papers are exceptionally highly-cited and the world's top 1% (by field and year) is a marker of global excellence. The UK has 13% of papers in this elite category compared to 9% of total papers and 12% of total citations. The UK's highly-cited papers (2,300 in the sample) covers about one-third of the EU's highly-cited total (6,794), similar to the figure for Germany and twice that for France. The USA has an exceptional share of the highly-cited papers (60%, 10,399 papers). The UK's average impact for this dataset is ranked 10th but that places it 2nd among G8 countries. (Indicator 1.12)

Theme 2 – Collaboration

Collaboration is increasing globally and for all research subject areas. Previous studies have shown that co-authored papers tend to have greater impact than domestic papers. The UK has had a strong record as a collaborative partner, in terms of frequency of co-authorship and in terms of the value it gains and adds to its partners.

Over ten years, the number of the UK's internationally co-authored papers has risen from 22,500 (32% of total) to 37,000 (45%). The relative frequencies of co-authored papers with the USA, Germany, France, China and India are all rising. The fastest increase is with China, but EU partners are rising faster than the USA, which remains the overall most frequent co-author. (Indicator 2.01)

Historically, the UK has gained most from its collaboration with the USA but both France and Germany now add greater impact to papers co-authored with the UK. The trend over the last ten years reveals a clear shift towards greater EU benefits and the greatest impact gain overall is with other, smaller European partners. The impact gain from co-authorship with China and India remains negative in the short-term but these partnerships may realise benefit through other outcomes. (Indicator 2.02)

Theme 3 – Research postgraduate training

The UK has a rising output of highly-trained researchers, measured as individuals with PhD awards. By volume it is 3rd behind the USA and Germany. However, its overall share of world training output has dropped from 9 to 8.5%, less than its share of papers (Indicator 1.01). (Indicator 3.01)

The subject areas for training data are five main OECD fields. The UK's position is unchanged in medical sciences, where it is 4th behind the USA, Germany and Japan. It has an above average share in natural sciences

where it is 3rd but it is 4th again in engineering. In the social sciences, its position with respect to most G8 countries is typical but the USA has a disproportionate share of papers. (Indicator 3.02)

Relative to population size, the UK produces more PhD awards than any G8 country except Germany and the figure is rising. It still lies behind Finland, Sweden and Switzerland, however. Relative to the current researcher population, which would be the recruiting sink for many PhDs, UK performance is on a par with Germany but is exceeded by Poland and Italy, although the data for these two may be volatile. (Indicators 3.03, 3.04)

Theme 4 – Research workforce

Relative research capacity is analysed in terms of researchers and R&D personnel and in relation to the total population and to the workforce. OECD data indicate that the UK has fewer highly skilled people with research training – in relation to population and to the workforce as a whole - than many of the DIUS comparator group countries. However, current shifts in research work patterns may not be adequately captured by current data which rely on definitions in the OECD Frascati manual that relate to a more technology-based than knowledge-based economy.

UK 'researchers per population' is gradually rising and the UK's rank position has improved. It has a similar relative capacity to its EU partners but lags other G8 countries. The indicators for researchers per workforce have a similar national relativity since in the G8 economies the workforce is about the same proportion of the total population. (Indicators 4.01, 4.02)

R&D personnel constitute a less specialised definition than researchers. UK R&D personnel are increasing in frequency within the workforce and population and the UK's rank position is improving. Its position within the G8 is largely unchanged and it consistently lags all but Italy. (Indicators 4.03, 4.04)

Researchers as a proportion of total R&D personnel are fewer than the average, one of the lowest in the DIUS comparator group and the index is falling. The UK has fallen behind Germany and is ahead only of Italy among the countries for which data are available. (Indicator 4.05)

Theme 5 – Output productivity

Within the DIUS comparator group, successive reports have shown that the UK has consistently had an exceptionally high level of output productivity.

The UK is ranked 1st in the G8 for productivity of research papers in relation to the economy as a whole (GDP). It remains well ahead of most competitors but Canada, in 2nd, has recently narrowed the gap. The UK is behind some smaller European nations, including Switzerland and the Scandinavian group. On citations per unit GDP, the UK has maintained its overall lead within the G8. Germany has a steadily rising index, but this is related to slower GDP growth as well as improved citation accumulation. (Indicators 5.01, 5.02)

Research productivity is more directly indexed against relevant investment if the index accounts for stated R&D expenditure rather than total GDP. The UK's performance and lead on papers and citations relative to Gross Expenditure on R&D (GERD) has been maintained in the G8, where its productivity is twice that of France, Germany and the USA, placing it 3rd in the comparator group as a whole. It has in fact moved further ahead on citations per GERD, reflecting the increased impact (as share of world citations) that the UK has acquired (Indicator 1.04). China's cites/GERD now exceeds that of Japan. (Indicators 5.03, 5.04)

Within GERD, Public expenditure on R&D (PUBERD) is associated with publication activity, whereas Business expenditure (BERD) is not. The UK is again 1st in the G8 and 4th across the comparator group with an index more than 1.5 times group average. The Higher Education sector is likely to be the most prolific publishing entity. Within PUBERD, citations per HERD again places the UK 1st in the G8 and it has risen from 4th to 3rd overall. Excepting the USA, the lead that the UK has over other countries on this indicator is declining. That is not because of reduced performance but because of recent increases in public investment which are likely to generate increased returns in future years because publication lags 3-5 years on activity. (Indicators 5.05, 5.06)

The subject areas for financial data are five main OECD fields. The accumulation of citations relative to expenditure as HERD is indexed across

these fields. The UK's position is unchanged in medical sciences, where it is nominally 2nd in the G8 but in fact 1st as Russia's data are anomalous. It is in a similar position in natural sciences, but its index has declined markedly due to boosts in expenditure. Nonetheless, it remains well ahead of the USA, whereas in engineering it is slightly behind the USA. That is partly due to the relative database coverage for these subjects, which also affects Social sciences and humanities. In these latter areas the UK is maintaining its performance, although this cannot be absolutely compared with other countries. (Indicator 5.07)

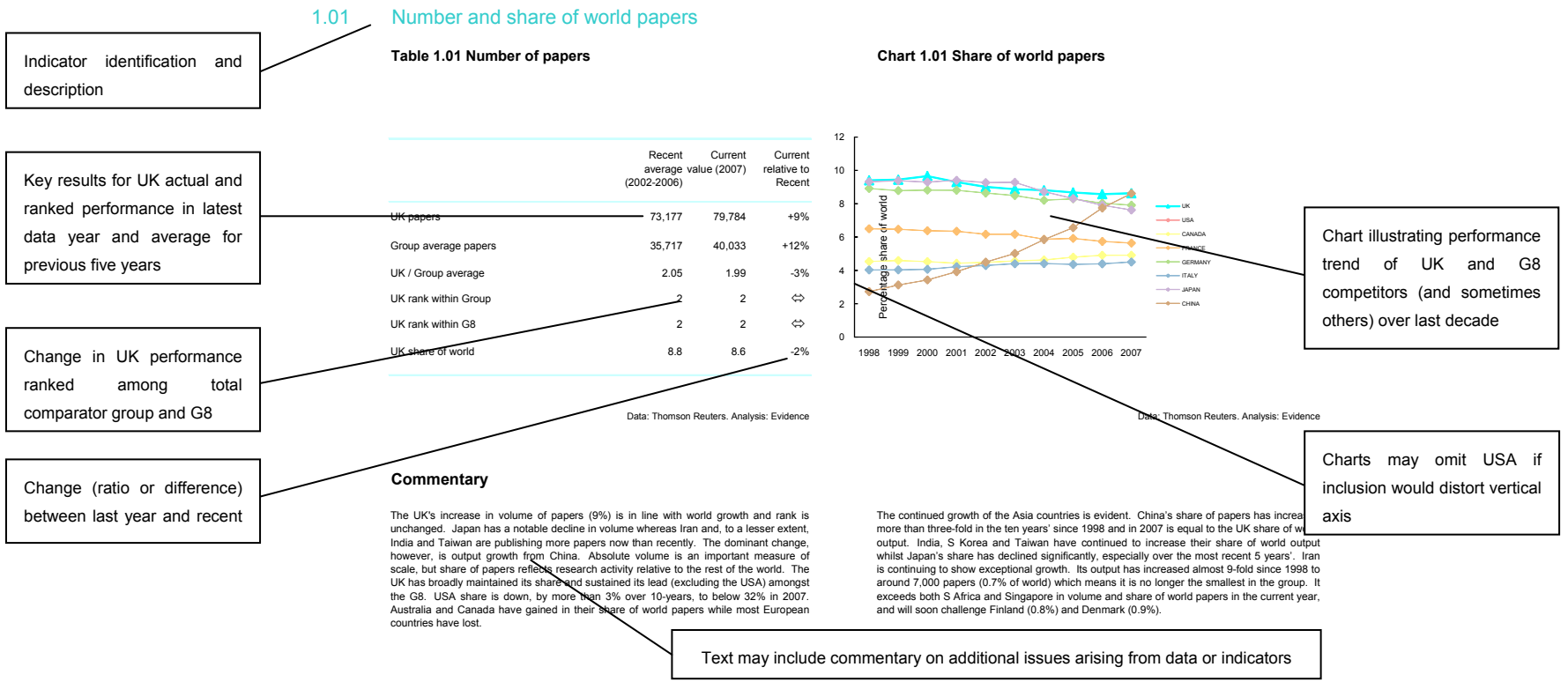
For PhD awards in relation to HERD, the UK is ranked 2nd in the G8, behind Germany. It has maintained its relative performance within the DIUS comparator group and has moved further ahead of other competitors such as the USA and France. (Indicator 5.08)

OECD data for both PhD awards and HERD at subject level are supplied by only some countries. From the data available across subject areas, the UK has slightly improved its position in medical sciences. Although its index has declined in natural sciences, it has improved its ranked position relative to Germany and is well ahead of the USA. In engineering, the UK's relative position is unchanged and its productivity is again well ahead of the USA and better than Germany. In social sciences and humanities, the UK has improved its ranked position partly due to negative growth in the group as a whole. (Indicator 5.09)

Indicator summary pages

The body of this report is a page by page summary of the detailed quantitative analyses for each indicator. Each page follows a similar pattern within a layout updated from previous years. Additional explanatory notes are in the Background section at the end of this document.

- Table of key results (actual values and ranked performance among comparators) for the latest year for which data are available and the average value for the previous five years. The Table shows performance relative to comparator group average and ranked UK performance against G8 nations and the comparator group generally. Also shown is the UK share of group (sometimes world); for 'relative' indicators (where one measure is expressed relative to another) this becomes (UK share of group in measure A) / (UK share of group in measure).
- Charts of data for UK and competitors (usually G8 and occasionally others where data are sparse for UK countries) showing trends.
- Description of and commentary on the indicator.



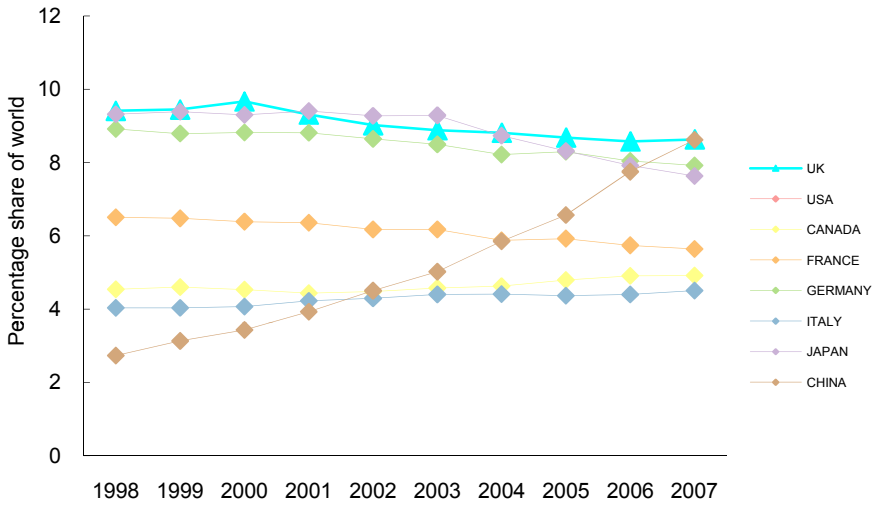
1.01 Number and share of world papers

Table 1.01 Number of papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	73,177	79,784	+9%
Group average papers	35,717	40,033	+12%
UK / Group average	2.05	1.99	-3%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	8.8	8.6	-2%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.01 Share of world papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK's increase in volume of papers (9%) is in line with world growth and rank is unchanged. Japan has a notable decline in volume whereas Iran and, to a lesser extent, India and Taiwan are publishing more papers now than recently. The dominant change, however, is output growth from China. Absolute volume is an important measure of scale, but share of papers reflects research activity relative to the rest of the world. The UK has broadly maintained its share and sustained its lead (excluding the USA) amongst the G8. USA share is down, by more than 3% over 10-years, to below 32% in 2007. Australia and Canada have gained in their share of world papers while most European countries have lost.

The continued growth of the Asia countries is evident. China's share of papers has increased more than three-fold in the ten years' since 1998 and in 2007 is equal to the UK share of world output. India, S Korea and Taiwan have continued to increase their share of world output whilst Japan's share has declined significantly, especially over the most recent 5 years'. Iran is continuing to show exceptional growth. Its output has increased almost 9-fold since 1998 to around 7,000 papers (0.7% of world) which means it is no longer the smallest in the group. It exceeds both S Africa and Singapore in volume and share of world papers in the current year, and will soon challenge Finland (0.8%) and Denmark (0.9%).

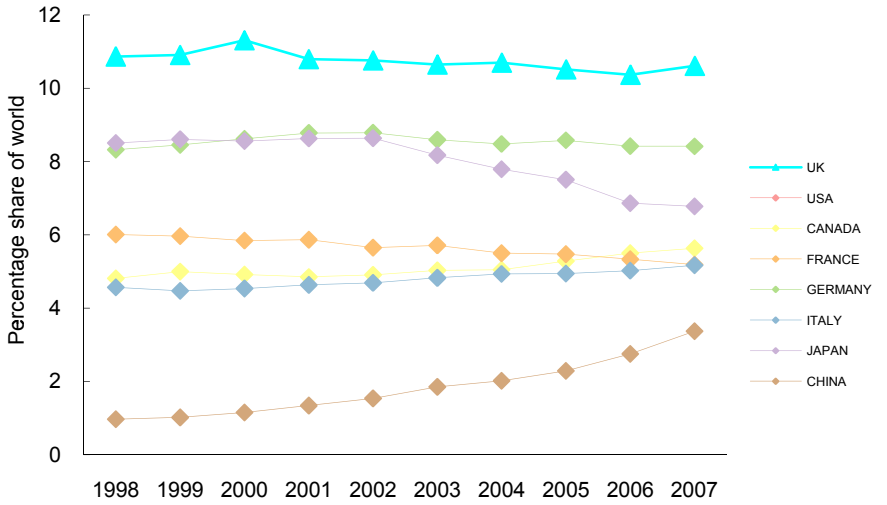
1.02.01 Number and share of world papers in ten main research areas

Table 1.02.01 Number of clinical papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	39,648	42,628	+8%
Group average papers	16,177	17,747	+10%
UK / Group average	2.45	2.40	-2%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	10.6	10.6	+0%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.01 Share of world clinical papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

This is a strong research area for the UK, where it also shows an increase in output in the number of research papers published. Within the G8, the UK is ranked 2nd to the USA and it is also ranked 2nd within the comparator group. Most European and North American countries within the comparator group actually show a peak in output in 2005, with current (2007) output approaching this earlier volume after a decline in 2006. This peak was not seen in output for the east and south-eastern Asian countries, which show a consistent increase in output over the 10-year period. The EU total is comparable with the USA output.

The UK shows no increase in share of world clinical papers but the USA share has actually declined over the monitoring period. Italy and Canada have made gains in share of world clinical papers against all other countries in the G8. Outside the G8, Iran has made the greatest improvement in share of world clinical papers, increasing almost 10-fold since 1998. In volume terms, the number of clinical papers published by Iran is approaching the output of Singapore and S Africa. China and S Korea have both shown a 3-fold increase in world share of clinical papers, with the other east and south-eastern Asian nations also improving their share, albeit at a slower pace.

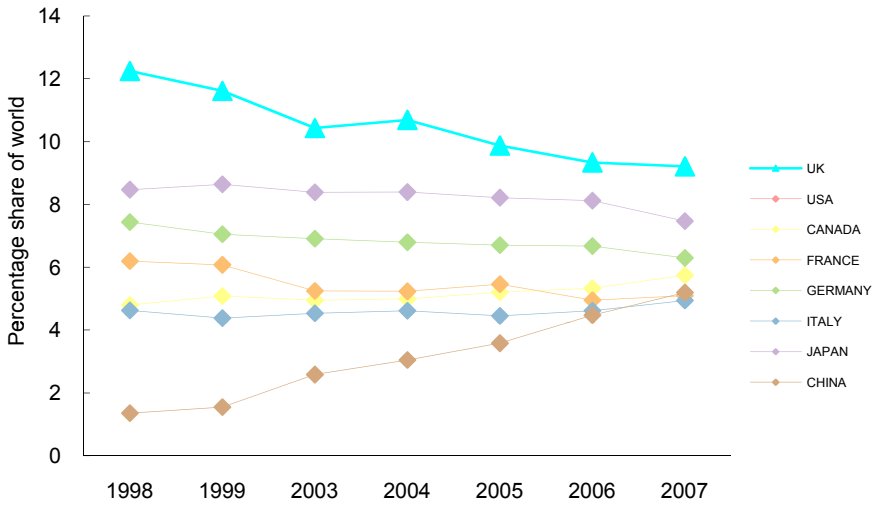
1.02.02 Number and share of world papers in ten main research areas

Table 1.02.02 Number of health & medically-related papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	4,194	3,992	-5%
Group average papers	1,726	1,864	+8%
UK / Group average	2.43	2.14	-12%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	10.3	9.2	-11%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.02 Share of world health & medically-related papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

This is a strong research area for the UK. The UK maintains a dominant position in the comparator group but there is a fall in absolute volume terms and hence in world share of health and medically-related papers . On both measures, the UK is ranked 2nd to the USA, but the USA benefits from increasing volume and so maintains its world share of health and medically-related papers, in contrast to the UK. As in clinical research, Italy and Canada are the only members of G8 to have made substantial gains in world share of papers. China's volume and share is increasing and is now similar to Canada.

Amongst the comparator group, the east and south-east Asian countries have, in general, made the greatest gains in share of world health and medically-related papers. However, Iran has also improved its world share by a similar percentage to that of China, though from a much lower base. Iran's absolute number of health and medically-related papers in the current year has exceeded that of Singapore. This has also been an area of research in which Canada has made significant gains in share of world papers.

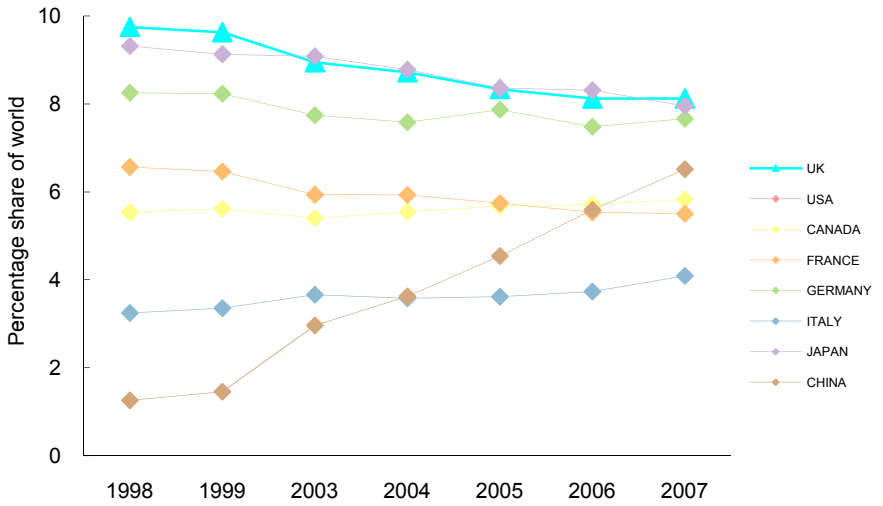
1.02.03 Number and share of world papers in ten main research areas

Table 1.02.03 Number of biological sciences papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	15,993	16,276	+2%
Group average papers	7,963	8,721	+10%
UK / Group average	2.01	1.87	-7%
UK rank within Group	3	2	⇧
UK rank within G8	3	2	⇧
UK share of world	8.6	8.1	-6%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.03 Share of world biological sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK shows no increase in output and a consequent decrease in world share of papers in biological sciences. This is, however, an area in which its output quality is very high. Most countries within the G8 have increased their output in biological sciences papers by only 1-2%, which has resulted in concomitant decreases in their world share of these papers. The exceptions to this are Italy and Canada. By contrast, output from China has increased more than 5-fold over the 10-year period and its share of world biological sciences papers is currently only 1.5% behind the UK and already 1% ahead of France and Canada.

The chart emphasises the relatively rapid growth of output from China, influencing the slight downward trajectory of world share for other countries. Biological sciences has also been an area of strong growth for Brazil, where share of world papers has almost doubled since 1998. This is the largest increase for any comparator nation except for China and Iran.

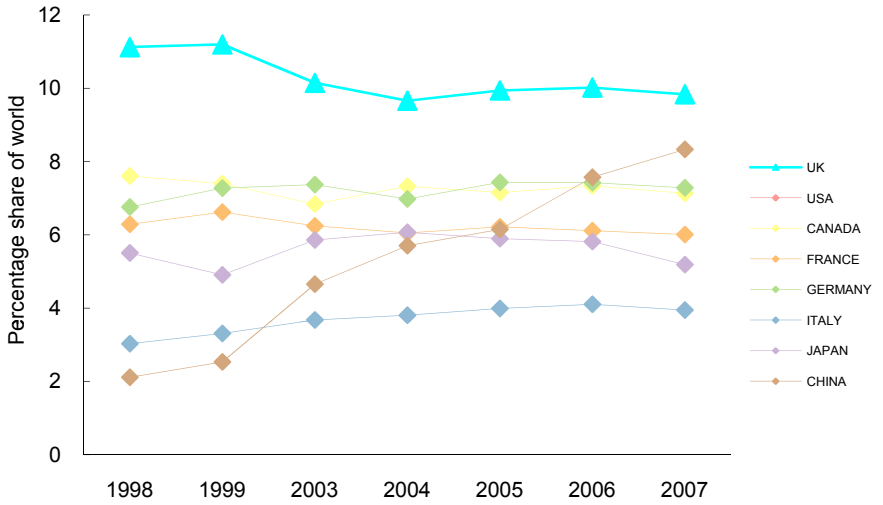
1.02.04 Number and share of world papers in ten main research areas

Table 1.02.04 Number of environment papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	6,635	7,660	+15%
Group average papers	2,913	3,490	+20%
UK / Group average	2.28	2.19	-4%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	10.0	9.8	-2%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.04 Share of world environment papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK shows an increase in output but no increase in world share of papers in environmental sciences. All countries in the G8 have published more papers in this research area and consequently the rankings have not changed. The UK remains 2nd to the USA. Russia is still ranked at the bottom of the group but has shown the largest increase in volume terms, whilst Japan has increased its output by only 5%. Within Europe, Spain and Switzerland have increased their world share of environment papers more than the comparator group average, to 4.2% and 2.2% respectively.

Amongst the comparator group, China and Iran have made the largest gains in world share of environment papers. The chart shows that this has increased China's position to 3rd in this group. India has also published more papers in environment recently, as output has doubled over the 10-year period and currently stands higher than the Netherlands and several European countries at just over 2,300 papers. This is an exceptional growth rate for India.

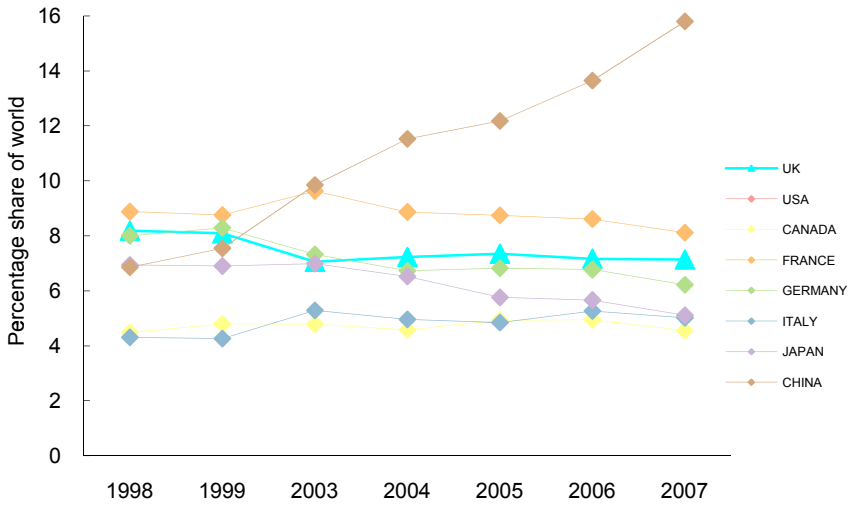
1.02.05 Number and share of world papers in ten main research areas

Table 1.02.05 Number of mathematics papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	2,508	2,826	+13%
Group average papers	1,464	1,660	+13%
UK / Group average	1.71	1.70	-1%
UK rank within Group	4	4	⇔
UK rank within G8	3	3	⇔
UK share of world	7.3	7.1	-2%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.05 Share of world mathematics papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK shows an increase in output but no increase in world share of mathematics papers. The UK is ranked 3rd behind the USA and France in the G8. The USA has maintained its global lead in mathematics research but its share of world mathematics papers is declining whereas China's share continues to climb at an extraordinary pace, currently passing 15% and rising compared to the USA's rather static 25%. China's success in mathematics papers is not mirrored by the other east and south-eastern Asian countries – S Korea and Singapore have dropped their world share of mathematics papers.

Behind China and Iran, S Africa has made the greatest gain in share of world mathematics papers, although its output is still small. In 2007 S Africa published 200 mathematics papers, which is comparable to Finland and Denmark. Iran has increased its Mathematics output ten-fold since 1998 and now publishes over 700 papers, equal to Israel and twice as much as Singapore.

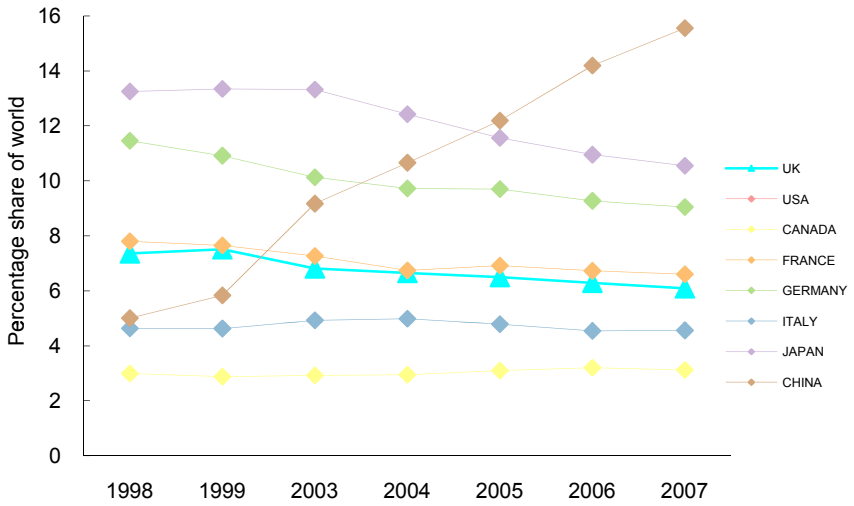
1.02.06 Number and share of world papers in ten main research areas

Table 1.02.06 Number of physical sciences papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	18,912	19,209	+2%
Group average papers	12,609	13,956	+11%
UK / Group average	1.50	1.38	-8%
UK rank within Group	6	6	⇔
UK rank within G8	5	5	⇔
UK share of world	6.6	6.1	-8%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.06 Share of world physical sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The balance of recorded output for the USA and Europe differs in the physical sciences from that seen in biomedical and life sciences research. In biomedicine, the USA publication volume and share is comparable to the EU. In physical sciences, the USA has published about two-thirds the volume that the EU publishes. It is, however, not such a prominent research area for the UK as the biomedical sciences. The UK is ranked 5th by volume in the G8, ahead of Russia, Italy and Canada. Within the comparator group, the UK is ranked 6th, ahead of other European countries but behind China.

Canada and Australia have made substantial gains in their shares of world physical sciences papers; in the comparator group, this is not seen in other Anglophone countries such as the UK and USA. Considering share of world physical sciences papers, China, Iran (which now exceeds Israel) and India (which has doubled over ten years to now exceed Italy) have made the greatest gains with Japan and the Netherlands losing share in recent and current years. China currently publishes around 50,000 papers in physical sciences compared to the USA output of 70,000 papers in 2007.

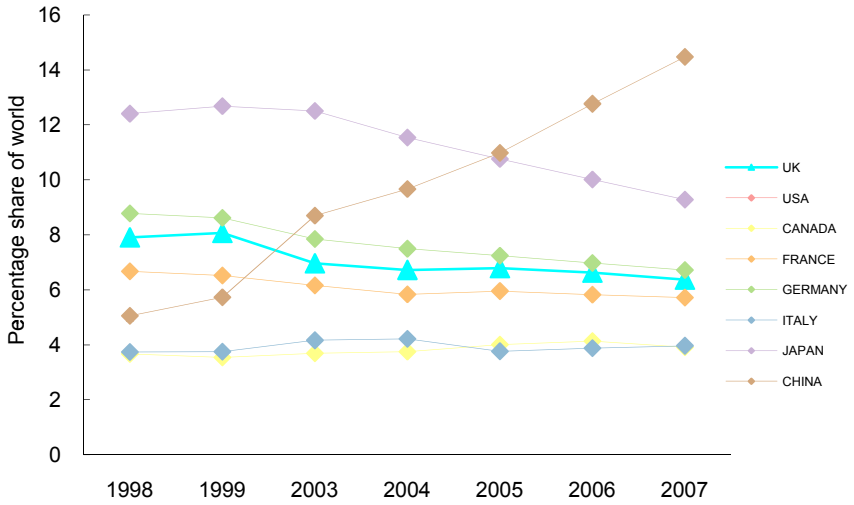
1.02.07 Number and share of world papers in ten main research areas

Table 1.02.07 Number of engineering papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	14,711	16,297	+11%
Group average papers	9,072	10,735	+18%
UK / Group average	1.62	1.52	-6%
UK rank within Group	5	5	⇔
UK rank within G8	4	4	⇔
UK share of world	6.8	6.4	-7%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.07 Share of world engineering papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The trends in engineering papers are similar to those seen in physical sciences. Within the G8, the UK is ranked behind the USA, Japan and Germany in volume of engineering papers but actually has done better than these countries in real terms. Japan has actually lost volume recently while Germany has not increased by as much as the UK. The greatest volume change is for China, which passed Japan in 2005 and already has more than half as much again in volume output. With 37,000 papers per year it looks to challenge the USA at 58,000.

The chart confirms that China is ranked 2nd to the USA, within the comparator group, on share of world engineering papers. In the current year, China, Taiwan and S Korea combined together (60,000 papers) have a greater share of world engineering papers than the USA but the EU group produces more than 85,000 papers annually. There appears to have been an almost universal growth in engineering papers for all countries, which hits those like Japan, the Netherlands and Scandinavia which have remained static or declined.

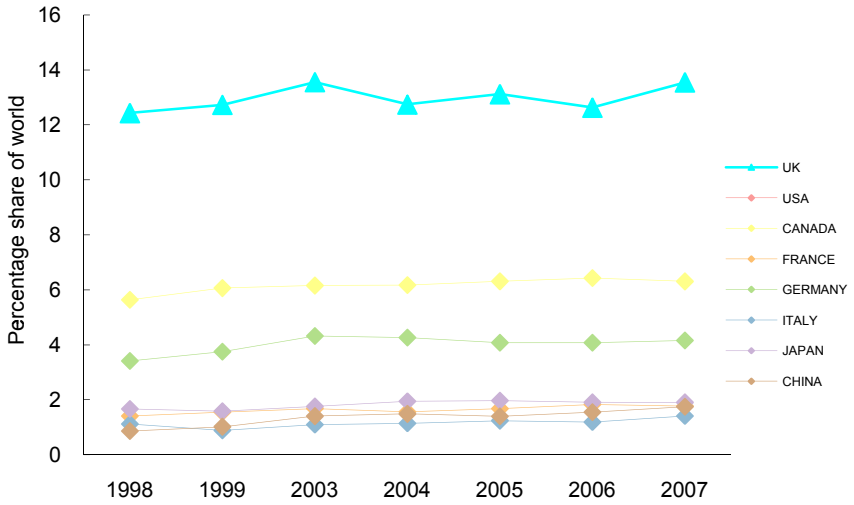
1.02.08 Number and share of world papers in ten main research areas

Table 1.02.08 Number of social science papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	3,973	4,879	+23%
Group average papers	1,227	1,461	+19%
UK / Group average	3.24	3.34	+3%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.9	13.5	+5%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.08 Share of world social science papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

There is a substantial increase in the UK's output of social science papers. This has appeared an exceptionally strong research area for the USA because an unusual balance in database coverage has disproportionately represented north American/Anglophone research. The USA's recorded output in this subject has dropped from almost 60% of world share in 1998 and the UK (2nd to the USA) has around 13% of share on an upward trend. The subject area's Anglophone dominance means the two other nations in the top four (ranked by world share) are Canada and Australia. The journal balance is now being progressively enriched and Germany is ranked 5th.

The five countries in the comparator group which have made the greatest gains in world share of social science papers in the period are Iran, India, Poland, S Korea and Spain. Iran published just 3 papers in 1998 and in the current year (2007) this had increased to 99. The other four countries have each approximately doubled their share of world papers over the 10-year period. Among the G8, the anomalous disparity between the UK, Canada, Germany and the rest is obvious. This consequently affects other bibliometric indicators in this subject area.

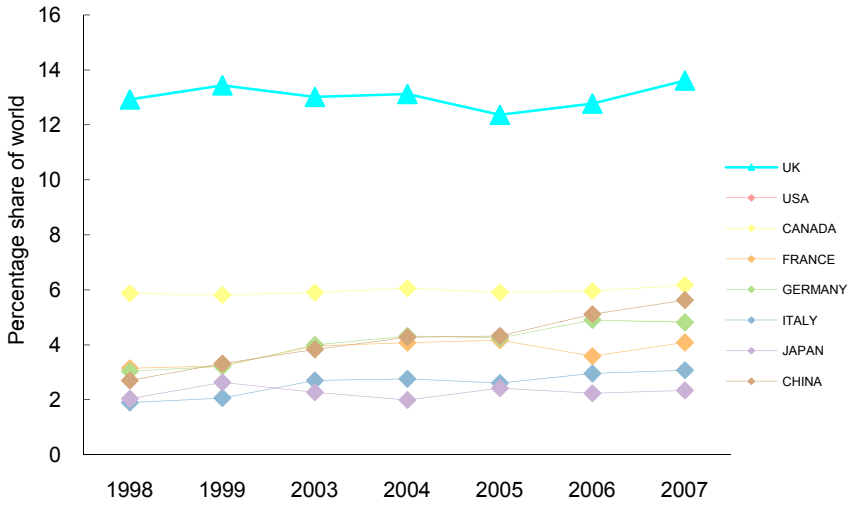
1.02.09 Number and share of world papers in ten main research areas

Table 1.02.09 Number of business papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	2,160	2,792	+29%
Group average papers	728	894	+23%
UK / Group average	2.97	3.12	+5%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.7	13.6	+7%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.09 Share of world business papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK shows an increase in the output of business papers, up by 50% over the period since 1998 and by 30% in the last five years. This has been a growth subject for all countries in the comparator group with the group average rising by almost a quarter not he recent past. The exceptions are Russia, which has been static, and Israel, which has published fewer papers in 2007 (the current year) than in the recent past. Growth in UK output in business is slightly ahead of both the EU and group averages whereas the USA share of world business papers has dropped over the 10-year period, partly due to database changes.

Despite the language differences, China has published significantly more over the period and relatively more in this subject area than in social science. It is ranked 4th behind the USA, UK and Canada within the comparator group on volume and share of world business papers. This is a more diverse area bibliometrically than social sciences: Taiwan and France are ranked ahead of Australia on world share.

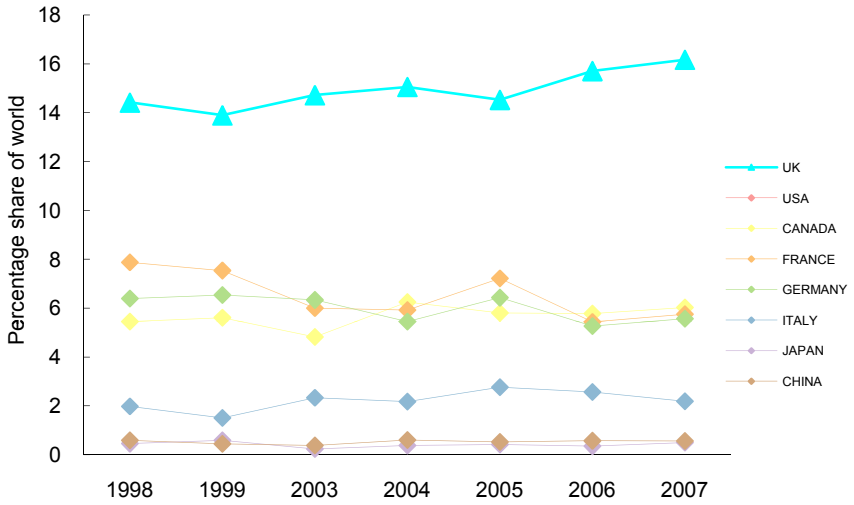
1.02.10 Number and share of world papers in ten main research areas

Table 1.02.10 Number of humanities papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers	1,380	1,543	+12%
Group average papers	363	367	+1%
UK / Group average	3.80	4.20	+10%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	14.8	16.2	+9%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.10 Share of world humanities papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK shows an increase in the output of humanities papers that is well ahead of comparator group average and thereby increases a share that was already greater than for most of the subject areas. The data balance between the USA and the rest of the world is anomalous in this area where there is a distinct bias towards Anglophone journals. There are, for example, fewer than 40 article records for India and barely more than 50 for China in any year. The UK's relative volume is thrice that of France or Germany whereas it is usually of a similar scale. It is therefore more valuable to compare within than between countries.

The chart shows that the UK has progressively increased its share compared to other countries and compared to its position at the start of the decade. It has a greater share relative to the rest of the world and the disproportionate lead that it has over European competitors has increased. At the same time, the USA's share and volume has fallen so the UK's improved position is not due to a general Anglophone effect.

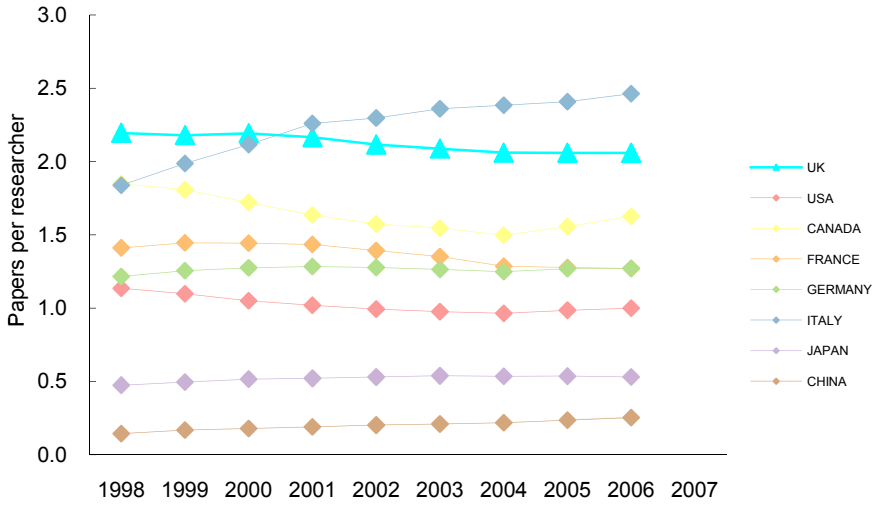
1.03 Papers relative to researchers

Table 1.03 Share of papers relative to share of researchers

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK papers per researcher	2.10	2.06	-0.02
Group average papers per researcher	1.36	1.38	+0.02
UK / Group average	1.54	1.49	-0.03
UK rank within Group	4	4	⇔
UK rank within G8	2	2	⇔
UK share of papers / UK share of researchers	2.31	2.27	-0.02

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 1.03 Papers per researcher



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

One aspect of the competitiveness of the research base can be measured by the volume of papers published compared to the numbers of active researchers. Despite having declined slightly in absolute terms, the UK retains a strong relative position on this indicator, at 4th place within the comparator group behind Switzerland, the Netherlands and Italy. (Recent 'staff' data for Italy are anomalous - see note in Background on Labour Productivity in Italy). Canada remains above group average and continues its recent rise, while Germany is just below group average and falling. The group average itself has risen very slightly this year but is still less than 70% of UK productivity.

On this indicator the USA's productivity is less than half of the UK's and it ranks consistently 6th out of the G8 nations. After declining at the beginning of the period, the USA has risen slightly in the most recent four years while the combined EU productivity has fallen slightly, though it still remains 20% higher than the USA. China remains relatively unproductive on this measure, with a very large research workforce for its output, but continues to rise. Although Italy tops the G8 table, and is in third place for the comparator group as a whole, note that recent data for Italy are anomalous.

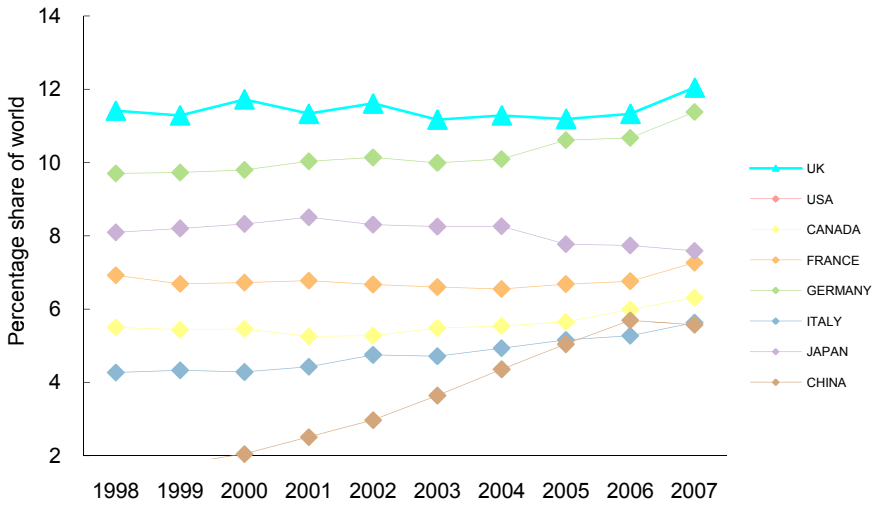
1.04 Number and share of world citations

Table 1.04 Total citations

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	658,599	42,252	-
Group average citations	284,835	18,313	-
UK / Group average	2.31	2.31	0%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	11.3	12.0	+6%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.04 Share of world citations



Data: Thomson Reuters. Analysis: Evidence

Commentary

Papers that are cited more often are generally agreed to have greater influence. It is essential to use relative measures, such as share of world citations, for comparisons because older papers have more citations than more recent ones. Here, there is a decrease in UK cites for current year (42,252) compared to the previous report (45,368) but the 'recent 5-year' average citation count has increased between 2000-04 and 2002-06. This probably indicates a database-year effect. UK research is well-cited with a 12% share in world citations compared to a 9% share in papers. A rise in share suggests good 'immediacy', an indication of UK research being 'picked up' rapidly.

The UK's increase in citation share means that it remains 2nd only to the USA. USA share has fallen to just over one-third of comparator group citations and Japan also falls but other G8 countries have increased citation share. As with output share, Australia and Canada increase their share of citations relative to others in the comparator group. China has not increased its position with regard to citation share, remaining 8th with over 5.5% of world, but its trajectory is impressive. Strong gains in share of world citations have been made by Iran and S Africa, and to a lesser extent, India but south-east Asia has not sustained the growth apparent in previous reports.

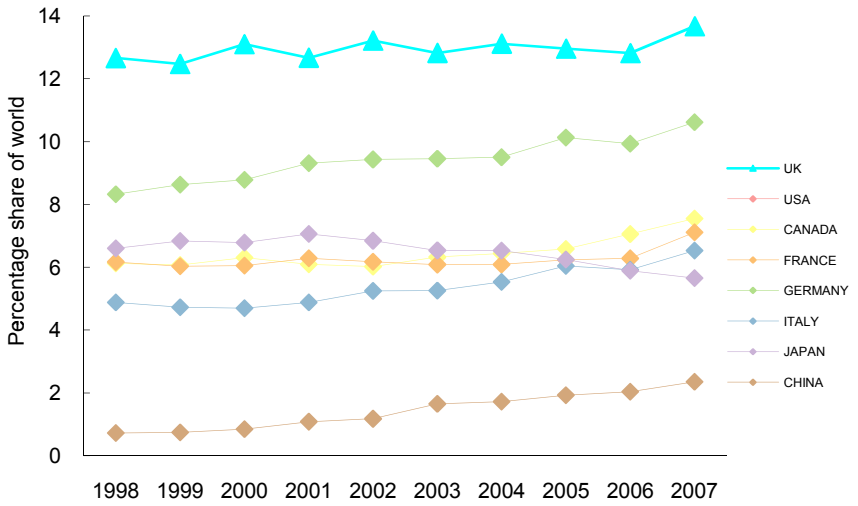
1.05.01 Number and share of world citations in ten main research areas

Table 1.05.01 Total citations to clinical papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	492,964	28,849	-
Group average citations	189,826	11,439	-
UK / Group average	2.60	2.52	-3%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	13.0	13.7	+5%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.01 Share of world citations to clinical papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In clinical sciences, the UK's rank position remains 2nd behind the USA and its underlying performance has improved. Its share of world citations has risen slightly above the 13% of world citations it has maintained over the last decade. Germany has improved most markedly among the G8, remaining 3rd but with share rising by 2.3% and now reaching 10.6% of world. China has trebled its share of world cites over the decade, to 2.35%, but is ranked 14th, while India has doubled its share although remaining below 1% of world. The USA continues to plateau at around 53% while the EU share has grown from below 40% in 1998 to over 43% in 2007.

The chart confirms the positive trend on UK performance, and the rising position of Germany. These two are clearly ahead of the rest of the G8 though Canada has improved markedly compared to the other countries. Japan's position has shown a progressive decline throughout the period and it now trails in the G8. China and India remain at a low level which does not display effectively in this chart.

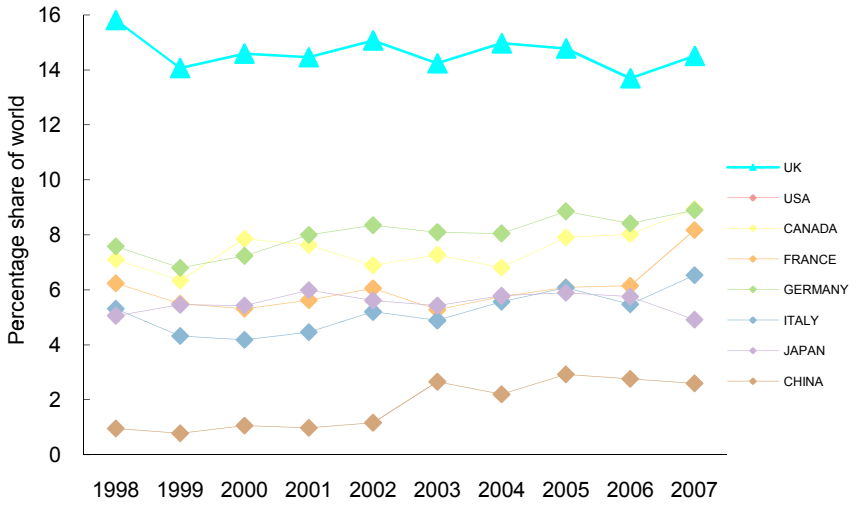
1.05.02 Number and share of world citations in ten main research areas

Table 1.05.02 Total citations to health & medically-related papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	63,699	3,529	-
Group average citations	22,393	1,387	-
UK / Group average	2.84	2.54	-11%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	14.5	14.5	-0%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.02 Share of world citations to health & medically-related papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In health & medically related sciences, the UK remains 2nd behind the USA and its underlying performance has been broadly maintained. UK share of world citations is good, at 14%, and has changed little over the decade. EU countries have increased their share of citations by only a little over the period, and some such as Finland have fallen. EU share remains around 41% while the USA has fluctuated at around 51%, rising to 53% in 2007. China doubled its share of world cites in the middle of the period (2003) but has remained level since and is ranked 13th while Brazil and India doubled their share.

Iran's share has increased ten-fold in a decade while smaller Asian countries were broadly stable. The chart reflects the stable share of citations that the UK has retained over the decade. Other countries have generally increased their share and have gained marginally on the UK in an area of increasing public policy interest. China and India remain at a low level that does not display effectively in this chart.

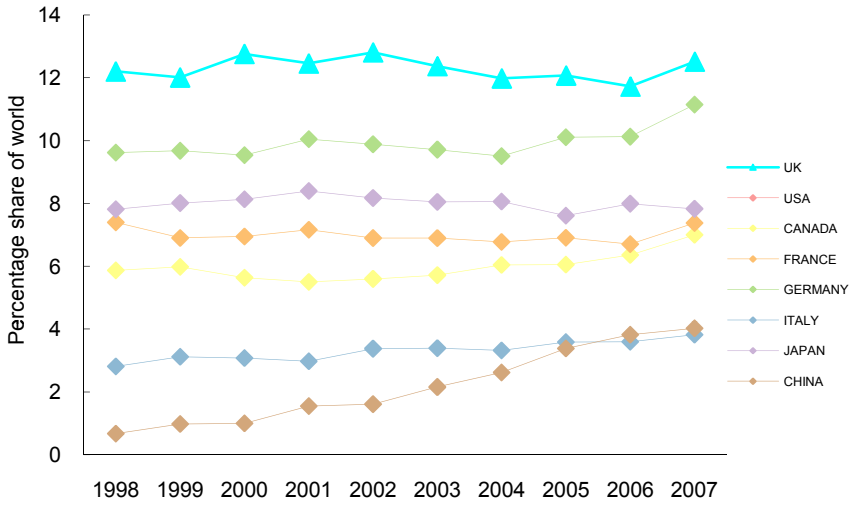
1.05.03 Number and share of world citations in ten main research areas

Table 1.05.03 Total citations to biological sciences papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	203,203	11,109	-
Group average citations	79,931	4,596	-
UK / Group average	2.54	2.42	-5%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.2	12.5	+3%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.03 Share of world citations to biological sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In biological sciences, the UK remains 2nd behind the USA and its underlying performance has been broadly maintained. UK share of world citations has been stable at around 12% in a highly competitive area. It climbed slightly in 2007 to maintain the UK's narrow lead over Germany, which has improved its share from 9.6% to over 11% over the last decade. The USA has fallen from over 51% to less than 48% of world share in the decade while China (ranked 9th) has increased its share from 0.66% to over 4%. Iran has increased ten-fold, India and Brazil have not quite doubled their share and Israel is broadly level over the decade.

Within Europe, individual countries have increased share while the EU itself is roughly level, which is presumably a consequence of increased intra-European collaboration: a similar total output but more collaboration across borders. The chart shows that the UK and Germany are now moving slightly ahead of other G8 countries, excepting the USA (at 48%). Canada is now cited as often as Japan and France, and these three form a small cluster but it is likely that this will be joined by China.

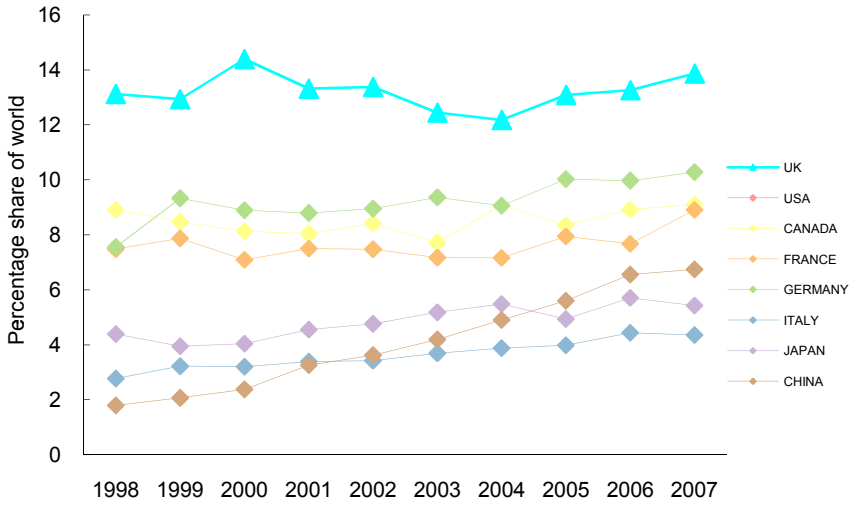
1.05.04 Number and share of world citations in ten main research areas

Table 1.05.04 Total citations to environment papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	47,770	3,322	-
Group average citations	18,709	1,296	-
UK / Group average	2.55	2.56	+0%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.9	13.9	+8%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.04 Share of world citations to environment papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In environmental sciences, the UK's rank position remains 2nd behind the USA. The UK's underlying performance has improved in the last few years, recovering from a dip after 2000, and its share of world cites has risen to 13.9%, up 1% from the recent average. The USA's share has dropped markedly, from 47% in 1998 to less than 42% in 2007. China has shown a marked increase and now has a substantial 6.7% share placing it 6th globally. Germany has also increased its share by a substantial amount while other leading nations, including India, have tended to vary rather little.

The EU share has risen from 40% to 44%, so the low growth in share of individual European countries may suggest rather less collaboration in this area than in some others. The chart reflects the varying performance of the UK, which nonetheless retains a lead over other G8 countries (except the USA). Germany has is slightly but consistently ahead of France and Canada. Japan and Italy lag some way behind these and have now been overtaken by China.

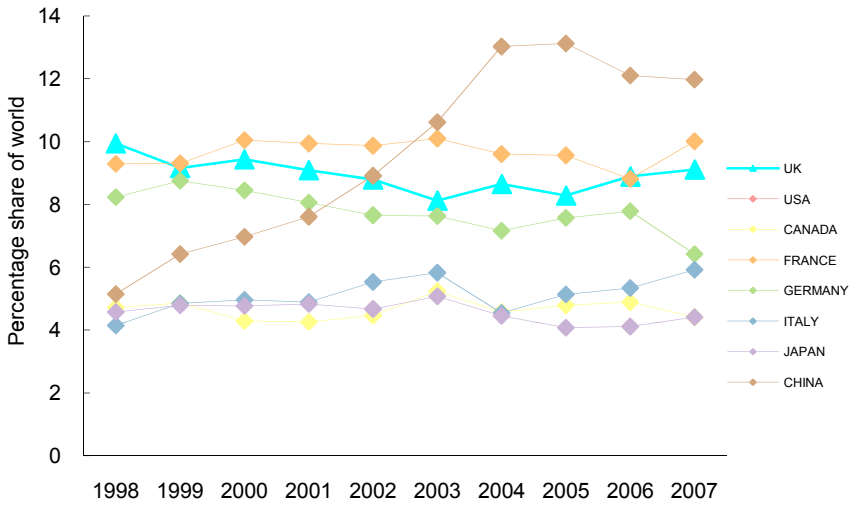
1.05.05 Number and share of world citations in ten main research areas

Table 1.05.05 Total citations to mathematics papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	7,101	436	-
Group average citations	3,785	214	-
UK / Group average	1.88	2.03	+8%
UK rank within Group	4	4	⇔
UK rank within G8	3	3	⇔
UK share of world	8.5	9.1	+7%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.05 Share of world citations to mathematics papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In mathematics, the UK's rank position is 3rd behind the USA and France in the G8 and 4th overall behind also China. The UK's share has increased, however, to 9.1% of world citations. Mathematics citations can be low and volatile and this is a subject area in which the value of citation data has been challenged. However, the data this year are consistent with last year's report when we noted the rapid rise of China, which now has 12% of world citations. China is ranked 2nd behind the USA, whose share has fallen rapidly from 44% to 33% since 1998. This is now much less than the more stable EU share at 42.4%.

India has shown no increase in share but Iran is up to 1.6% - its highest share in any field. A number of countries have fallen back consistently, including Germany, Denmark and Israel while the SE Asian group seem to have peaked. However, output volumes are small and citation shares can change quickly. The UK has recovered from a decline to 2003 while Germany has evidently suffered a progressive decline through to 2007. This puts the UK and France in a leading position in the G8, excepting the USA. The chart shows that China is now just ahead of the leading G8 group.

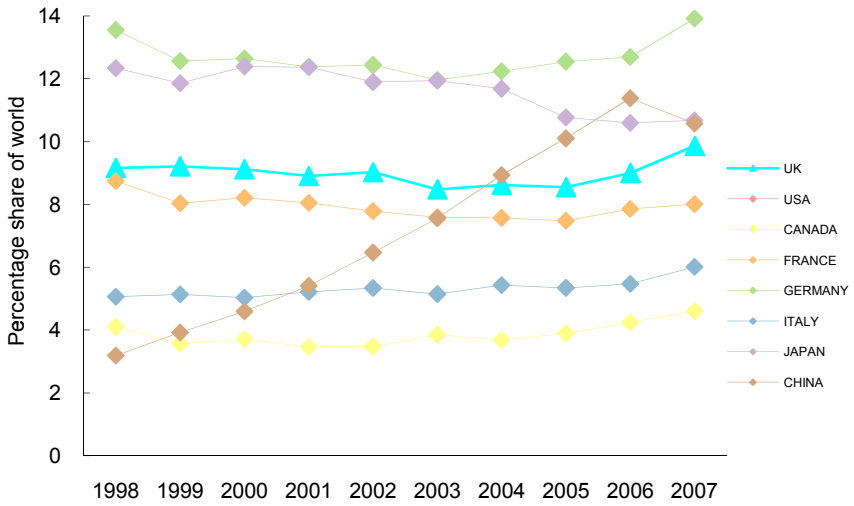
1.05.06 Number and share of world citations in ten main research areas

Table 1.05.06 Total citations to physical sciences papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	162,967	12,417	-
Group average citations	92,172	6,581	-
UK / Group average	1.77	1.89	+7%
UK rank within Group	4	5	⇩
UK rank within G8	4	4	⇔
UK share of world	8.7	9.9	+13%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.06 Share of world citations to physical sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In physical sciences, UK share has improved to 9.9% from a recent 8.7% average and the UK ranks 4th behind the USA, Germany and Japan in the G8 and 5th overall behind also China. This has been a consistently strong area for China and its share is over 10% of world citations, which it has achieved on growth that is substantial yet lower than in some other areas. It ranked 3rd last year but drops back to 4th behind Japan, for which this has also been a key focus. The improvement in the UK position is mirrored by Germany but the USA, on a long downward trend, falls to less than 35% of world citations while the EU is stable in the low 40%s.

The chart shows that UK's recovery from a position and trend that looked worrying in 2003 is now clear and sustained. It looks set to overtake Japan in the near future, which would be a powerful indicator of its relative position. Certainly, it can now be seen in the chart that the UK is moving ahead of France and other G8 countries, though it is some way behind Germany. Among smaller nations, Iran has seen a five-fold increase to 0.72 % while Israel is relatively stable at 1.4%.

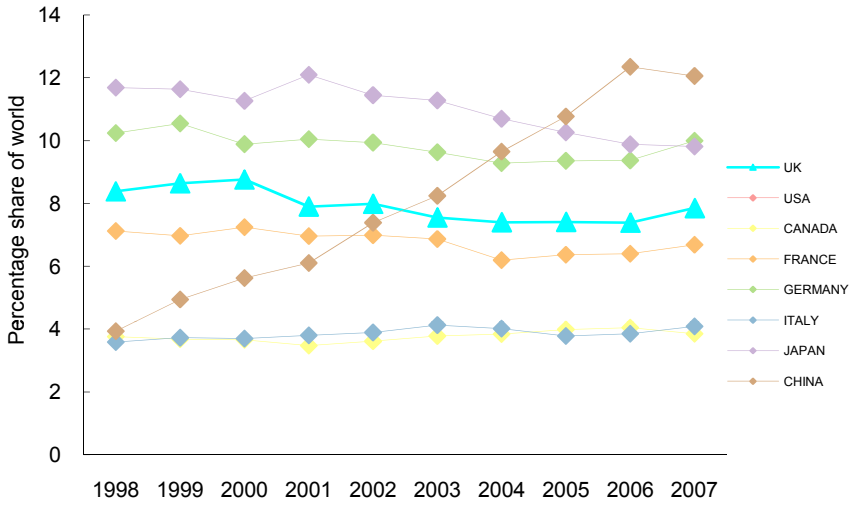
1.05.07 Number and share of world citations in ten main research areas

Table 1.05.07 Total citations to engineering papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	69,218	4,451	-
Group average citations	41,214	2,622	-
UK / Group average	1.68	1.70	+1%
UK rank within Group	5	5	⇔
UK rank within G8	4	4	⇔
UK share of world	7.5	7.8	+4%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.07 Share of world citations to engineering papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. In engineering, the UK's rank position is 4th behind the USA, Germany and Japan in the G8 and 5th overall behind also China. UK share has remained broadly level since 2001, and is now 7.8% which is still below the 8.5% of the 1990s and is a low citation share compared to other subject areas. The USA still leads but its share is down from 38% to just over 30% while China, ranked 2nd, has risen from 4% in 1998 to 12% of world citations in 2007. Despite its investment in steel, India has increased share from only 1.9% to less than 3% while Iran is up to 0.84% and both Singapore and South Korea have doubled share.

The EU is level at about 39% across the decade, with small variations across most individual countries and little clear trend. The chart shows that Germany has now overtaken Japan but more due to the latter's decline while Germany and the UK broadly maintain share in recent years. There has, in fact, been little change in the relative position of the countries displayed.

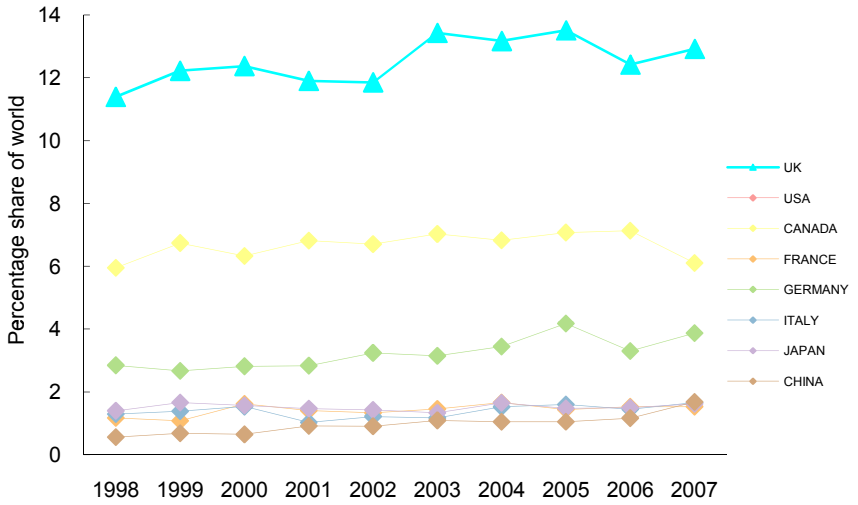
1.05.08 Number and share of world citations in ten main research areas

Table 1.05.08 Total citations to social science papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	14,667	1,029	-
Group average citations	4,842	346	-
UK / Group average	3.03	2.97	-2%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.9	12.9	+0%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.08 Share of world citations to social science papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. Citation data are widely considered to require cautious interpretation in the social sciences. In social sciences, the UK's rank position is 2nd behind the USA with Canada in 3rd place and most other countries well behind. The outcome is a reflection of the balance of records in the database, which in social sciences is only now being populated with more diverse global rather than Anglophone data. Nonetheless, the UK has maintained its relative position against growth in other countries.

The chart confirms that the UK is not only in a good ranked position but is also maintaining its share and relative performance across the period. It has increased its lead over the other G7 countries. The EU total has risen to about 28% but many countries are sparsely represented in the data. China has less investment in this subject area but has increased to about 1.7% of world citations. India has shown little change and other Asian countries remain below 1%.

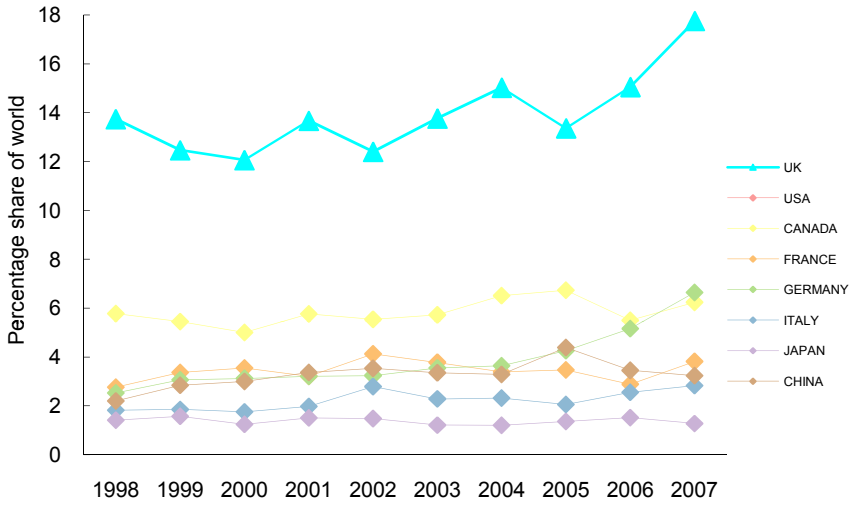
1.05.09 Number and share of world citations in ten main research areas

Table 1.05.09 Total citations to business papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	6,786	489	-
Group average citations	2,301	129	-
UK / Group average	2.95	3.80	+29%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	13.9	17.7	+28%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.09 Share of world citations to business papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. Citation data are widely considered to require cautious interpretation in business as for the social sciences. In business, the UK's rank position is 2nd behind the USA with Canada dropping from 3rd to 4th place behind Germany. The UK's share has risen steeply in 2006 and 2007 which reverses a dip seen in our last report. The USA has seen a marked fall in share from 66% in 1998 to 57% recently. Germany has more than doubled its share and France and Italy have increased by over half.

The chart reflects the strong improvement in UK share of world citations, placing it relatively further ahead of the rest of the G7. Germany has now moved up to place behind the UK and ahead of other countries, but its lag on the UK remains substantial. Other countries are little changed over the period. It is possible that Canada will suffer from the fall-back of the USA and may decline further relative to EU countries. The EU total share is up from 28% to almost 40%, which reflects a consistent improvement pattern across countries. This is an area where China has much less presence than in the natural sciences and its share has risen from around 2% to around 3%.

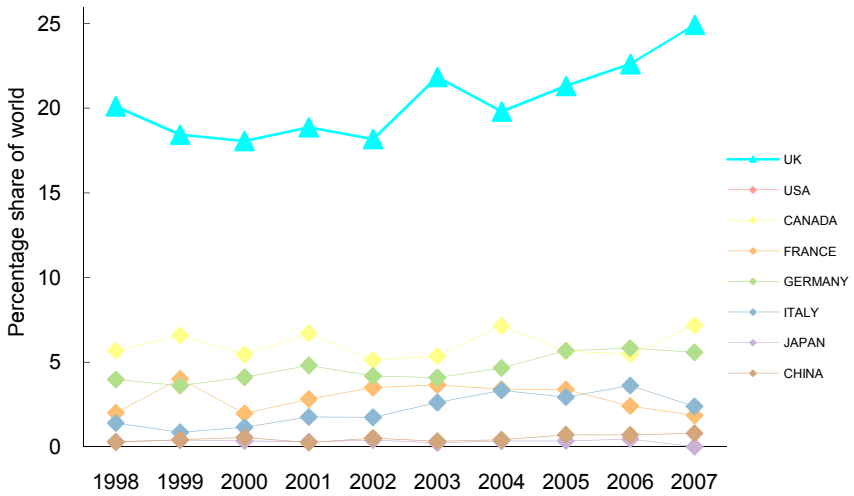
1.05.10 Number and share of world citations in ten main research areas

Table 1.05.10 Total citations to humanities papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
Citations to UK papers	1,325	94	-
Group average citations	387	23	-
UK / Group average	3.42	4.18	+22%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	20.8	24.9	+20%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.05.10 Share of world citations to humanities papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years, so citation share is the critical value. Citation data are widely considered to require very cautious interpretation in the humanities as papers in journal are only one main mode of publication. The UK's rank position is 2nd behind the USA with Canada competing for 3rd place with Germany. Although the database has a strong Anglophone bias, the UK has performed powerfully and consolidated its strong position with an increase in share to almost 25% of world citations and a strong upwards trend over the period. The USA has a falling share, down from 55% in 1997 to 44% in 2007.

The chart confirms the strong upward trend in UK relative performance. Its share is disproportionately large but it has managed to build on and increase that share, bringing it closer to the USA than in any other field. The EU share is up from 30% to 38%, the bulk of which change is due to the UK, Germany and Italy. Some other smaller countries are now better represented in the data than previously and this indicator may show some volatility in the next few years.

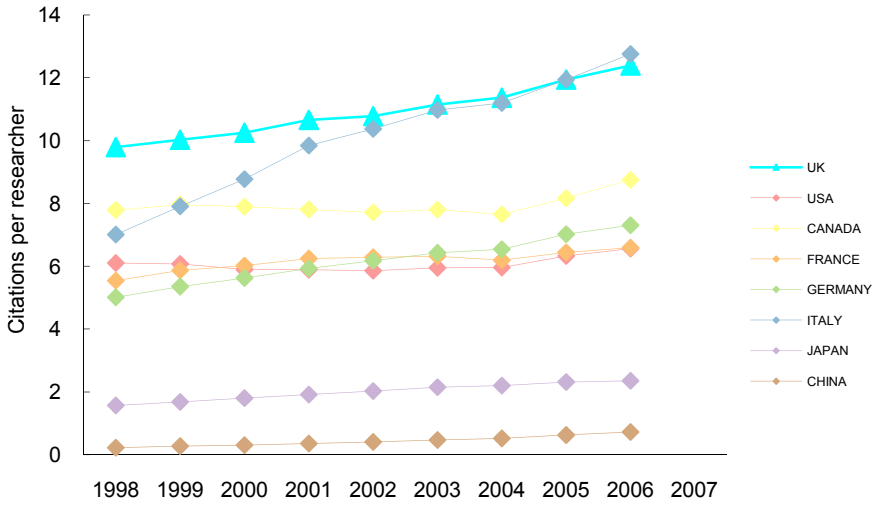
1.06 Citations relative to researchers

Table 1.06 Share of citations relative to share of researchers

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per researcher	11.18	12.38	+0.11
Group average citations per researcher	6.54	7.46	+0.14
UK / Group average	1.71	1.66	-0.03
UK rank within Group	3	4	⇩
UK rank within G8	1	2	⇩
UK share of citations / UK share of researchers	2.54	2.57	+0.01

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 1.06 Citations per researcher



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Where indicator 1.03 concerns output productivity, indicator 1.05 also uses quality, by counting subsequent references to those papers (citations). This indicator indexes citations against numbers of active researchers and the data are combined in moving five-year windows to take account of time-delays in citation accumulation. The UK shows a clear, sustained pattern of improvement over the period, and has a productivity of 12.4 citations per researcher in the most recent year for which data are available (2006). This compares with a slight decline for indicator 1.03, suggesting that whereas the volume of UK output per person may be falling slightly, the quality of the output per person is rising.

The chart shows that France and Germany also continue to improve their numbers of citations per researcher but currently still have a productivity of only about half the UK value. On this indicator, the USA's performance remains relatively stable, rising slightly in the most recent five-year period and remaining just ahead of the European Union. China remains relatively unproductive on this measure but continues to rise. The data for Italy are anomalous, driven by a marked fall in the researcher population.

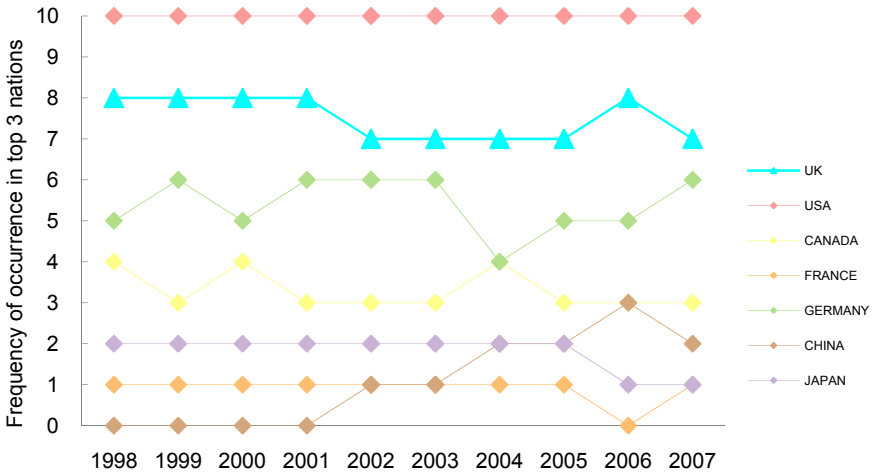
1.07 Rank on citation volume in nine main research areas - frequency of occurrence in top 3 nations

Table 1.07 Frequency of occurrence in top three nations by citation volume

Frequency of occurrence in top 3 comparator group nations	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK	7.2	7.0	⇔
USA	10.0	10.0	⇔
Germany	5.2	6.0	⇧
Japan	1.8	1.0	⇩
Canada	3.2	3.0	⇩
China	1.8	2.0	⇧

Data: Thomson Reuters. Analysis: Evidence

Chart 1.07 Frequency of occurrence in top three nations by citation volume



Data: Thomson Reuters. Analysis: Evidence

Commentary

The indicator shown here extends indicator 1.05 by assessing consistency of performance across the ten main research fields. The national share of world citations by field (indicator 1.05) gives a good measure of research strength in a particular field but does not identify whether countries have strengths across all fields or where there may be isolated peaks. This is acquired by counting the number of times a country is ranked in the top-three (out of 26 countries) across fields. Humanities is now included in this indicator for completeness, but there are obvious uncertainties about the value of national ranked performance in relation to the current Humanities' data.

Seven countries account for the top-three places in all subject areas across the ten-year period. The UK has top-three places across eight subject areas for three years, dropping to seven from 2002 onwards. This puts the UK 2nd overall behind the USA, where citation share is driven by relative historical volume. China moved into this analysis in last year's report with a single top-three place. As predicted then, recent citations to earlier China papers mean that it has improved on this performance and currently appears in the top-three in three subjects for papers published in 2006, dropping to two subjects for 2007. China's increased citation share has displaced Germany (in Engineering), Japan (in Physical Sciences for 2006 only) and the UK/France (Mathematics).

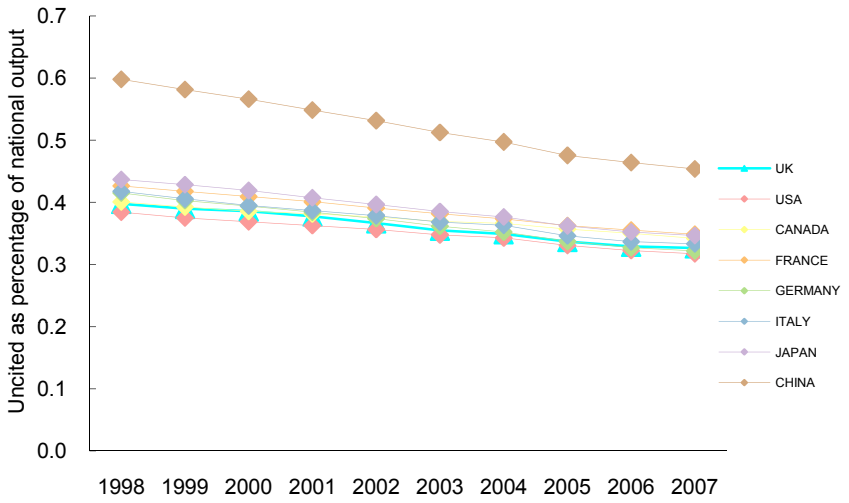
1.08 Proportion and share of uncited papers

Table 1.08 Uncited papers as share of world

	Recent 5 year value (1997-2001)	Recent 5 year value (2002-2006)	Current relative to Recent
UK uncited as percentage of all papers	0.35	0.33	-5%
Group average uncited as percentage of all papers	0.37	0.35	-5%
UK / Group average	0.93	0.93	0%
UK rank within Group	8	9	⇧
UK rank within G8	2	3	⇧
UK uncited as share of world uncited papers	0.08	0.08	-4%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.08 Proportion of uncited papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The status of uncited papers is uncertain so interpretation must be approached cautiously. The UK's proportion of uncited papers has fallen by 5% while its output has risen in the same successive five-year periods, so uncited papers are now a smaller proportion of total. Only the USA and the Scandinavian countries have had a smaller proportion of uncited papers. This year, Germany has decreased its level of uncitedness more rapidly than the UK. The UK has in the past reduced its relative production of uncited papers compared to EU competitors but they are now moving to achieve similar levels. Uncitedness has improved across the EU as a whole by around 1% in successive periods and the proportion uncited is now around 0.35.

In the chart, the trend is downwards at about the same rate for all the G8. Papers are more likely to be cited as time progresses. Thus, the proportion of uncited papers falls with time. This can be taken into account by using fixed, five-year citing 'windows' for each set of papers, which makes citation patterns in the early and late 'windows' comparable. The reason why the five-year windows still show a decline in uncitedness is probably a consequence of rising international collaboration and cross-national citations. The lines not only trend down together but begin to cluster, reflecting the growing overlap in national portfolios.

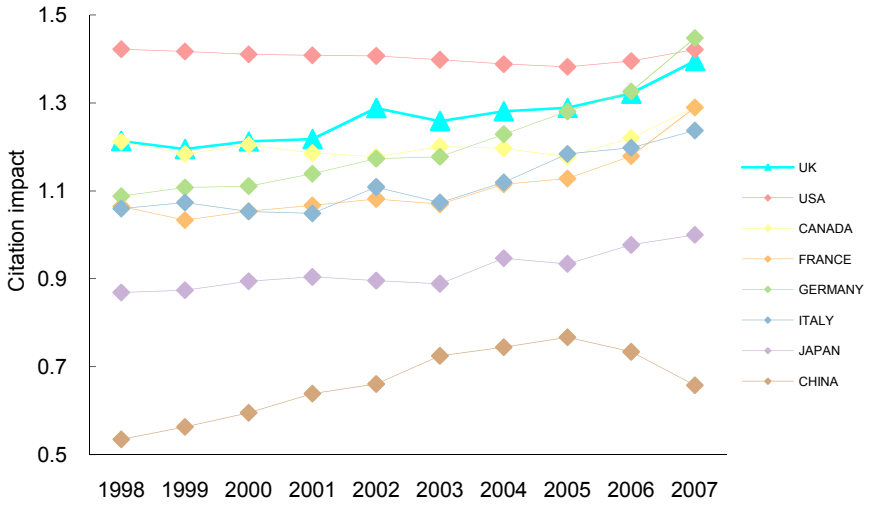
1.09 Citation impact (citations per paper) relative to world baselines

Table 1.09 Citation impact

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.29	1.39	+8%
Group average citation impact	1.02	1.11	+9%
UK / Group average	1.26	1.25	-0%
UK rank within Group	6	7	⇩
UK rank within G8	2	3	⇩

Data: Thomson Reuters. Analysis: Evidence

Chart 1.09 Citation impact



Data: Thomson Reuters. Analysis: Evidence

Commentary

The most frequently used index of research performance is that of impact, measured as citations per paper. This is widely accepted internationally as a research quality index. Because actual impact grows with time, as citations accumulate, the index is normalised (rebased) relative to world average within year (hence, world average becomes 1.0). The UK has improved its citation impact by 8% which is slightly less than the group average improvement of 9% (current relative to recent.) The rebased impact for the UK now stands at 1.39 (i.e.39% above world average). For most of the ten-year period, the UK has been consistently in 2nd place to the USA on this indicator.

On citation impact for the most recently-published papers (to end 2007), Germany has overtaken both the UK and the USA and is in 1st place in the G8 group with an impact at 45% above world average. Interestingly, the rebased citation impact for China's most recently published papers (2006, 2007), decreases relative to world and group baselines. All other countries in the comparator group, with the exception of South Korea, Iran and Taiwan, show increasing rebased impact for papers published in the most recent two years. Top of the whole comparator group for this indicator is Switzerland (recent average impact of 1.59), followed by Denmark and the Netherlands, then the USA. Note that the top three countries have smaller, more specialised research bases than the G8 nations.

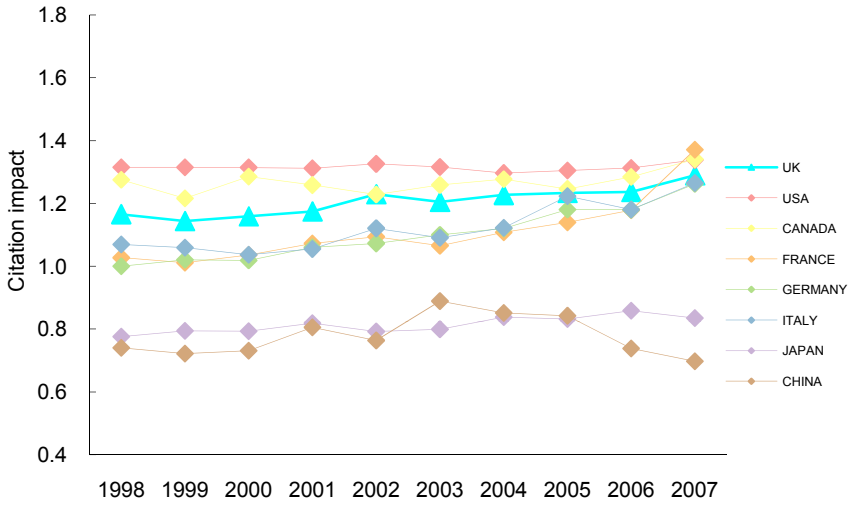
1.10.01 Citation impact relative to world baselines in ten main research fields

Table 1.10.01 Citation impact of clinical papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.23	1.29	+5%
Group average citation impact	1.01	1.12	+11%
UK / Group average	1.21	1.15	-5%
UK rank within Group	7	12	⇩
UK rank within G8	3	4	⇩

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.01 Citation impact of clinical papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. The UK's position in clinical sciences has changed since last year, but the longer-term trends may be a better guide than the 2007 data because of a number of significant changes in performance. For example, France has vaulted from 12th to 6th and Poland from 17th to 5th, while Sweden has dropped from 8th to 15th. The French normalised impact has improved from 1.11 to 1.37, which is substantial but feasible and Sweden's impact is simply static while Poland's index shifts from around 1.05 to 1.44. It will be informative to see if this can be sustained.

The UK's relative impact has risen from 1.17 in 1998 to 1.23 recently and 1.29 in 2007. Within the G8 it lies behind the USA and Canada (both 1.34) and, now, France. Belgium (1.58) has sustained the good performance reported last year and is the world leader ahead of Denmark (1.52) and Switzerland (1.5). The chart shows an improving performance and position for all G8 countries over the period, with the exception of Japan. As a consequence, there is now a tightly bunched group of competitors. Collaboration may, to some extent, influence this bunching, so that differentiation is driven by national but rather marginal papers while high-performing and highly-cited research is held in common.

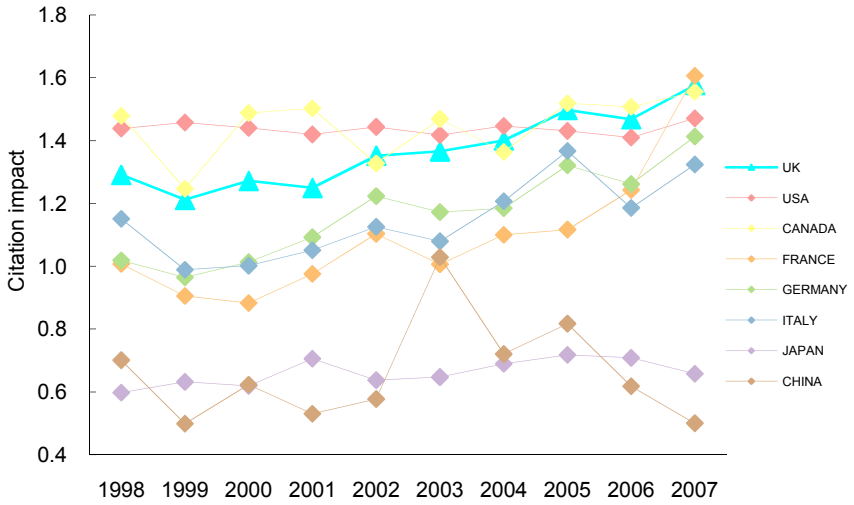
1.10.02 Citation impact relative to world baselines in ten main research fields

Table 1.10.02 Citation impact of health & medically-related papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.42	1.58	+11%
Group average citation impact	1.12	1.33	+18%
UK / Group average	1.26	1.19	-6%
UK rank within Group	7	8	⇩
UK rank within G8	3	2	⇧

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.02 Citation impact of health & medically-related papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. The UK's performance in this area has been noted in several previous reports and is sustained this year, although an exceptional outcome for France (impact up from 1.2 to 1.6) puts it into 2nd place in the G8. It is informative to compare the very stable impact profile if the USA, with its large volume output in this area, with the erratic impact of some of the smaller countries. It is the sudden leap in impact for countries such as Poland (2.91) and Singapore (1.70) that pushes the UK into 8th place overall while it has overtaken Canada in the G8.

Impact has risen in a number of the comparator countries, hence the sharp increase (+18%) in the comparator group average. This may not be sustained in the future. The chart shows a bunching of impact values across the G8, similar to that seen in clinical science. The lower performing countries may be lifted by increased collaboration with the leading research nations and this will make it increasingly difficult to separate the national strands of performance. Nonetheless, the UK remains in a relatively strong position.

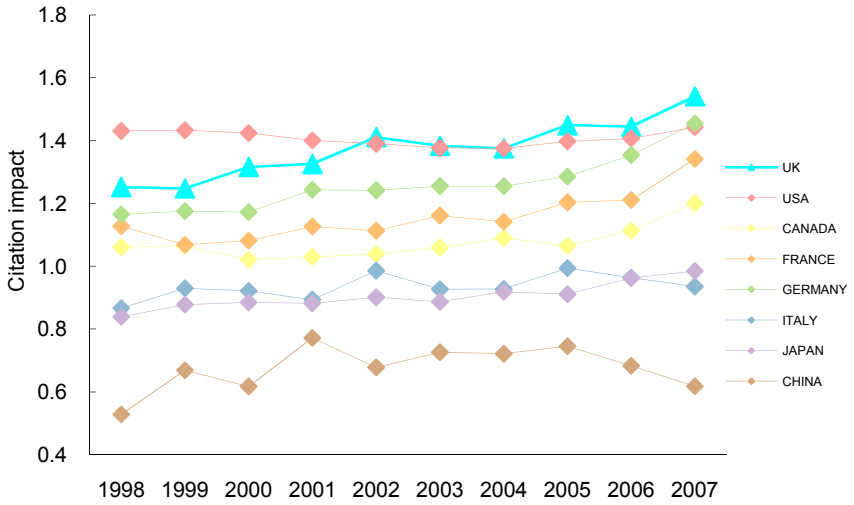
1.10.03 Citation impact relative to world baselines in ten main research fields

Table 1.10.03 Citation impact of biological sciences papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.41	1.54	+9%
Group average citation impact	0.96	1.05	+10%
UK / Group average	1.47	1.47	-1%
UK rank within Group	2	3	⇩
UK rank within G8	1	1	⇔

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.03 Citation impact of biological sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. The UK has the highest impact in the G8 in the biological sciences, having improved from 1.25 relative to world in 1998, 1.41 recent five-year average and to 1.54 in 2007. The UK's position in biological sciences has continued to improve since last year when it first moved ahead of the USA. Although the rank position shows it as 3rd, this is behind long-term world leader Switzerland (1.69) and an erratic boost for Singapore (1.62, but 1.25 recently). This latter outcome may not be sustained; such an anomaly appeared in 2005 and dropped out in 2007.

While Germany, France and the Netherlands have improved, the UK maintains a clear lead over these key European competitors. A surprisingly slow gain in the EU average may indicate concentrated research excellence within the community. China has a flat impact profile in biological sciences, but we have noted in previous reports the diluting effect of rapid expansion. China has not invested heavily in this subject area in the past but its growth is now more evident. The chart confirms the UK's rising trend in performance and its strong position within the G8. The major economies broadly keep pace with the exception of the USA (falling from 1st place to 8th within the comparator group).

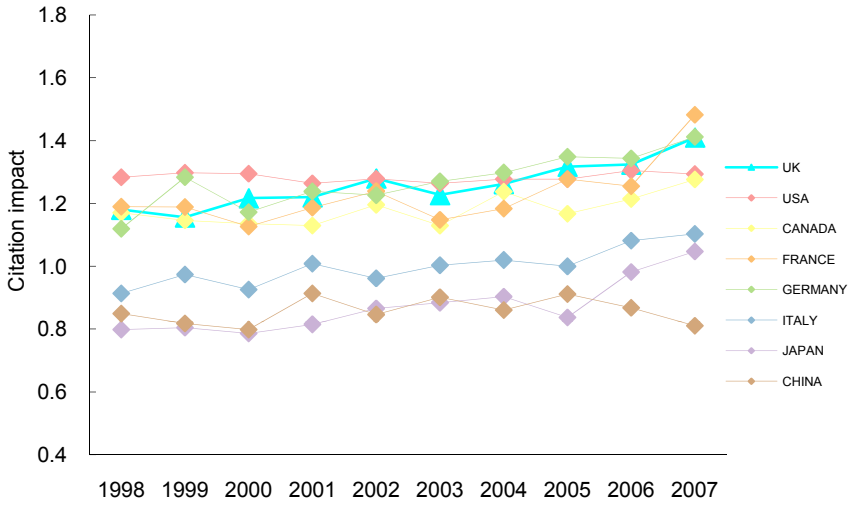
1.10.04 Citation impact relative to world baselines in ten main research fields

Table 1.10.04 Citation impact of environment papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.28	1.41	+10%
Group average citation impact	1.05	1.13	+8%
UK / Group average	1.22	1.24	+2%
UK rank within Group	7	9	⇩
UK rank within G8	2	3	⇩

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.04 Citation impact of environment papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. We have previously noted a rapid increase in research in this subject area consequence upon global policy initiatives and priorities. International collaboration also affects national outcomes, with smaller countries benefitting from participation while larger economies carry a diverse domestic portfolio. The UK's performance has improved in impact (1.4 in 2005 up from 1.28 recently) but slipped in ranking (9th from 7th). The consistent improvement of the UK, Germany and the Netherlands has been bypassed by a sharp rise in impact across the Scandinavian countries.

Whether that will be sustained will wait on next year's report. The unusual rise in French impact (1.48 in 2005 from 1.2 recently), which puts the UK into 3rd place in the G8, may also prove not to be sustainable. The USA has had a steady pattern of performance over the last ten years but it is gradually declining relative to other leading research nations. The chart confirms the UK's consistent improvement in impact over the decade. It has gradually moved ahead of other G8 countries alongside Germany. With the exception of the USA, all these countries have higher impact now than in 1998. The sudden upsurge of France, seen here as in some other subject areas, puts it ahead of the G8.

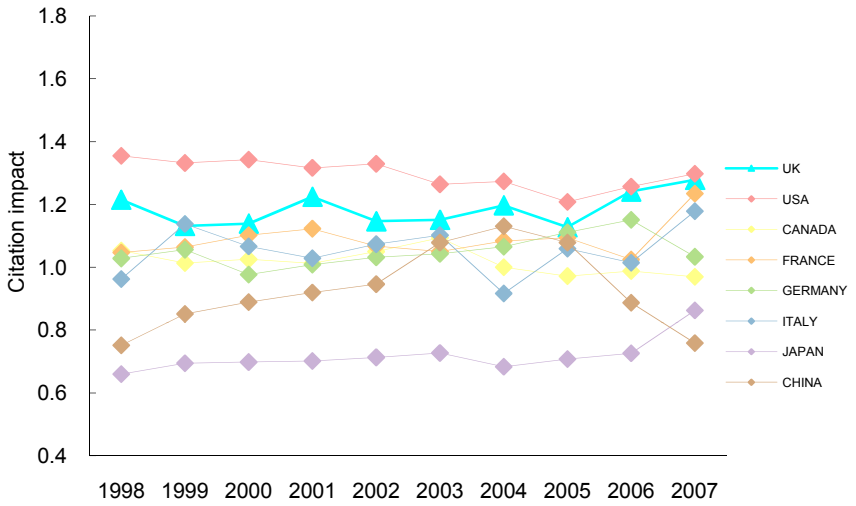
1.10.05 Citation impact relative to world baselines in ten main research fields

Table 1.10.05 Citation impact of mathematics papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.17	1.28	+9%
Group average citation impact	1.03	1.08	+4%
UK / Group average	1.14	1.19	+4%
UK rank within Group	7	7	⇔
UK rank within G8	2	2	⇔

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.05 Citation impact of mathematics papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. Publication output in mathematics can be variable and citation patterns can be volatile. The UK's impact has improved markedly over the last few years (1.28 in 2005 from 1.17 recently) but while the trend is maintained it is not as marked in the current data as it has been in previous reports. By comparison, the USA has improved on last year whereas Germany seems to have suffered a significant relapse. France, Italy and Japan all show a clear upward trend.

The data may require re-examination next year. Denmark has shown an exceptional drop in impact (from 1.52 down to 0.85) while Sweden has shot up (1.17 up to 1.99) with accompanying rank changes. One such change is possible but simultaneous changes in opposite directions would benefit from further examination. The chart shows that the UK has established a strong and consistent position. It has maintained its long-term lead over Germany and is now challenging the USA for a lead in the G8. This is a substantial improvement on the position we reported for mathematics in earlier reports and is excellent news for a key, underpinning subject area.

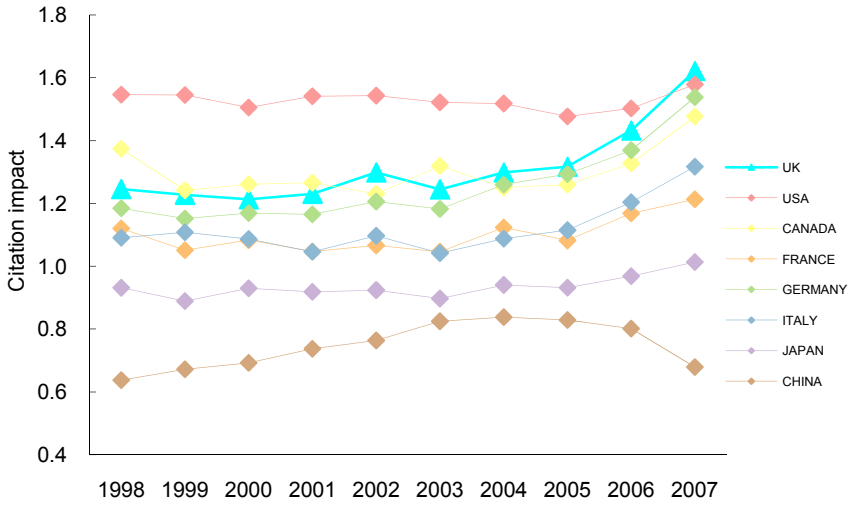
1.10.06 Citation impact relative to world baselines in ten main research fields

Table 1.10.06 Citation impact of physical sciences papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.32	1.62	+23%
Group average citation impact	1.08	1.18	+10%
UK / Group average	1.23	1.37	+12%
UK rank within Group	6	4	⇧
UK rank within G8	2	1	⇧

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.06 Citation impact of physical sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. In the physical sciences, the UK has moved into lead position in the G8 (ahead of the USA at 1.58) and 4th overall with an increase in impact from 1.32 recently to 1.62. The three nations ahead of the UK are Switzerland (1.98), Netherlands (1.81) and Denmark (1.78). All have shown sustained upward trends in performance through the last ten years. Germany has also shown a substantial improvement close behind the UK. Both of these have moved ahead of Canada. The USA, by comparison, the same impact as in 1998 and has lost its substantial lead.

The chart confirms the strong upward trend in performance for the UK and Germany. Given the platform from which the UK has moved in the first half of the period, this is an excellent achievement. China's impact rarely exceeds 0.8 compared to world and India's impact has been consistently less than that. There is some evidence here of convergence in impact values, seen in the clinical sciences but not in biology. The large physics-based international programmes may be drawing countries' performance outcomes together on shared high-impact papers.

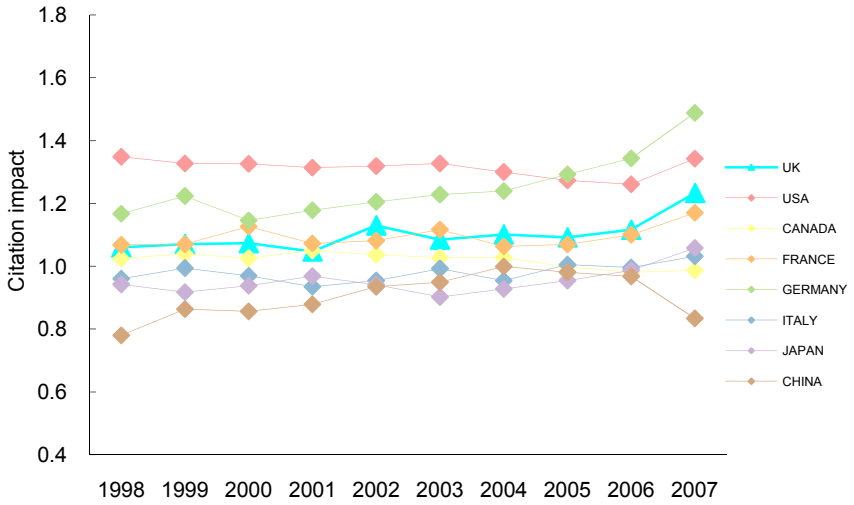
1.10.07 Citation impact relative to world baselines in ten main research fields

Table 1.10.07 Citation impact of engineering papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.10	1.23	+12%
Group average citation impact	1.04	1.10	+6%
UK / Group average	1.06	1.12	+6%
UK rank within Group	10	10	⇔
UK rank within G8	3	3	⇔

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.07 Citation impact of engineering papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. In engineering, the UK has shown a steady improvement in impact over the decade from 1.06 in 1998 to 1.10 recently and 1.23 in 2007. It maintains rank position in the G8 and in the comparator group, but is moving closer to the USA (2nd). The USA slowly declines in impact over the period, with the exception of the upward shift this year. We noted last year that it had been overtaken by Germany, which now has a clear lead in performance. The performance of Japan may be surprising as its technological strengths might be expected to be evident. The other Asian economies also have relatively weak performance, around or below world average.

The chart illustrates the marked rise in German research impact over the decade. The UK has followed a similar track to France, which was noted in the early 1990s as a key European nation in this research area. On present trajectory, the UK and France may well overtake the USA in research performance in the next few years and join Germany as they gradually move away from the rest of the G8. The declining position of the USA is clear and it will be interesting to see whether the upturn in 2007 is sustained or flattens in later data. The impact of China's research continues to improve into the recent period; the drop for the latest year was a pattern noted in our last report. India has yet to make a strong impact in engineering research.

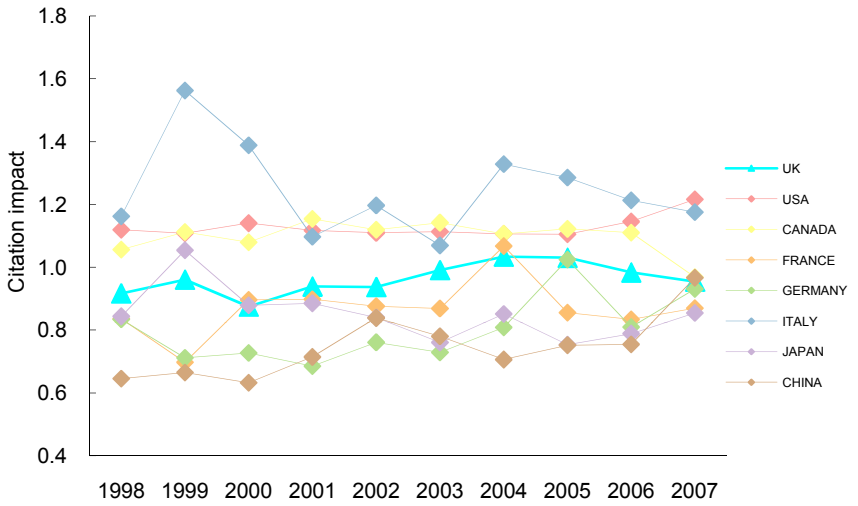
1.10.08 Citation impact relative to world baselines in ten main research fields

Table 1.10.08 Citation impact of social science papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	0.99	0.95	-4%
Group average citation impact	0.94	0.92	-3%
UK / Group average	1.05	1.04	-1%
UK rank within Group	12	13	⇩
UK rank within G8	4	5	⇩

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.08 Citation impact of social science papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. Bibliometric data for the Social Sciences should always be treated with caution. The chart shows marked annual changes, even for larger research economies. The comparisons here are like-for-like, but the database is richer in Anglophone journals and this affects coverage and outcomes. The general down-turn in performance noted - and queried - in our last report has now flattened. The UK's position within the G8 is essentially unchanged, but its general underlying impact has improved although the index shows a slight drop in 2007. Germany has settled after an erratic leap in 2005. The USA has begun to improve after a long plateau.

The chart reveals a more erratic profile for some of the G8 than would be seen in impact trends for the natural sciences. This is a consequence of relatively small data pools for some countries and a lower rate of citation accumulation. Italy is now set into a decline from the 2004 peak but its 1999 'spike' remains a distinctive achievement. Some smaller countries including Belgium, Denmark and Switzerland continue to be strong in social sciences, but Finland and Sweden, which were strong, have sharp, recent falls in performance. The UK's position is calculated relative to the rest of the world, a large part of which is the USA for this indicator. The upward turn for the USA tends to depress the UK outcome.

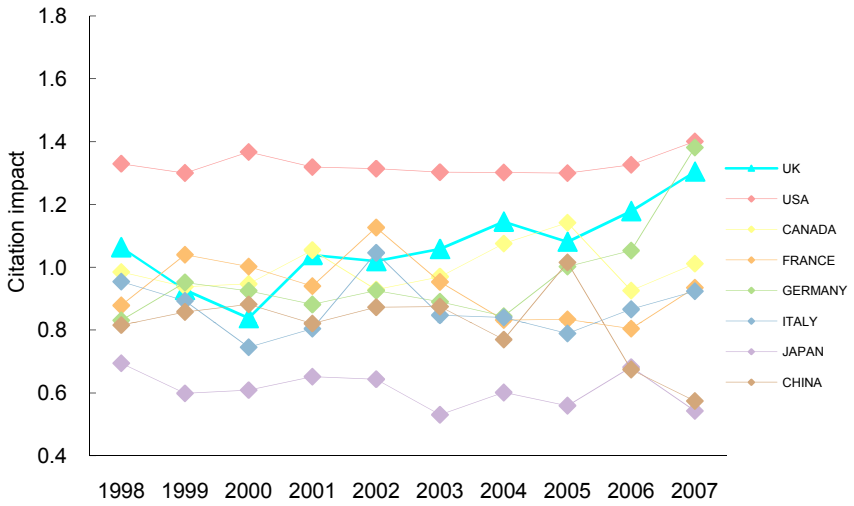
1.10.09 Citation impact relative to world baselines in ten main research fields

Table 1.10.09 Citation impact of business papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.10	1.30	+19%
Group average citation impact	0.89	0.77	-13%
UK / Group average	1.24	1.70	+37%
UK rank within Group	5	3	⇧
UK rank within G8	2	3	⇩

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.09 Citation impact of business papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. As with the Social Sciences, bibliometric analyses applied to Business and related subject areas should be treated with caution. The bibliometric databases are dominated by the USA in particular and Anglophone serials in general. The UK's performance is very good. The downturn in 2005 noted in our last report was temporary and has been succeeded by a continuation of the upwards trend from 2000. The UK's impact in 2007 (1.3) is up by 19% on recent (1.1) where it was below world average in the 1990s. The comparator group average has dropped, so the UK moves ahead of all but the USA and Germany.

Germany has a significant change in profile, which had been falling and now rises steeply. This shift may not be sustained, as Germany's 2005 peak in social science was also temporary, but for the present it is hot on the heels of the USA. The latter country shows a consistent upward swing in the last year of every data series which is never maintained subsequently. The chart shows the UK's strong position, moving away from the G8 pack within which it fell in the 1990s and progressively closing on the USA. The exceptional – perhaps unsustainable – performance of Germany is also clear, from well-below world average to now challenge the USA. The USA's performance is very stable since it effectively 'sets' the world average by its volume dominance.

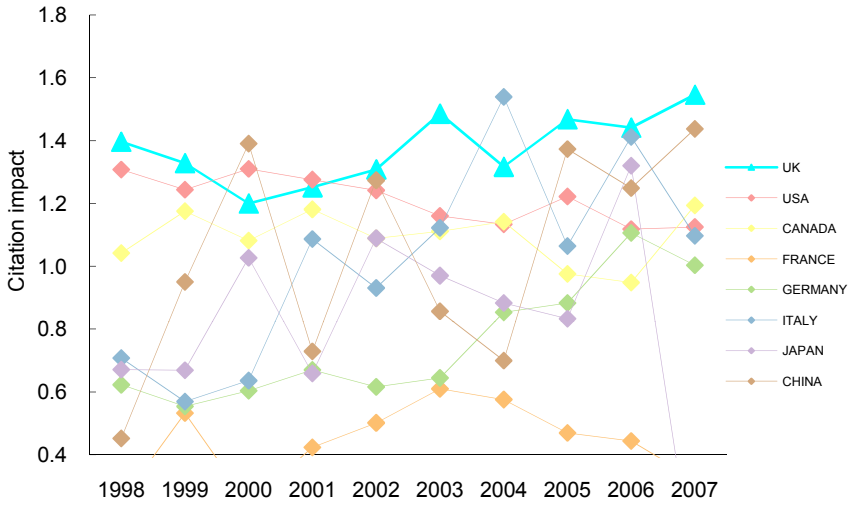
1.10.10 Citation impact relative to world baselines in ten main research fields

Table 1.10.10 Citation impact of humanities papers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK citation impact	1.40	1.55	+10%
Group average citation impact	1.09	1.04	-5%
UK / Group average	1.29	1.49	+16%
UK rank within Group	3	4	⇩
UK rank within G8	1	1	⇔

Data: Thomson Reuters. Analysis: Evidence

Chart 1.10.10 Citation impact of humanities papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Impact (citations/paper) is normalised to world average for year and subject, so world average = 1. Bibliometric data should be treated with great caution when applied to the Humanities because the preferred mode of output is via books rather than serials. Humanities researchers across Europe are reviewing the use of publication-indicators and more informed analyses will become available. The UK's impact and ranked position have improved markedly compared to the recent past and sustain its position, 1st among the G8. Its performance profile compares well with other leading research nations. It improved consistently against the US, overtaking that country in 2002, which suggests that UK research publications are well regarded.

The sound and consistent performance of the UK is evident in the chart. It has moved ahead of the USA, which has continued to decline year on year. The UK's position now lies 3rd or 4th whereas in our last analysis it had moved to 6th from 13th. It may be that as the European Research Area develops in humanities, so the value, utility and impact of UK research is becoming increasingly widely acknowledged. Although Italy has overtaken the UK in one year it tends to an erratic profile. Germany is on an upward trend while the French are far behind, perhaps more firmly attached to traditional, non-journal outputs. Japan shows a slightly erratic profile but it is more consistently in a net upward direction and it seems likely to be part of the leading group in the future.

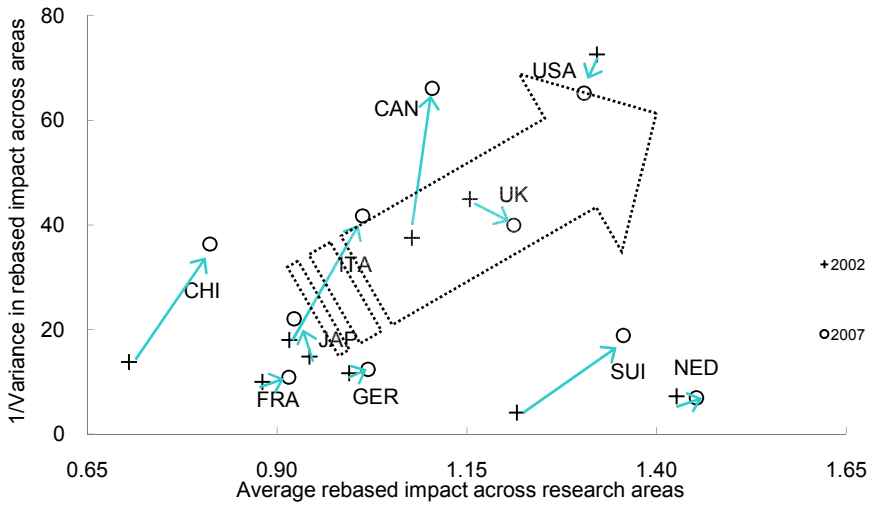
1.11 Variety and consistency of research strength

Table 1.11 Average and variance of rebased bibliometric impact across nine main research areas

	Recent (1998-2002)			Current (2003-2007)			Current/ Recent
	Average	1/Variance	Avg/Var	Average	1/Variance	Avg/Var	Avg/Var
UK	1.2	44.9	51.8	1.2	39.9	48.4	-7%
USA	1.3	72.6	95.9	1.3	65.2	85.0	-11%
CAN	1.1	37.5	40.4	1.1	66.1	73.0	+81%
FRA	0.9	10.0	8.8	0.9	10.8	9.9	+13%
GER	1.0	11.6	11.6	1.0	12.3	12.6	+9%
ITA	0.9	18.0	16.5	1.0	41.7	42.2	+156%
JAP	0.9	14.8	13.9	0.9	22.0	20.3	+46%
NED	1.4	7.2	10.3	1.5	6.9	10.0	-3%
SUI	1.2	4.1	4.9	1.4	18.8	25.6	+418%
CHI	0.7	13.7	9.7	0.8	36.3	29.5	+205%

Data: Thomson Scientific® Inc Analysis: Evidence Ltd

Chart 1.11 Analysis of rebased impact across research areas



Data: Thomson Scientific® Inc Analysis: Evidence Ltd

Commentary

A research economy needs balance between competitive strength and a diversity of competence which contributes to national capacity to appraise research developments in other countries and to respond to research opportunities. High average quality across fields is enhanced by low variation between them. This is desirable because undue concentration of research strength constrains shifts into new areas. Research is long term, capacity takes years to build and not all needs and opportunities can be foreseen. Small nations can also have sharp but narrow peaks of high impact (indicator 1.12). Annual fluctuations in performance for some countries that otherwise perform well – noted in several indicators - are another consequence of lower diversity.

We visualise this characteristic of the research base by looking simultaneously at average impact and the reciprocal of variance across fields (the reciprocal because we are interested in systems that minimise variation). For the UK, high impact is matched with a consistent performance across disciplines, placing the country in the upper, right-hand part of the chart. Its impact improves between early (1998-2002) and late (2003-2007) periods at a slight cost to diversity, so it has improved performance by becoming slightly more specialised. The USA has fallen back on performance and diversity while France, Germany and the Netherlands are unchanged. China has moved up in research diversity as it spreads its investment. The Swiss improve in average performance with increased evenness.

1.12 Papers in top 1% by citation count

Share of papers in top 1% by citation count

Country	Publications in top 1% (pubs.)	Publications as share of Group	Citations to these publications (cites)	Average citations per paper (impact)	Rank by pubs.	Rank by cites	Rank by impact	G8 rank by impact	Country
Finland	178	0.01	9,022	50.69	20	19	1		Finland
Netherlands	760	0.04	38,358	50.47	8	7	2		Netherlands
Sweden	459	0.03	23,161	50.46	13	13	3		Sweden
Poland	180	0.01	8,758	48.66	19	20	4		Poland
Canada	1,062	0.06	50,734	47.77	6	6	5	1	Canada
Spain	564	0.03	26,731	47.40	12	10	6		Spain
Denmark	335	0.02	15,842	47.29	15	15	7		Denmark
Singapore	92	0.01	4,281	46.53	24	24	8		Singapore
India	176	0.01	8,137	46.23	21	21	9		India
UK	2,318	0.13	106,996	46.16	2	2	10	2	UK
Japan	1,215	0.07	55,577	45.74	5	4	11	3	Japan
Switzerland	748	0.04	34,177	45.69	9	9	12		Switzerland
Taiwan	136	0.01	6,181	45.45	23	22	13		Taiwan
Belgium	377	0.02	17,127	45.43	14	14	14		Belgium
South Korea	259	0.02	11,730	45.29	17	17	15		South Korea
USA	10,399	0.60	469,408	45.14	1	1	16	4	USA
Russia	271	0.02	11,960	44.13	16	16	17	5	Russia
Israel	256	0.01	11,285	44.08	18	18	18		Israel
Italy	848	0.05	37,254	43.93	7	8	19	6	Italy
France	1,264	0.07	55,382	43.81	4	5	20	7	France
Germany	2,086	0.12	87,689	42.04	3	3	21	8	Germany
Australia	604	0.04	24,466	40.51	11	12	22		Australia
Brazil	158	0.01	6,161	38.99	22	23	23		Brazil
China	634	0.04	24,578	38.77	10	11	24		China
South Africa	70	0.00	2,676	38.23	25	25	25		South Africa
Iran	12	0.00	263	21.92	26	26	26		Iran
European Union	6,794	0.39	283,088	41.67	0	0	0		European Union

Commentary

Some publications have exceptional citation rates compared to others in their field. Thomson Reuters has found that share of the most cited 1% of world papers is an international indicator of interest. The data cover the five-year period 2002-2006 (not to 2007, because citation counts are low and too variable in the most recent year). The UK has 2,318 papers among the world's most highly-cited 1% by impact with an average impact of 46.16 citations per paper. It lies second in the G8 by volume (where the USA is 1st with 10,399) and impact (where Canada is 1st at 47.77). The UK increased its share, from 12.9% in 2004 through 13.2% in 2005 to 13.4% now. This compares to a recent UK average of around 9% of world sources (indicator 1.01) and reflects its competitive excellence.

The USA remains the clear leader on volume - even by compariosn to the EU colelctively - but Finland remains the leader on average impact (the highest average impact in the top 1% but only 178 papers). Smaller nations (Singapore, 92 papers; Taiwan, 136) have narrow peaks of excellence. [NOTE data counts vary from last year's sample and relativities rather than absolute values should be used in any comparison]

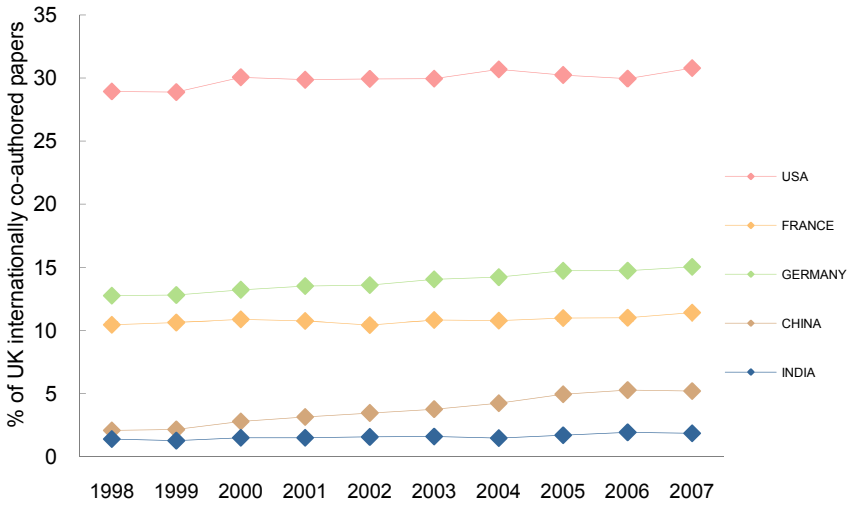
2.01 UK co-authorship for select partner countries relative to total UK co-authorship

Table 2.01 Share of UK internationally co-authored papers

	Recent average 2002-2006	Current value 2007	Current relative to Recent
USA-UK as % UK co-authored papers	30.15	30.79	+1.02
France-UK as % UK co-authored papers	10.80	11.42	+1.06
Germany-UK as % UK co-authored papers	14.27	15.04	+1.05
China-UK as % UK co-authored papers	4.33	5.19	+1.20
India-UK as % UK co-authored papers	1.64	1.85	+1.13
(Partner countries selected by DIUS)			

Data: Thomson Reuters Analysis: *Evidence* Ltd

Chart 2.01 Share of UK internationally co-authored papers



Data: Thomson Reuters Analysis: *Evidence* Ltd

Commentary

International research collaboration is of growing significance as nations seek to share the costs and opportunities of tackling major challenges. Co-authorship is used here as a proxy for collaboration. It does not cover all types of collaboration but is likely broadly to reflect other interactions. The number of the UK's publications that have a non-UK co-author has risen from about 22,500 (31.7% of total output) in 1998 to almost 37,000 (44.6%) in 2007, a rise of about two-thirds in volume and one-third relative to total activity. The volume of co-authorship with every member of the DIUS comparator group has increased, typically by a factor of 3 but fourfold in the cases of China and Iran.

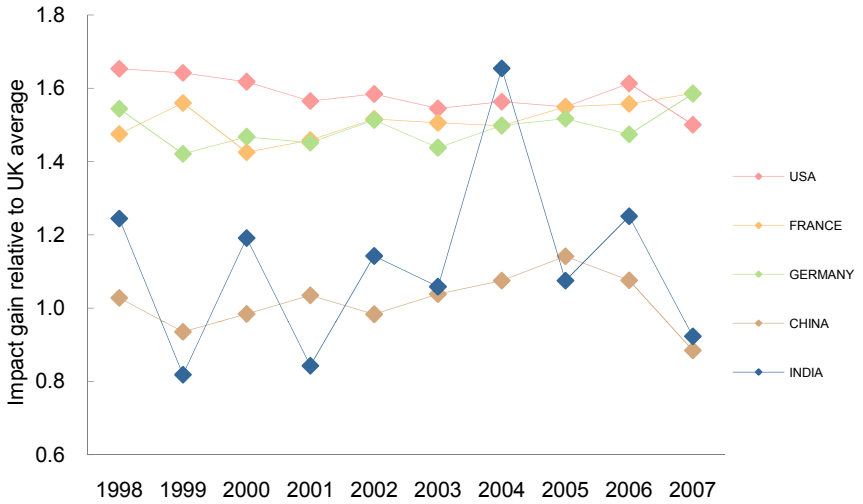
The table and chart shows that the greatest level of collaboration is with traditional research partners in the G8. Collaboration with the USA is relatively stable as a proportion of UK volume but is increasing for EU partners. It has increased by a greater proportion for China (now almost 2,000 papers per year) and India (about 700 papers per year). Increases above average are also recorded for South Africa and for Singapore, S Korea and Taiwan. Collaboration with Brazil has remained relatively low-key thus far but the least increase has been with Israel.

2.02 Impact gain from co-authorship for UK with select partner countries

Table 2.02 RBI for co-authored papers relative to UK RBI

	Recent average 2002-2006	Current value 2007	Current relative to Recent
RBI for USA-UK relative to RBI for UK	1.57	1.50	+0.96
RBI for France-UK relative to RBI for UK	1.53	1.59	+1.04
RBI for Germany-UK relative to RBI for UK	1.49	1.58	+1.07
RBI for China-UK relative to RBI for UK	1.06	0.88	+0.83
RBI for India-UK relative to RBI for UK	1.24	0.92	+0.75

Chart 2.02 RBI for co-authored papers relative to UK RBI



Previous studies have confirmed that co-authored work often tends to be highly-cited work. This is perhaps because there is a cost to collaboration and researchers are more likely to become involved where the prospects of valuable outcomes are high. Shared resources also contribute to creative ventures. The table analyses the recent and current normalised citation impact of papers co-authored with another country to the UK baseline (including collaboration); the chart tracks that 'impact gain' across the last ten years. Historically, the UK has gained most from its collaboration with the USA. That is no longer the case: the UK now has a greater return on collaboration through its EU partnerships

Furthermore, the gain on USA collaborations has actually declined. Collaboration with the USA still produces impact that is 50% higher than the domestic average, but the balance of research leadership may be changing. The greatest returns on collaboration come from smaller partners: Switzerland, Denmark and Belgium, which have high domestic impact in areas of niche strength. Co-authorship with China and India produces outcomes which are often of lower citation impact than the average UK paper and 2007 papers drop below recent impact average. In these instances, the benefits of collaboration may be realised through other outcomes.

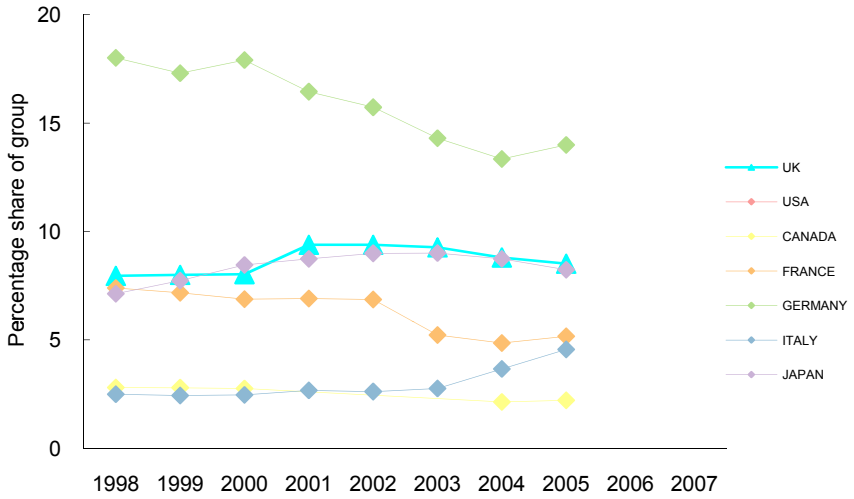
3.01 Number and share of OECD PhD awards

Table 3.01 Doctoral awards

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs	14,028	15,778	+12%
Group average PhDs	10,649	12,090	+14%
UK / Group average	1.32	1.31	-1%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	9.0	8.5	-5%

Data: OECD. Analysis: Evidence

Chart 3.01 Doctoral awards as share of group



Data: OECD. Analysis: Evidence

Commentary

There are now eight years' of OECD Education data for many countries but there are still no data for China, India and some other countries in the comparator group. Canada and some European countries lack complete data for the whole time period. The UK shows an increase in the number of doctoral awards, in common with most nations in the comparator group, the only exceptions being Spain and Sweden. In absolute terms, the UK records as many PhDs awards as Japan, but fewer than either Germany or the USA. Its share of the group total has fallen slightly and is below its share of papers although some countries are missing from this data-set.

Both France and Germany appear to have reversed their recent decline in PhD awards as share of group. The UK and Japan, although still declining, have still not lost as much share of group doctoral awards as these countries. The data indicate that Italy has increased its share of group doctoral awards by more than 60% and nearly doubled the number of PhDs trained in the current year as compared to the recent 5-year average; this seems a disproportionate change and will need verification in later censuses. Across the EU as a whole, there was a roughly 50% increase in PhD awards since 1998, to 95,000 in 2005 compared to 53,000 for the USA.

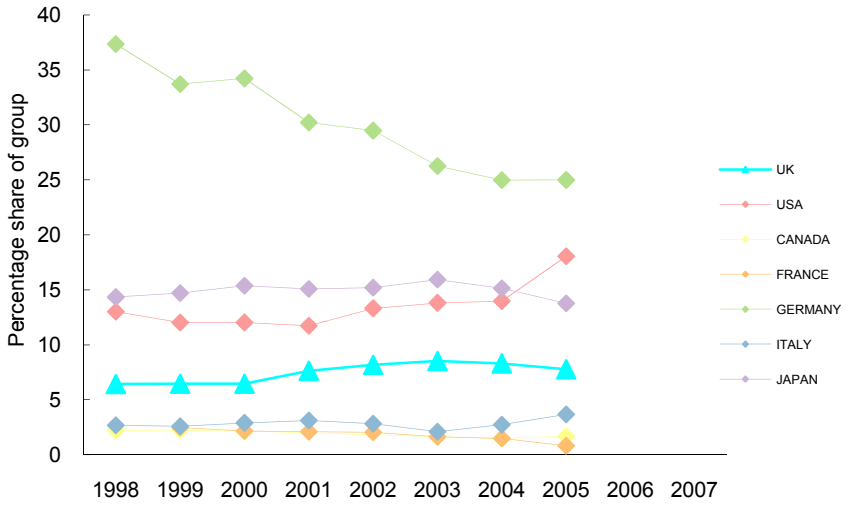
3.02.01 Number and share of OECD PhD awards in five main research areas

Table 3.02.01 Doctoral awards in medical sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs	2,218	2,669	+20%
Group average PhDs	2,084	2,482	+19%
UK / Group average	1.06	1.08	+1%
UK rank within Group	4	4	⇔
UK rank within G8	4	4	⇔
UK share of group	7.8	7.8	-1%

Data: OECD. Analysis: Evidence

Chart 3.02.01 Doctoral awards in medical sciences as share of group



Data: OECD. Analysis: Evidence

Commentary

This indicator measures the UK's share of PhDs for each of five main research areas, and is a disaggregation of the data used in Indicator 3.01. It is the first time that we have reported these data at subject level. Highly-skilled people are the key output from the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of group allows for comparison with other input and output measures (e.g. indicators 5.07 and 5.08). The OECD Education database contains eight years' of data for many countries but still no data for China, India and some other countries in the comparator group. Canada and some European countries do not have complete data for the whole time period.

OECD Medical Sciences include both clinical and pre-clinical areas including nursing and health. In this research area, the UK has maintained its share of group PhDs (at 8%), and increased its absolute output to 2669 in 2005. It has been in 4th place within both the G8 and the comparator group as a whole over the eight-year period. Top of the group, but falling steadily over the period, is Germany followed by Japan and then the USA which overtook Japan for the first time this year.

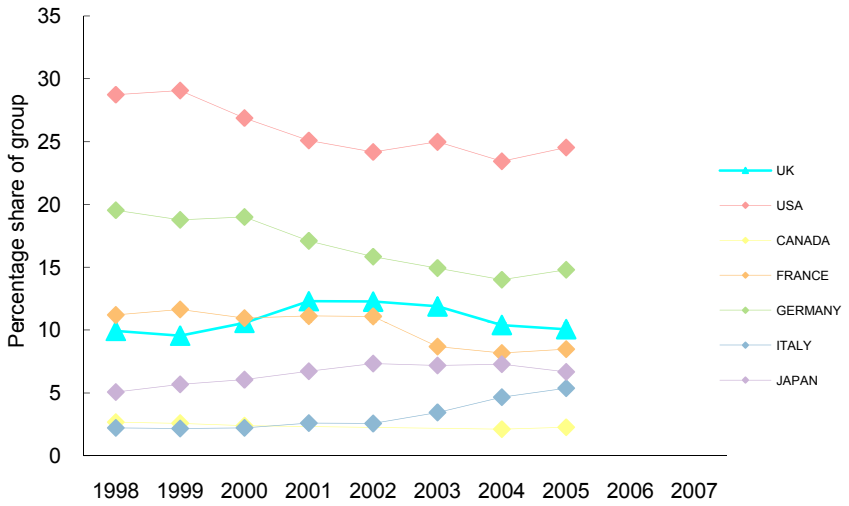
3.02.02 Number and share of OECD PhD awards in five main research areas

Table 3.02.02 Doctoral awards in natural sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs	5,283	5,304	+0%
Group average PhDs	3,140	3,417	+9%
UK / Group average	1.68	1.55	-8%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	11.5	10.1	-12%

Data: OECD. Analysis: Evidence

Chart 3.02.02 Doctoral awards in natural sciences as share of group



Data: OECD. Analysis: Evidence

Commentary

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OECD Natural Sciences includes biological, physical, environmental and agricultural fields. In this research area, the UK's share of comparator group PhDs rose slightly in 2001/2002 but has since fallen so its share remains at 10.5% of comparator group representing an annual output, in 2005, of 5304 PhDs. The UK remains in third place within both the G8 and the whole comparator group behind the USA and Germany, which both show a fall in share. Italy and some smaller European countries have increased their training output.

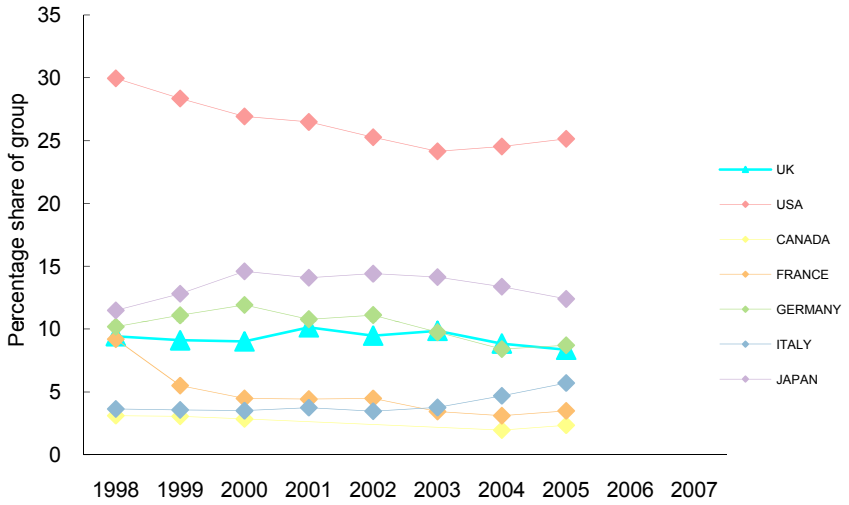
3.02.03 Number and share of OECD PhD awards in five main research areas

Table 3.02.03 Doctoral awards in engineering and technology

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs	2,103	2,252	+7%
Group average PhDs	1,496	1,706	+14%
UK / Group average	1.41	1.32	-6%
UK rank within Group	4	5	⇩
UK rank within G8	4	4	⇔
UK share of group	9.5	8.4	-12%

Data: OECD. Analysis: Evidence

Chart 3.02.03 Doctoral awards in engineering and technology as share of group



Data: OECD. Analysis: Evidence

Commentary

This indicator measures the UK's share of PhDs for each of five main research areas, and is a disaggregation of the data used in Indicator 3.01. It is the first time that we have reported these data at subject level. Highly-skilled people are the key output from the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of group allows for comparison with other input and output measures (e.g. indicators 5.07 and 5.08). The OECD Education database contains eight years' of data for many countries but still no data for China, India and some other countries in the comparator group. Canada and some European countries do not have complete data for the whole time period.

In Engineering and Technology, the UK's produces rather more than 2000 PhDs per year. This is the only one of the five research areas in which the UK has decreased its rank within the comparator group for share of PhDs (falling behind South Korea) although the UK's absolute output has remained stable over the period. It has been consistently behind the USA and Japan but now has a similar output to Germany. These are the major training nations in this field.

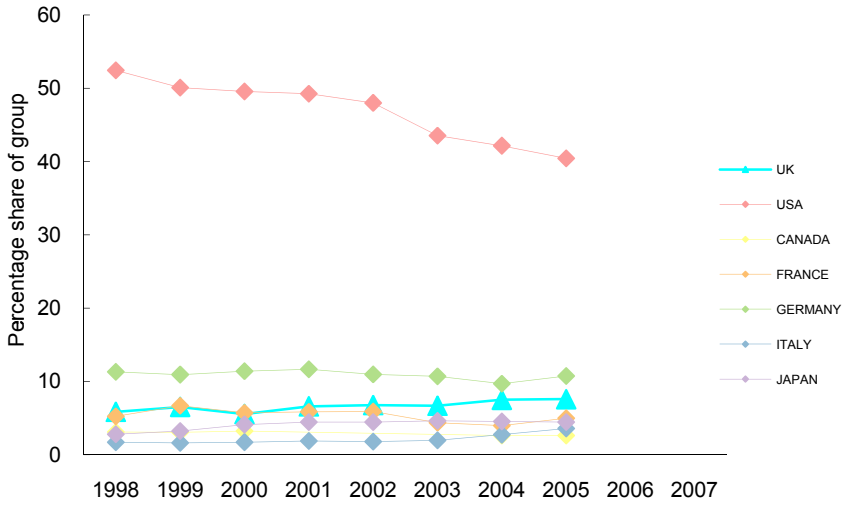
3.02.04 Number and share of OECD PhD awards in five main research areas

Table 3.02.04 Doctoral awards in social sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs	2,516	3,446	+37%
Group average PhDs	2,605	2,991	+15%
UK / Group average	0.97	1.15	+19%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	6.6	7.6	+15%

Data: OECD. Analysis: Evidence

Chart 3.02.04 Doctoral awards in social sciences as share of group



Data: OECD. Analysis: Evidence

Commentary

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OECD Social Sciences includes the business and management fields. The UK's absolute output shows a 37% increase (nearly 1000 PhDs) between the current value and the recent five-year average. The UK remains in third place in this research area for this indicator, behind Germany and the USA. Other countries with a significant increase in share of Social Science PhDs are Italy, Denmark, Poland and Israel. The USA share has a massive share compared to other fields, but this has fallen steadily over the period from over 50% of the comparator group to just above 40%.

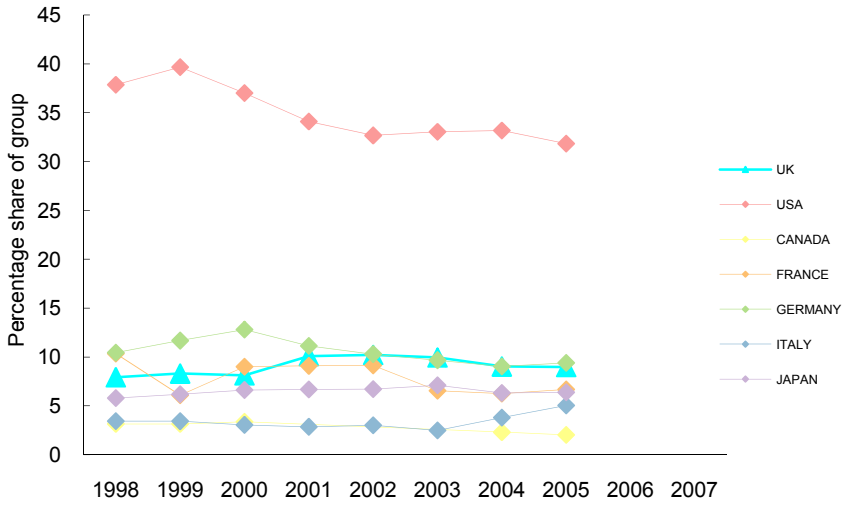
3.02.05 Number and share of OECD PhD awards in five main research areas

Table 3.02.05 Doctoral awards in humanities

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs	1,854	2,094	+13%
Group average PhDs	1,302	1,474	+13%
UK / Group average	1.42	1.42	-0%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	9.5	9.0	-5%

Data: OECD. Analysis: Evidence

Chart 3.02.05 Doctoral awards in humanities as share of group



Data: OECD. Analysis: Evidence

Commentary

This indicator measures the UK's share of PhDs for each of five main research areas, and is a disaggregation of the data used in Indicator 3.01. It is the first time that we have reported these data at subject level. Highly-skilled people are the key output from the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of group allows for comparison with other input and output measures (e.g. indicators 5.07 and 5.08). The OECD Education database contains eight years' of data for many countries but still no data for China, India and some other countries in the comparator group. Canada and some European countries do not have complete data for the whole time period.

In the Humanities, the UK's absolute output shows a 13% increase between the current value and the recent five-year average, broadly in line with the comparator group average. The UK remains in third place in this research area behind the USA and just behind Germany. The USA share, which is exceptionally large, has fallen steadily over the period from over 38% to just above 32%.

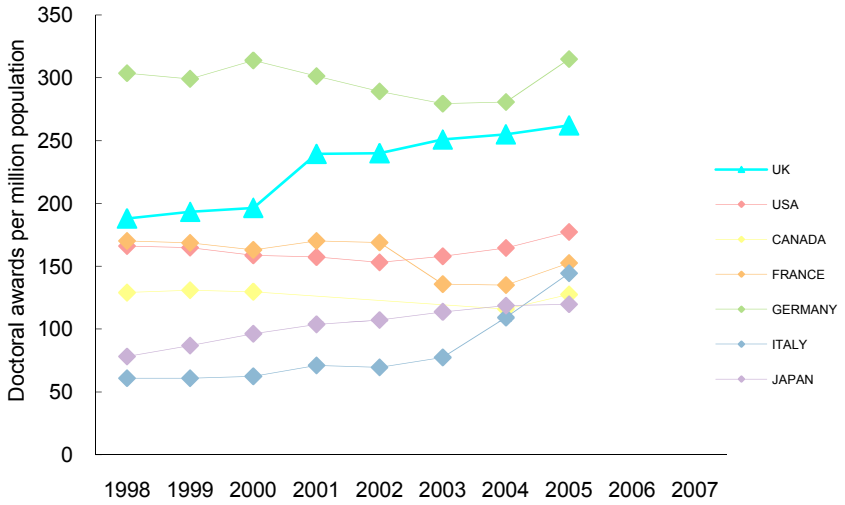
3.03 PhDs awarded relative to population

Table 3.03 Share of doctoral awards relative to share of population

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs per million population	236.29	262.01	+0.11
Group average PhDs per million population	215.69	233.71	+0.08
UK / Group average	1.10	1.12	+0.02
UK rank within Group	5	5	⇔
UK rank within G8	2	2	⇔
UK share of PhDs / UK share of population	3.83	3.73	-0.03

Data: OECD. Analysis: Evidence

Chart 3.03 Doctoral awards per million population



Data: OECD. Analysis: Evidence

Commentary

The numbers of PhDs awarded relative to population size as a whole is a broad measure of the relative training capacity and productivity of different nations. Within the comparator group, the USA, Germany, UK and Japan each award more than twice as many PhDs as any other country for which data are currently available (indicator 3.01). Relative to population however, only Germany maintains its position in the top four, where it is joined by Finland, Sweden and Switzerland. The UK shows an increase of 11% in doctoral awards per million population and continues to advance steadily away from the comparator group and EU average throughout the period.

Italy, Israel and S Korea show the greatest increases in relative productivity of PhDs awarded and now train as many PhDs per head of population as the USA. Australia currently awards almost as many PhDs relative to its population as the UK and Germany whereas Canada performs poorly on this measure with only around half as many. There are no data on this indicator for Brazil, China or India

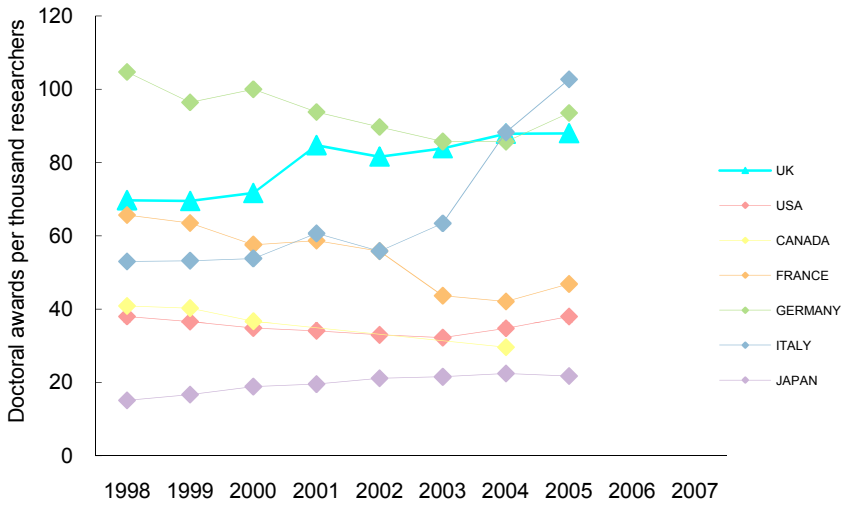
3.04 PhDs awarded relative to researchers

Table 3.04 Share of doctoral awards relative to share of researchers

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhDs per thousand researchers	81.94	87.96	+0.07
Group average PhDs per thousand researchers	59.51	60.03	+0.01
UK / Group average	1.38	1.47	+0.06
UK rank within Group	4	4	⇔
UK rank within G8	2	3	⇩
UK share of PhDs / UK share of researchers	2.65	2.60	-0.02

Data: OECD. Analysis: Evidence

Chart 3.04 Doctoral awards per thousand researchers



Data: OECD. Analysis: Evidence

Commentary

Doctoral awards relative to current researcher population is an indicator of renewal and sustainability. The UK shows an increase in doctoral awards per thousand researchers since 1998. However, the recent average figure includes data for 2000, before HESA changed its data collection process in 2001, effectively reducing the count of UK researchers. Nonetheless, the UK remains ahead of the comparator group average by almost 50% and is still improving its relative position. Within the G8, it has a similar performance to Germany (the Italy data are anomalous).

S Korea is the only non-Western nation in the dataset and maintains a steady output of around 50 PhDs awarded per thousand researchers. The USA, after declining in relative productivity in the early part of the decade, is now producing a similar number of PhDs awarded per researcher as its output in 1998. Both Germany and France suffered a decline early in the period and, whereas this levelled out for Germany, France is now almost 50% down on its 1998 position. There are no current data for researchers for Switzerland so it is not possible to ascertain whether this nation has maintained its global lead.

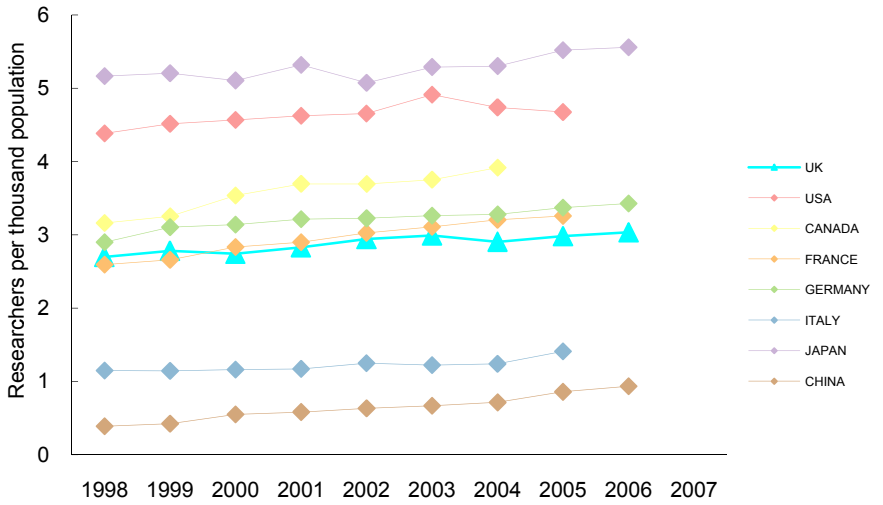
4.01 Researchers relative to population

Table 4.01 Share of researchers relative to share of population

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Researchers per thousand population	2.93	3.03	+0.04
Group average Researchers per thousand population	3.59	3.97	+0.10
UK / Group average	0.82	0.76	-0.06
UK rank within Group	16	11	⇧
UK rank within G8	7	4	⇧
UK share of researchers / UK share of population	1.45	2.10	+0.45

Data: OECD. Analysis: Evidence

Chart 4.01 Researchers per thousand population



Data: OECD. Analysis: Evidence

Commentary

The numbers of researchers in the population as a whole provides a measure of the capacity of each country with regard to research and innovation and may be a partial indicator of the technological orientation of the country. Researchers represent around 0.36% of the total population in the (24) countries in the comparator group for which data are available. This percentage which has been rising consistently throughout the period since 1998. The UK researcher population has increased from 158,000 in 1998 to 180,000 in 2006 but the researcher density is only about 0.8 of comparator group average.

All countries in the comparator group for which 2006 data for researchers are available have an increase in relative density of researchers per thousand population, with the exception of Russia. The UK has made less gain than the EU average (4% compared to 9% increase) where increases are led by Spain and the Netherlands. S Korea, Taiwan and China have made the greatest gains in researchers per thousand population. In 2006 and in absolute terms, China had almost as many researchers as did the EU and both lag slightly on the USA.

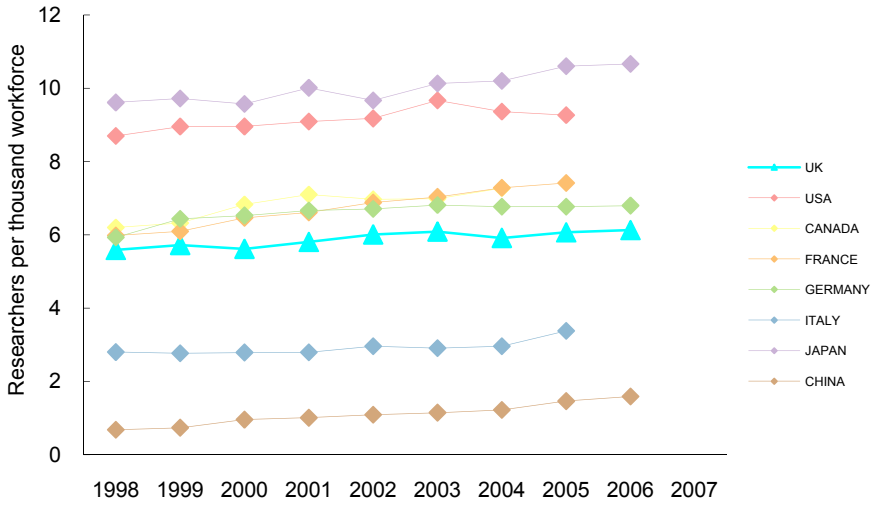
4.02 Researchers relative to workforce

Table 4.02 Share of researchers relative to share of workforce

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Researchers per thousand workforce	5.98	6.13	+0.03
Group average Researchers per thousand workforce	7.21	7.79	+0.08
UK / Group average	0.83	0.79	-0.05
UK rank within Group	15	11	⇧
UK rank within G8	7	4	⇧
UK share of researchers / UK share of workforce	1.59	2.31	+0.45

Data: OECD. Analysis: Evidence

Chart 4.02 Researchers per thousand workforce



Data: OECD. Analysis: Evidence

Commentary

The 2006 OECD researcher data are missing for the USA, Canada, France and Italy among the G8 group. Consequently, the apparent gains in ranked position are due to missing data; they do not reflect the position in reality. The UK position is clear. It has a broadly stable position across the last decade and remains relatively low ranked: that is to say; it has rather fewer researchers within the workforce than its competitors. As with Indicator 4.01, the UK's relative capacity is similar to that of Germany and Japan, but lower than many of the comparator group including the Netherlands and Spain.

Outside the G8 S Korea, Taiwan and China have made the greatest gains in relative research workforce capacity. As noted in 2007, the south-east Asian nations, excluding China, have more researchers per thousand workforce than the UK. Countries with less than 0.5% workforce as researchers include China, Poland, Italy and South Africa. China is likely gradually to improve its position but will lag on this indicator for the foreseeable future.

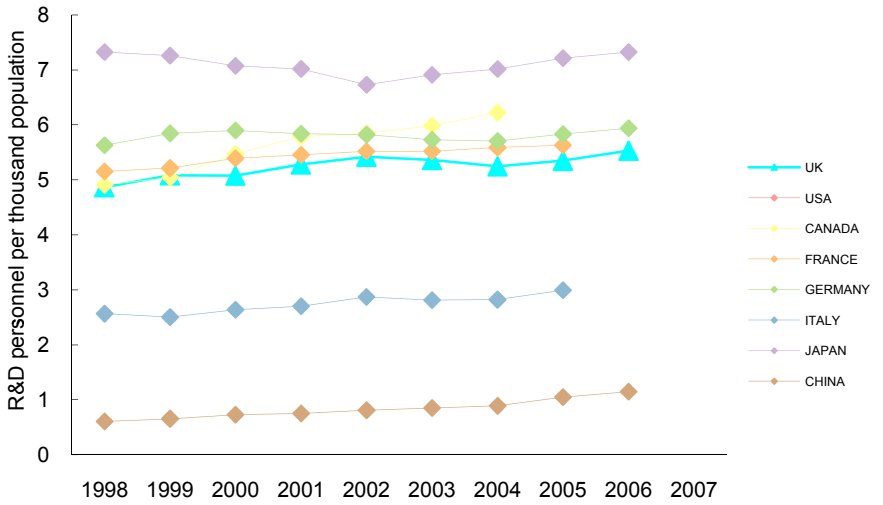
4.03 R&D personnel relative to population

Table 4.03 Share of R&D personnel relative to share of population

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK R&D personnel per thousand population	5.33	5.53	+0.04
Group average R&D personnel per thousand population	5.59	6.03	+0.08
UK / Group average	0.95	0.92	-0.04
UK rank within Group	14	10	⇧
UK rank within G8	6	4	⇧
UK share of R&D Personnel / UK share of population	2.37	2.63	+0.11

Data: OECD. Analysis: Evidence

Chart 4.03 R&D personnel per thousand population



Data: OECD. Analysis: Evidence

Commentary

R&D personnel is a more general measure of research capacity than the 'researchers' analysed in indicators 4.01 and 4.02. There are no data for the USA or India. The number of UK R&D personnel as a proportion of total population has increased by 20 per thousand population between the recent 5-year average and the most recent year, 2006. However, this is less than the gain seen within both the European Union and the comparator group as a whole. The leader within the EU is Finland with more than twice as many R&D personnel per thousand population as the UK. The improvement in rank in the latest year is a consequence of missing data for some countries.

The chart shows that the UK has a similar profile to France and Germany. The Scandinavian nations have more and Spain has relatively fewer R&D personnel than the UK but the latter shows the strongest growth within Europe. Similar growth is seen in south-east Asia among S Korea, Singapore and Taiwan. China continues to show strong relative growth from its very low base and huge population of, almost doubling research capacity in the 10-year period, from 0.06% to 0.11% of the total population.

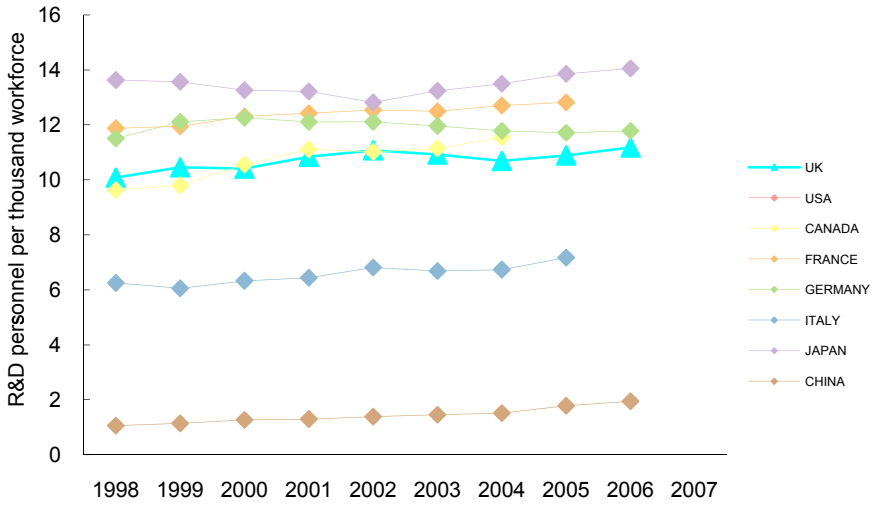
4.04 R&D personnel relative to workforce

Table 4.04 Share of R&D personnel relative to share of workforce

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK R&D personnel per thousand workforce	10.88	11.18	+0.03
Group average R&D personnel per thousand workforce	11.27	11.89	+0.06
UK / Group average	0.97	0.94	-0.03
UK rank within Group	13	10	⇧
UK rank within G8	6	4	⇧
UK share of R&D Personnel / UK share of workforce	2.60	2.88	+0.11

Data: OECD. Analysis: Evidence

Chart 4.04 R&D personnel per thousand workforce



Data: OECD. Analysis: Evidence

Commentary

There are no data for the USA. The UK with R&D personnel around 1% of workforce trails most competitors, and has been overtaken by Canada, although actual indicator values do not vary greatly across most of the comparator group. Within the G8, Japan and Russia lead the group with more R&D personnel per thousand workforce than other nations. For Russia, however, this continues to, decline over the 10-year period. Within the EU, Finland and Sweden continue to lead with R&D personnel in excess of 1.5% of workforce while Spain has shown the most growth over the recent period.

The expansion of R&D personnel in the east and south-east Asian workforces remains strong with China again demonstrating the greatest growth, though the percentage of R&D personnel of the workforce is still small compared to that of the European countries (almost 0.2% compared to the EU average of 1.1%). The other south-east Asian nations have had smaller increases in the relative capacity measure but the proportions of R&D personnel to the workforce are more similar to those in Scandinavia, especially Taiwan with almost 1.3% R&D personnel.

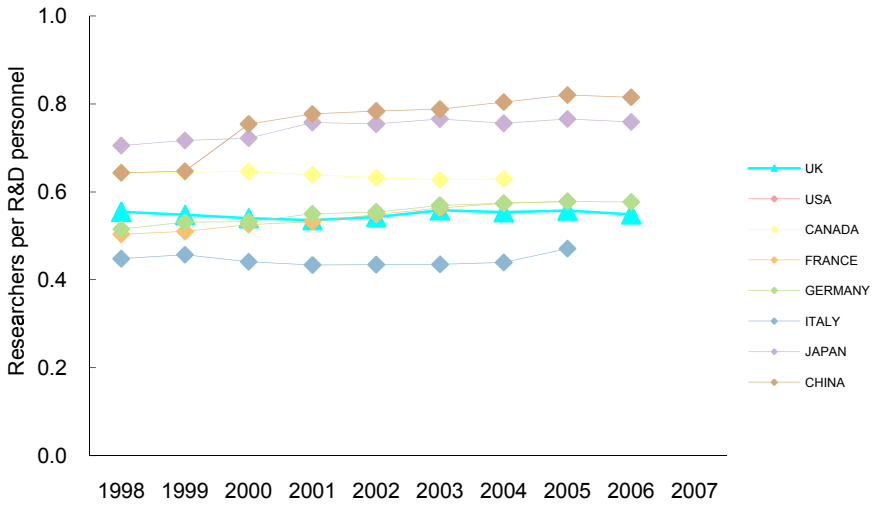
4.05 Researchers relative to R&D personnel

Table 4.05 Share of researchers relative to share of R&D personnel

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Researchers per R&D personnel	0.55	0.55	-0.00
Group average Researchers per R&D personnel	0.65	0.67	+0.02
UK / Group average	0.84	0.82	-0.02
UK rank within Group	17	13	⇧
UK rank within G8	5	3	⇧
UK share of researchers / UK share of R&D Personnel	0.61	0.80	+0.31

Data: OECD. Analysis: Evidence

Chart 4.05 Researchers per R&D personnel



Data: OECD. Analysis: Evidence

Commentary

The UK rank is affected by missing 2006 researcher data for the USA, Canada, France and Italy among the G8 group. Generally, this is an extremely stable measure – many countries within the comparator group have not changed in their numbers of researchers relative to R&D personnel over the monitoring period. Within the G8, Japan has sustained its lead position with a modest increase of around 10% over the 10 years since 1998. Germany has increased more in the recent 5-year period and has passed the UK. The UK appears to trail the comparator group average, but the researcher population in innovative, non-traditional knowledge-based business may not fit OECD Frascati definitions.

Amongst the EU nations, several show consistent increases over the 10-year period of around 1% per annum, including Denmark, Sweden, the Netherlands and Poland. Outside Europe, all the east and south-east Asian nations have increased the proportions of researchers relative to R&D personnel in the recent 5-year period, though by less than the European countries mentioned above. The strong position for China reflects the extent to which its business sector is rooted in traditional Frascati R&D areas that EU countries are now moving out from.

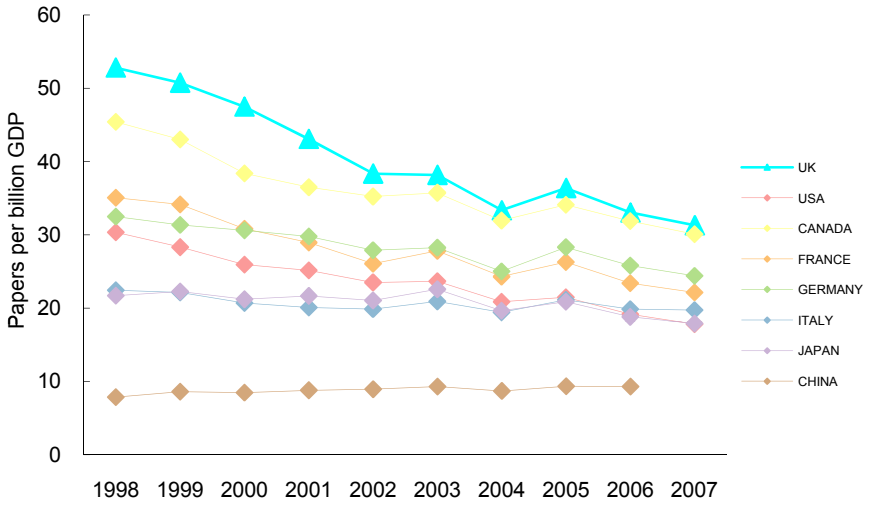
5.01 Papers relative to GDP

Table 5.01 Share of papers relative to share of GDP

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Papers per billion GDP	35.84	31.29	-0.13
Group average Papers per billion GDP	31.92	28.81	-0.10
UK / Group average	1.12	1.09	-0.03
UK rank within Group	6	6	⇔
UK rank within G8	1	1	⇔
UK share of sources / UK share of GDP	1.59	1.20	-0.25

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.01 Papers per billion GDP



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

This is the first of a series of indicators that measure research outputs in relation to the components of investment. This indicator has not been included in previous years' target metrics reports. It measures the association between total gross domestic product (GDP) and the papers published by each nation. Index values fall as GDP rises faster than research productivity. The UK is in first place among the G8 but Canada is narrowing the gap in second place. The UK is sixth within the comparator group behind smaller, mainly European, nations headed up by Switzerland which has moved from 2nd to 1st place in 2006 ahead of Israel, Sweden, Finland, Denmark.

Within the group, the highest climbers are Netherlands (6th), Taiwan (12th) and Italy (16th) each of which increased their position by three places between 1998 and 2006. China and Taiwan are the only two nations among the comparator group for which this indicator shows an increase. Despite this, China remains close to the bottom of the comparator group with 9.3 papers per £Billion GDP, or around one third of the group average value. China has a huge GDP relative to its current research base, its bibliometric data are still developing and thus its paper productivity is low compared to other countries.

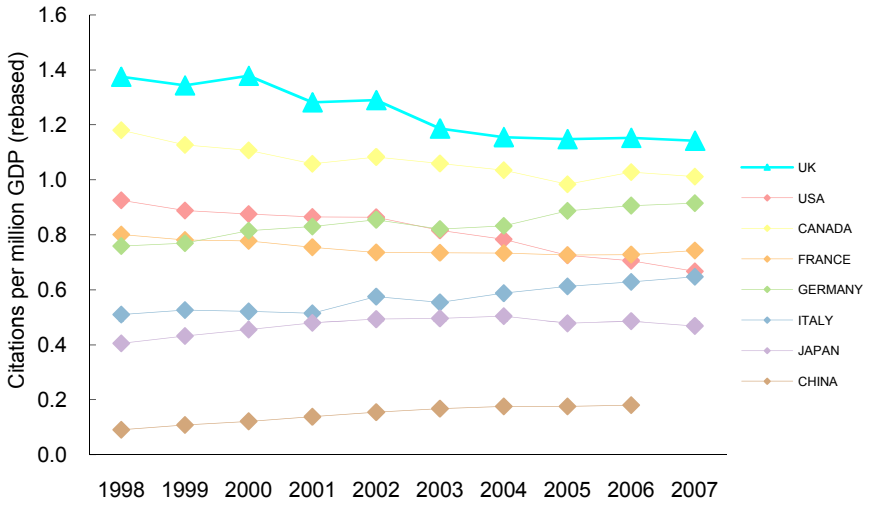
5.02 Citations relative to GDP

Table 5.02 Share of citations relative to share of GDP

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Citations per million GDP	0.34	0.02	-
Group average Citations per million GDP	0.28	0.01	-
UK / Group average	1.21	1.14	-0.05
UK rank within Group	7	7	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of GDP	1.19	1.14	-0.04

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.02 Citations per million GDP



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Citation counts to recent papers are fewer than to past years while GDP is rising in real terms, so the index rapidly falls. The informative comparison is a country's standing against the comparator group average. The UK has a consistently strong standing at the top of the G8 and has maintained its position, well above average within the comparator group. Germany has a steadily rising index value, but this is because of slower GDP growth as well as rising citation counts relative to the UK and USA. The USA's index is falling at a similar pace to the UK, but is much lower throughout the period and the USA's rank has tended to fall.

The leading nations on this index are Switzerland and the Scandinavian group which have high levels of public research funding relative to GDP. Switzerland's index is at an exceptional level, more than twice the group average throughout the decade, and Sweden and Denmark are also better than 1.5 times group average. Israel has typically performed very well but no data are available for the latest year (2006). The chart shows that the UK seems likely to maintain its relatively strong performance as its index levels out in the last few years keeping it well ahead of the rest of the G8 while the USA falls.

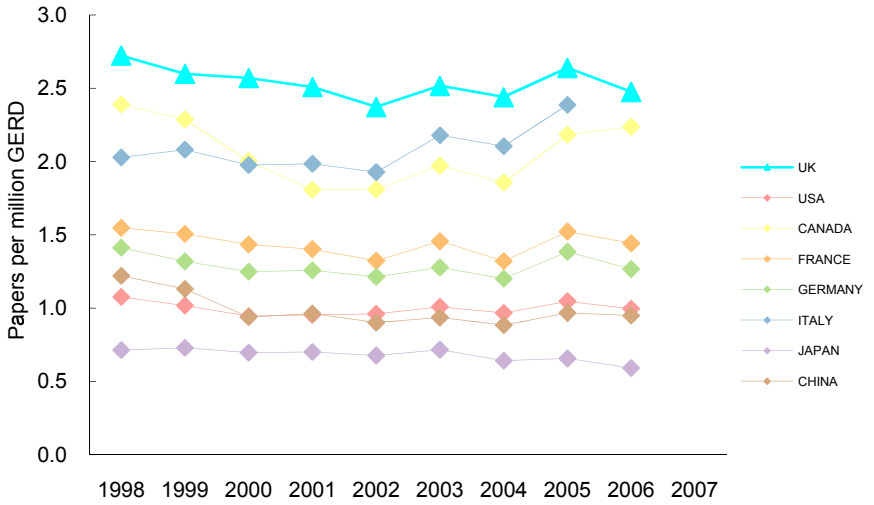
5.03 Papers relative to GERD

Table 5.03 Share of papers relative to share of GERD

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Papers per million GERD	2.49	2.47	-0.01
Group average Papers per million GERD	1.75	1.76	+0.00
UK / Group average	1.42	1.41	-0.01
UK rank within Group	3	3	⇔
UK rank within G8	1	1	⇔
UK share of sources / UK share of GERD	1.96	1.86	-0.05

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.03 Papers per million GERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Research output, in the form of papers, is related to gross expenditure on R&D (GERD) including both public and private sector spend. This indicator has not been included in previous years' target metrics reports. The chart shows that the UK consistently ranks in 1st place within the G8 group at around 2.5 papers per £M GERD. Apart from Canada's fall from second to third position in 2000, the relative positions of the G8 countries has remained stable, as has the comparator group average. The UK overtook Australia in 2001 and has remained at 3rd place within the comparator group.

Poland, an outlier for this indicator, heads the comparator group table with 4.7 papers per £M GERD in 2006. The Netherlands has risen consistently, from 10th in 1998 to 2nd in 2005, overtaking Spain and the UK. The average comparator group productivity has remained relatively stable over the period, as has the UK's performance. The USA and China are at 16th and 17th place in the comparator group with 1.00 and 0.95 papers per £M GERD respectively. The proximity of these two values should be interpreted with caution: bibliometric data for China are still developing and R&D expenditure may not be directly comparable.

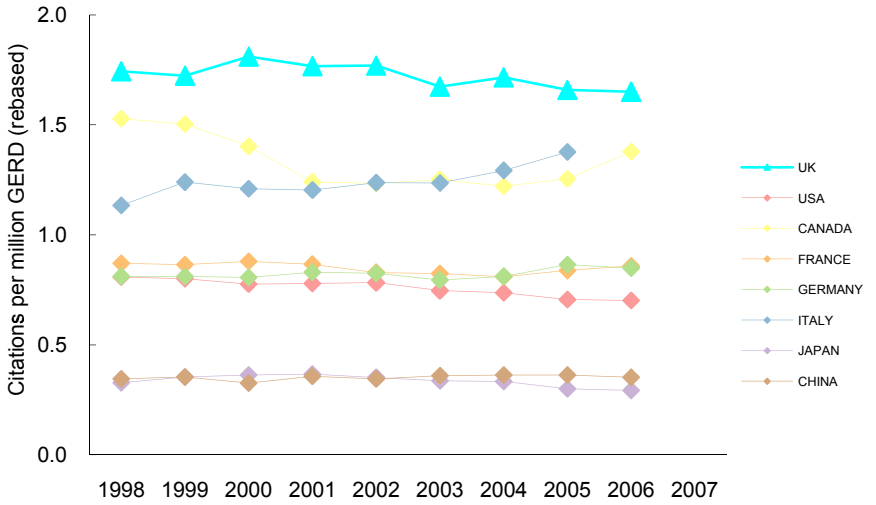
5.04 Citations relative to GERD

Table 5.04 Share of citations relative to share of GERD

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million GERD	29.51	7.12	-
Group average Citations per million GERD	17.09	4.31	-
UK / Group average	1.73	1.65	-0.04
UK rank within Group	3	3	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of GERD	1.72	1.65	-0.04

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.04 Citations per million GERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

This indicator looks at citation counts for papers relative to gross expenditure on R&D (GERD) including both public and private sector spend. Citations accumulate over time so the values charted for this indicator have been rebased to [group total citations/group total GERD] for each year. The UK has been 1st in the G8 throughout the period, and Italy has risen consistently so that it is now 2nd ahead of Canada. Italy has risen from 1.3 times group average to 1.7 times between 1998 and 2005 (there are no GERD data available for Italy for 2006.) The USA and Japan are declining slightly, and the USA, France and Germany track at about half the productivity of the UK.

The EU produces 1.3 times as many cites per unit GERD as the USA, compared with just 1.15 times as many in 1998. Most other countries show stable performance on this indicator. China's GERD rose from 10% of the EU value in 1998 to 35% in 2006 but its citations rose at a slightly faster rate to 2005 so that China's cites per unit GERD overtook Japan's in 2003. China's performance on this and other indicators typically levels off in the most recent year. [Note that the comparator group average shown in the table = average of each country's values for cites per GERD, not total group cites per total group GERD.]

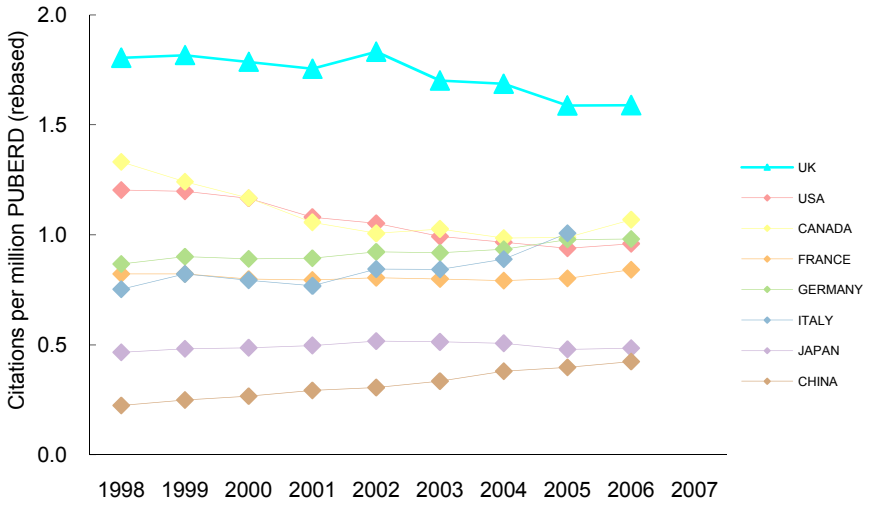
5.05 Citations relative to PUBERD (GOVERD + HERD)

Table 5.05 Share of citations relative to share of PUBERD

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million PUBERD	86.85	19.71	-
Group average Citations per million PUBERD	50.14	12.40	-
UK / Group average	1.73	1.59	-0.08
UK rank within Group	4	4	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of PUBERD	1.83	1.58	-0.14

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.05 Citations per million PUBERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

This resembles indicator 5.04, but the Business Expenditure on R&D (BERD) component of GERD has been excluded from the denominator, leaving PUBlic Expenditure on R&D (PUBERD). Because BERD is not generally aimed at producing papers, there is likely to be a more direct relationship between public sector investment expenditure and citations. For this indicator, annual productivity has been rebased against [comparator group total cites per comparator group total PUBERD] so as to take account of citation accumulation. The UK's PUBERD has declined slightly as share of GDP but grown slightly in total value while UK share of world citations has been broadly stable.

As the chart shows, UK performance on this indicator appears to decline (because PUBERD grows faster relative to citation share) but remains well above the other G8 nations, with UK productivity at 50% above the comparator group average. Within the EU, only Belgium and Denmark perform better. China's rise for this indicator is more marked than in indicator 5.04 because the level of BERD in China has increased relative to public sector R&D. Within the G8, Canada, France and Germany also have rising citation productivity, as have Singapore and Poland.

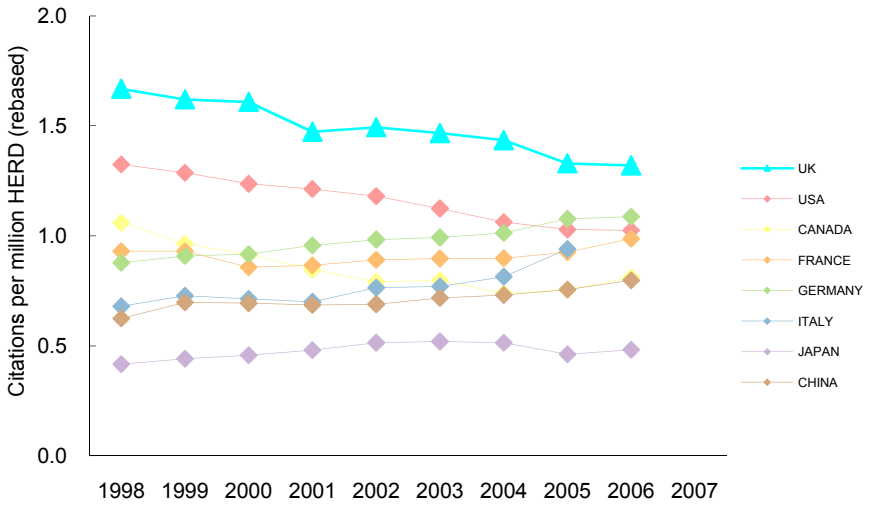
5.06 Citations relative to HERD

Table 5.06 Share of citations relative to share of HERD

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million HERD	123.38	27.25	-
Group average Citations per million HERD	84.84	20.64	-
UK / Group average	1.45	1.32	-0.09
UK rank within Group	4	3	⇧
UK rank within G8	1	1	⇔
UK share of citations / UK share of HERD	1.42	1.20	-0.16

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.06 Citations per million HERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

In this indicator the focus is on funding for R&D performed in the Higher Education sector (HERD). The UK leads the G8 and has risen from 4th to 3rd in the comparator group, behind Belgium and Israel. Within the G8, the UK, USA and Canada are declining (relative to comparator group average) while Germany, France and Italy continue to rise. This reflects the relative shift in HERD in these countries. Germany moved past the USA into 2nd place in 2005, but still only has citation productivity of 82% of the UK value.

Indicators 5.02-5.05 use the same citation counts, so the relative values of these citation productivity indicators, between countries, will depend on each country's ratio of GERD:PUBERD:HERD, i.e. the relative R&D funding of the private, public-non-HE and public-HE sectors. HERD for China has trebled over the period 1998-2006, but still only equates to 14% of the combined EU HERD, whereas China's PUBERD is 28% of the EU PUBERD and China's GERD is 35% of EU GERD. Consequently, China's citation productivity for HERD is higher, relative to other countries, than its citation productivity for GERD and PUBERD.

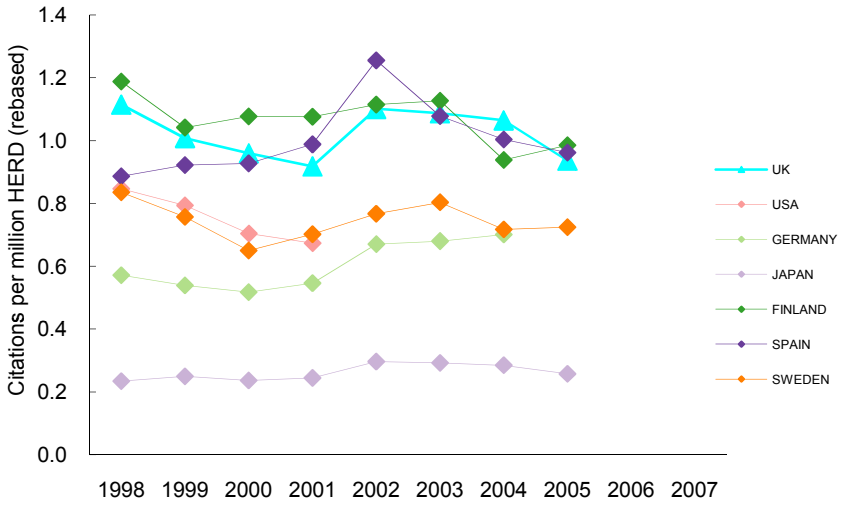
5.07.01 Citations relative to HERD in five main research areas

Table 5.07.01 Share of citations relative to share of HERD in medical sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK Citations per million HERD in medical sciences	425.36	169.26	-0.60
Group average Citations per million HERD in medical sciences	423.50	180.87	-0.57
UK / Group average	1.00	0.94	-0.07
UK rank within Group	7	7	⇔
UK rank within G8	2	2	⇔
UK share of citations / UK share of HERD	1.03	0.94	-0.09

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.07.01 Citations per million HERD in medical sciences



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

HERD is expected to increase whereas citations will be fewer for more recently published papers, so cites/HERD necessarily declines. The key indicator is national performance relative to the comparator group. The UK's performance relative to the group average appears to decline slightly because HERD for medical sciences has increased at a greater pace in the UK than elsewhere. However, the UK ranks 1st in the G8 with the exception of Russia where HERD is anomalously low and the productivity index is therefore unrealistically high. It does less well against some of the smaller European countries and the EU average.

The chart shows that the UK is keeping pace with countries leading on this indicator and has maintained a stable performance over the last decade. Data for the USA do not extend through the period but the decline over the first few years is evident. Most other countries show similar fluctuations to the UK.

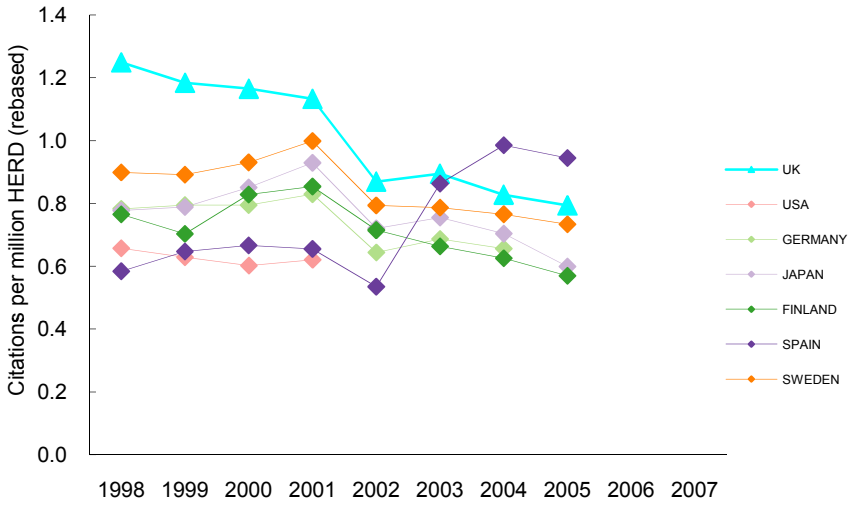
5.07.02 Citations relative to HERD in five main research areas

Table 5.07.02 Share of citations relative to share of HERD in natural sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK Citations per million HERD in natural sciences	279.89	120.15	-0.57
Group average Citations per million HERD in natural sciences	281.99	151.38	-0.46
UK / Group average	0.99	0.79	-0.20
UK rank within Group	5	6	⇩
UK rank within G8	2	2	⇔
UK share of citations / UK share of HERD	0.98	0.79	-0.19

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.07.02 Citations per million HERD in natural sciences



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

HERD is expected to increase whereas citations will be fewer for more recently published papers, so cites/HERD necessarily declines. The key indicator is national performance relative to the comparator group. All countries have shown a decrease in productivity as a consequence of greater HERD investment in by government. The drop in UK productivity is greater than most, due to that expanded investment, and it has dropped from near average to well-below average in the comparator group. This has had little effect on its ranking, however, because of its strong starting position. The UK is 2nd in the G8 only because Russia, with anomalously low HERD, has an unrealistically high productivity index.

The UK's decline in indexed productivity appears steep but this is influenced by the increase in HERD funding relative to other countries and indicates better underpinning resources. The UK remains ahead of key comparators including the USA, Germany and Japan. Spain's sudden change in performance is due to a major reduction in HERD in 2003.

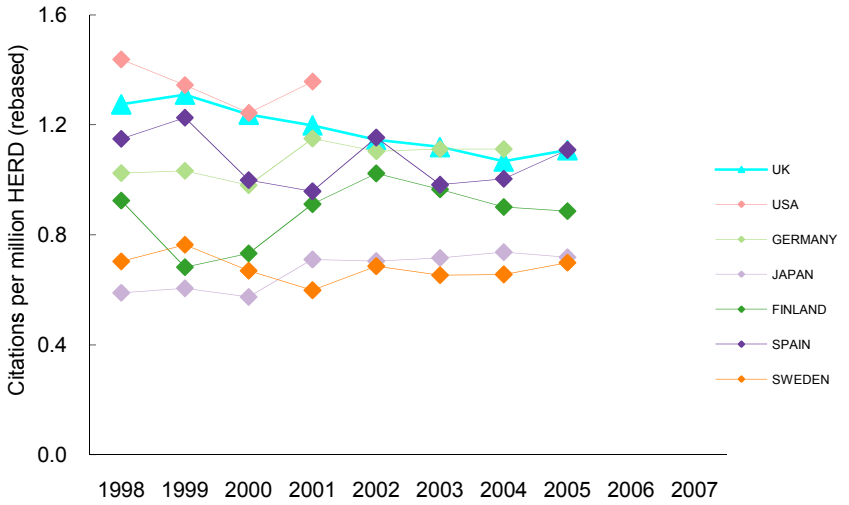
5.07.03 Citations relative to HERD in five main research areas

Table 5.07.03 Share of citations relative to share of HERD in engineering and technology

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK Citations per million HERD in engineering and technology	60.94	24.87	-0.59
Group average Citations per million HERD in engineering and technology	52.13	22.44	-0.57
UK / Group average	1.17	1.11	-0.05
UK rank within Group	7	5	⇧
UK rank within G8	3	2	⇧
UK share of citations / UK share of HERD	1.15	1.11	-0.04

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.07.03 Citations per million HERD in engineering and technology



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

HERD is expected to increase whereas citations will be fewer for more recently published papers, so cites/HERD necessarily declines. The key indicator is national performance relative to the comparator group. The shift in the UK's productivity between recent and current is in line with the changing group average. Although it was ahead of Germany early in the period, recently these two have moved closely in line. Other countries have changed more and the UK has in fact moved up in ranking to be 1st in the G8 with exception of Russia where HERD is anomalously low and the productivity index is therefore unrealistically high.

Most countries have relatively stable productivity over the period. The UK dropped back slightly early in the decade, with increasing HERD, but the citation rate has now picked up to match and the outcome is level. The USA is in a lead position in engineering but there are no HERD data for the last few years.

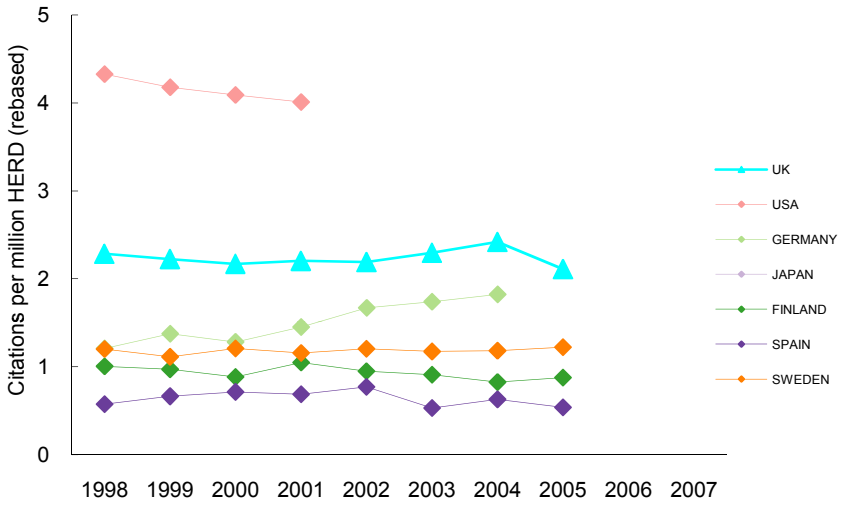
5.07.04 Citations relative to HERD in five main research areas

Table 5.07.04 Share of citations relative to share of HERD in social sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK Citations per million HERD in social sciences	149.17	54.46	-0.63
Group average Citations per million HERD in social sciences	67.01	25.81	-0.61
UK / Group average	2.23	2.11	-0.05
UK rank within Group	2	1	⇧
UK rank within G8	2	1	⇧
UK share of citations / UK share of HERD	2.25	2.11	-0.06

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.07.04 Citations per million HERD in social sciences



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

HERD is expected to increase whereas citations will be fewer for more recently published papers, so cites/HERD necessarily declines. The key indicator is national performance relative to the comparator group. Bibliometric data for the Social Sciences must be treated with caution and the database is dominated by Anglophone journals from which the UK benefits. The UK's performance is much better than the comparator group average and recent change is in line with that average. In the absence of the USA, for which no recent data are available, it leads the comparator group. The slight downturn in 2005, against the recent trend, suggests that it may be overtaken by Germany.

The chart confirms the UK's strong position in the comparator group but also highlights the downturn in the last year. However, it is unlikely that any country would be close to the USA, were its data available, and this reflects the balance of the database rather than real performance. The performance of the Germans does indicate that the Anglophone characteristics of the data are not necessarily a constraint. The data balance is shifting and may provoke further change in the next few years.

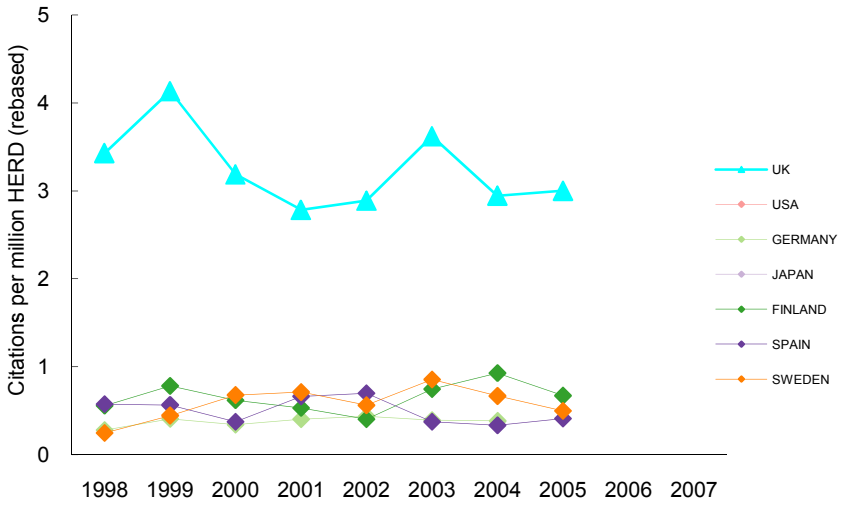
5.07.05 Citations relative to HERD in five main research areas

Table 5.07.05 Share of citations relative to share of HERD in humanities

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK Citations per million HERD in humanities	6.38	2.74	-0.57
Group average Citations per million HERD in humanities	2.09	0.92	-0.56
UK / Group average	3.05	3.00	-0.02
UK rank within Group	1	1	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of HERD	3.08	3.00	-0.03

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.07.05 Citations per million HERD in humanities



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

HERD is expected to increase whereas citations will be fewer for more recently published papers, so cites/HERD necessarily declines. The key indicator is national performance relative to the comparator group. The UK has an outstanding performance but this reflects the balance of data. HERD for Humanities is only available for some countries and the bibliometric data in this subject area are strongly Anglophone. Across the period the UK retains 1st rank but the overall trend in performance is slightly downwards relative to the comparator group average.

The chart is relatively uninformative. It confirms the strong UK position, which is heavily influenced by the data sources. The relative performance of the other countries is difficult to interpret. The characteristics of these data and their use as indicators continue to be explored by the Humanities in the European Research Area (HERA) group.

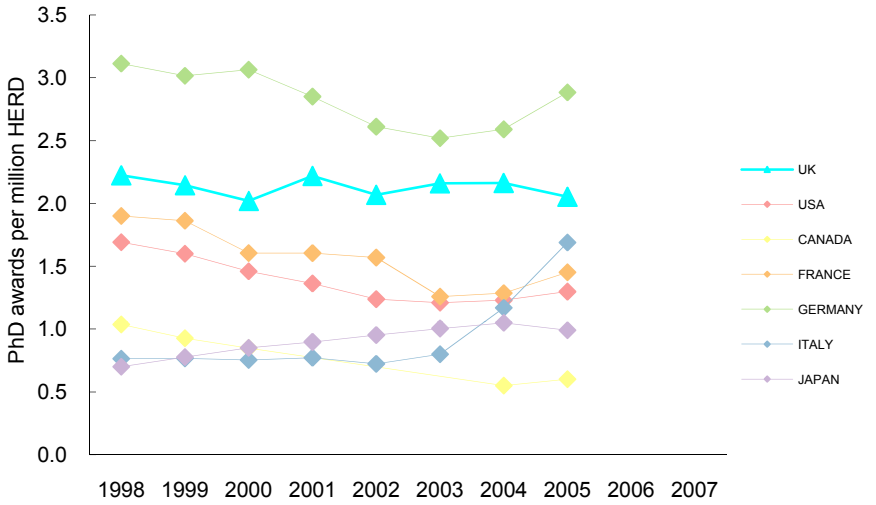
5.08 PhDs awarded relative to HERD

Table 5.08 Share of PhDs relative to share of HERD

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhD awards per million HERD	2.13	2.05	-0.03
Group average PhD awards per million HERD	1.79	1.82	+0.01
UK / Group average	1.19	1.13	-0.05
UK rank within Group	5	5	⇔
UK rank within G8	2	2	⇔
UK share of PhDs / UK share of HERD	1.54	1.36	-0.12

Data: OECD. Analysis: Evidence

Chart 5.08 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

This indicator compares the award of research degrees to Higher education Expenditure on R&D (HERD). The UK currently produces 9% of the comparator group's PhDs and invests 7% of the group's HERD making it relatively productive. The UK has consistently produced more PhDs per £million HERD than the comparator group average, as has Germany. All other G8 nations perform below comparator group average. The relative productivity for Germany declined from 2000 to 2003 but has risen since and is almost 40% higher than the UK. Italy's performance has risen sharply since 2002 and is now approaching the comparator group average while the USA has remained consistently well below that benchmark.

On comparing current to recent values, the UK's performance relative to the group is declining slightly, while Germany and the USA are now rising. In the comparator group as a whole, the UK remains in fifth place, behind Poland, South Korea, Germany and Spain. It is not necessarily the case, however, that low relative research spend (many PhDs awarded per R&D expenditure) is a good thing, since it may imply poor quality training. Highly skilled postgraduates are a key output, transferring knowledge, know-how and technological advances. The wider economy gains a trained and informed workforce capable of assessing and responding to technology related opportunities and issues.

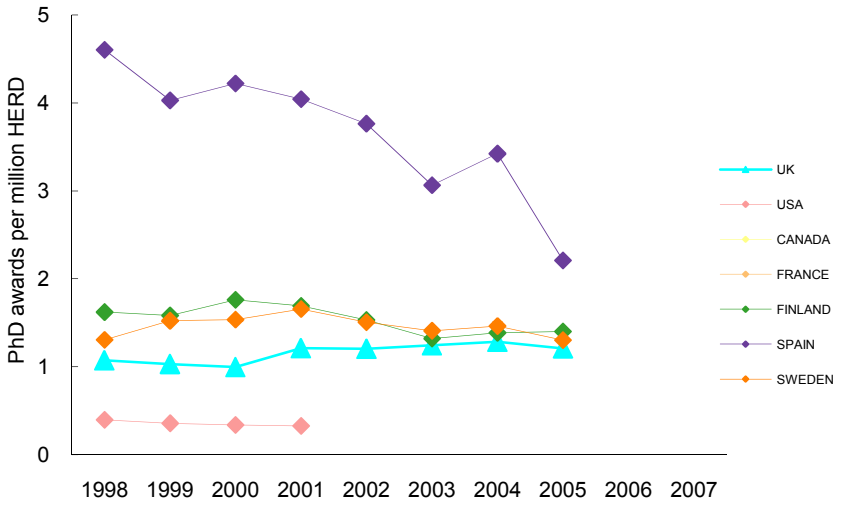
5.09.01 PhDs awarded relative to HERD in five main research areas

Table 5.09.01 Share of PhDs relative to share of HERD in Medical Sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhD awards per million HERD	1.19	1.21	+0.02
Group average PhD awards per million HERD	1.82	1.46	-0.20
UK / Group average	0.65	0.83	+0.27
UK rank within Group	8	5	⇧
UK rank within G8	2	1	⇧
UK share of PhDs / UK share of HERD	0.65	0.32	-0.51

Data: OECD. Analysis: Evidence

Chart 5.09.01 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

In this indicator awards of research degrees are compared to Higher education Expenditure on R&D (HERD). The availability of data disaggregated at this subject level varies between countries and between years. Consequently, the group of countries analysed graphically varies from that for other indicators. Data are available for 6 of the 26 comparator countries for indicator 5.08 in this research area.

OECD Medical Sciences include both clinical and pre-clinical areas including nursing and health. The UK's productivity of PhDs per unit HERD has been below group average but steadily rising to around 1.2 PhDs per $million HERD. The number of UK Medical Science PhDs qualifying per year has risen from 1,500 to 2,500 over the period 1998-2005 and the UK productivity has risen compared to group average. In 2001, the UK pulled ahead of Australia and Japan for this indicator and has remained ahead. The USA has a much lower productivity than comparator nations in this research area with less than 0.5 PhDs per $million HERD.

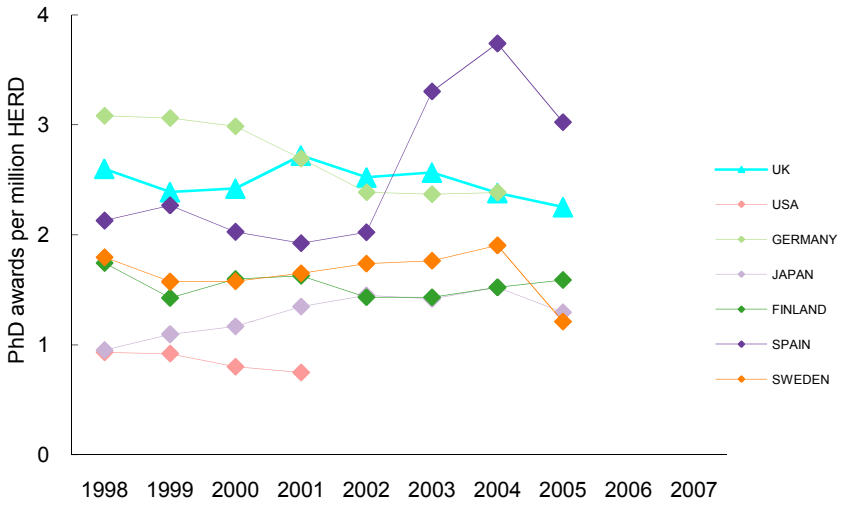
5.09.02 PhDs awarded relative to HERD in five main research areas

Table 5.09.02 Share of PhDs relative to share of HERD in Natural Sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhD awards per million HERD	2.52	2.25	-0.11
Group average PhD awards per million HERD	1.95	1.87	-0.04
UK / Group average	1.29	1.20	-0.07
UK rank within Group	5	3	⇧
UK rank within G8	2	1	⇧
UK share of PhDs / UK share of HERD	1.07	0.39	-0.64

Data: OECD. Analysis: Evidence

Chart 5.09.02 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

In this indicator awards of research degrees are compared to Higher education Expenditure on R&D (HERD). The availability of data disaggregated at this subject level varies between countries and between years. Consequently, the group of countries analysed graphically varies from that for other indicators. Full annual data are available for 6 of the 26 comparator countries for indicator 5.08 in this research area. For each year during the analysis period, the UK has performed above the group average.

OECD Natural Sciences include biological, physical, environmental and agricultural fields. The UK's productivity of PhDs per unit HERD remains strong relative to other countries', but has declined very slightly this year, from 29% above group average in the most recent five-year period to 20% above in the current year. Among the other G8 countries for which data are available, Germany performs best and remains level and close to the UK, after falling at the start of the period. Poland and Spain currently head the comparator group. The USA has a much lower productivity than comparator nations in this research area with less than 1.0 PhD per $million HERD.

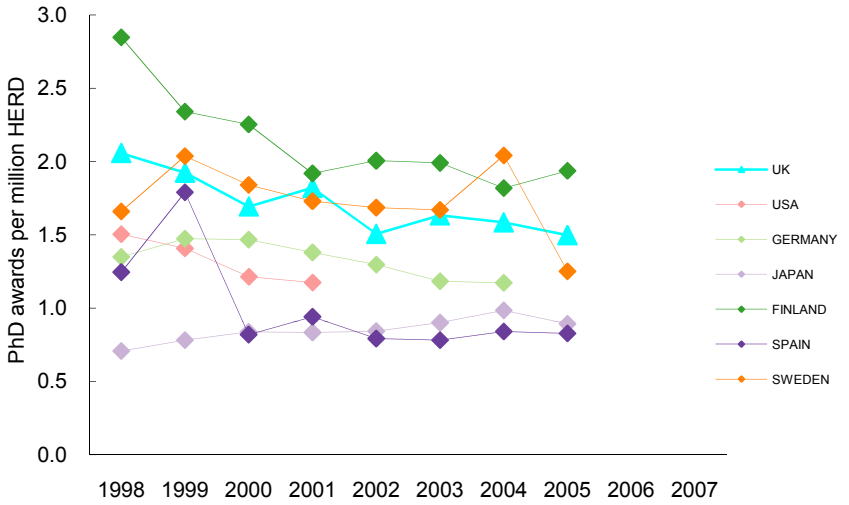
5.09.03 PhDs awarded relative to HERD in five main research areas

Table 5.09.03 Share of PhDs relative to share of HERD in Engineering and Technology

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhD awards per million HERD	1.65	1.50	-0.09
Group average PhD awards per million HERD	1.43	1.28	-0.10
UK / Group average	1.15	1.17	+0.02
UK rank within Group	7	4	⇧
UK rank within G8	1	1	⇔
UK share of PhDs / UK share of HERD	1.04	0.55	-0.47

Data: OECD. Analysis: Evidence

Chart 5.09.03 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

In this indicator awards of research degrees are compared to Higher education Expenditure on R&D (HERD). The availability of data disaggregated at this subject level varies between countries and between years. Consequently, the group of countries analysed graphically varies from that for other indicators. Data are available for 6 of the 26 comparator countries for indicator 5.08 in this research area. For each year during the analysis period, the UK has performed above the group average.

In Engineering and Technology, the UK's produces around 2000 PhDs per year and its productivity of PhDs per unit HERD remains strong relative to other countries'. In absolute terms the UK has declined very slightly this year, but has risen slightly relative to group average. The UK's apparent rise from 7th to 4th within the group is mainly due to lack of available data for some countries in the most recent year, although the UK has gained over Sweden. Among the other countries for which data are available, Finland, Poland and Denmark head the comparator group.

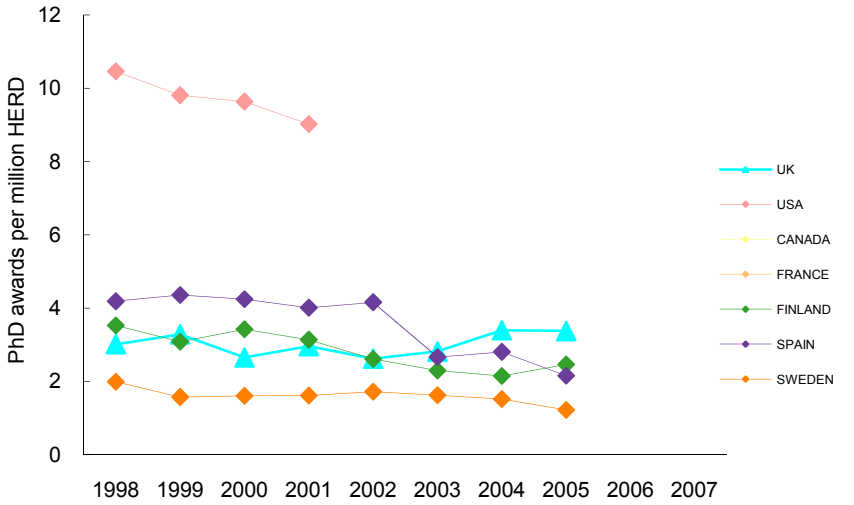
5.09.04 PhDs awarded relative to HERD in five main research areas

Table 5.09.04 Share of PhDs relative to share of HERD in Social Sciences

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhD awards per million HERD	2.89	3.37	+0.17
Group average PhD awards per million HERD	2.70	2.30	-0.15
UK / Group average	1.07	1.47	+0.37
UK rank within Group	5	2	⇧
UK rank within G8	3	1	⇧
UK share of PhDs / UK share of HERD	0.37	0.24	-0.35

Data: OECD. Analysis: Evidence

Chart 5.09.04 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

In this indicator awards of research degrees are compared to Higher education Expenditure on R&D (HERD). The availability of data disaggregated at this subject level varies between countries and between years. Consequently, the group of countries analysed graphically varies from that for other indicators. Data are available for 5 of the 26 comparator countries for indicator 5.08 in this research area. For each year during the analysis period, the UK has performed above the group average.

OECD Social Sciences include business and management fields. The UK's productivity of PhDs per unit HERD has risen relative to other countries', and is at 47% above group average in the current year. Germany is consistently in 2nd place within the comparator group, behind the USA which is an outlier for this indicator in this research area. (The USA produces 9 PhDs per $million HERD, compared to group average of 2.3.) Current-year data are unavailable for Germany or the USA, so the UK appears in 1st place within G8 and 2nd place in the comparator group, behind Poland.

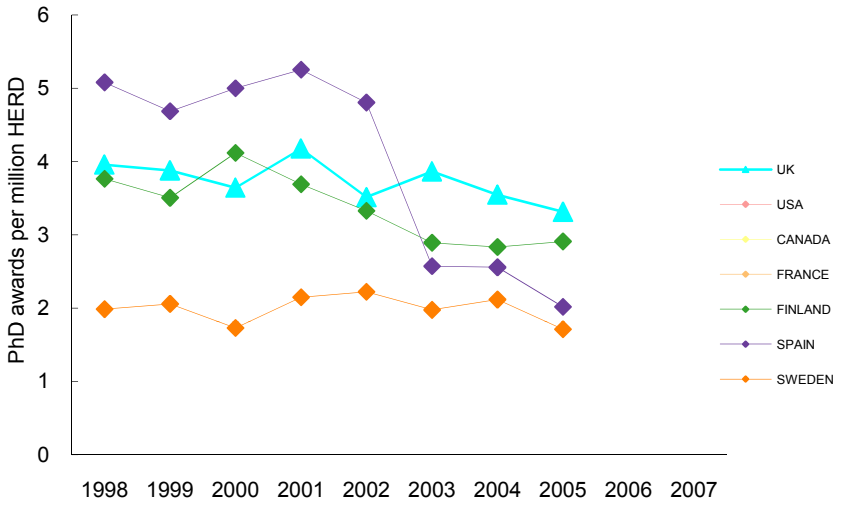
5.09.05 PhDs awarded relative to HERD in five main research areas

Table 5.09.05 Share of PhDs relative to share of HERD in Humanities

	Recent average (2000-2004)	Current value (2005)	Current relative to Recent
UK PhD awards per million HERD	3.75	3.31	-0.12
Group average PhD awards per million HERD	3.30	2.49	-0.25
UK / Group average	1.14	1.33	+0.17
UK rank within Group	3	2	⇧
UK rank within G8	1	1	⇔
UK share of PhDs / UK share of HERD	0.52	0.27	-0.48

Data: OECD. Analysis: Evidence

Chart 5.09.05 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

In this indicator awards of research degrees are compared to Higher education Expenditure on R&D (HERD). The availability of data disaggregated at this subject level varies between countries and between years. Consequently, the group of countries analysed graphically varies from that for other indicators. Data are available for 14 of the 26 comparator countries for indicator 5.08 in this research area.

This is the third time that Humanities data have been analysed in this indicator. The data coverage remains sparse, reducing the feasibility of interpretation. In Humanities, the UK's productivity of PhDs per unit HERD has declined slightly this year, but is rising relative to comparator group average. The UK now lies at 33% above group average producing 3.3 PhDs per %million HERD, in 2nd place within the group behind Poland. (There are no disaggregated HERD data for USA Humanities.)

Background to the indicators

The following pages provide background information on data sources, international coverage, subject level disaggregation, time frames and the theory and methodology used in bibliometric analyses.

Codes and abbreviations for countries and for fields of research are defined in the appropriate sections.

There is also a Glossary for other terminology and abbreviations.

Data and sources

The main data sources used for DIUS indicators are:

- Finance and people – OECD
- Publications – Thomson Reuters

The OECD is the main provider of internationally comparable data on research and development. Its two products on the measurement of science and technology, Main Science and Technology Indicators (MSTI, 2008-1, first edition) and Research and Development Statistics (RDS, 2007-1, first edition), provide the basis for much of the data used in these analyses. The latest editions of each of these products were used to generate the indicators listed in the table below. In addition, OECD provides the only reliable international comparisons of educational data via its online Education and Training Database, the latest edition of this was released in September 2007.

The OECD provides comments on a number of the data points in RDS and MSTI, explaining their derivation or discussing their accuracy. These comments have not been reproduced here but are available to the interested reader when referring to the original data. Sources can be found at:

http://stats.oecd.org/wbos/Index.aspx

There are some points of difference between MSTI and RDS. MSTI has been the preferred database for most of the analyses in this report as it provides data on a greater range of countries; RDS, however, provides data disaggregated at the level of fields of science.

Data are presented for the years 1998 to 2007, though some sources lack data for more recent years. Where an indicator uses data from two sources, one with missing data in recent years, data from the most recent year in common is taken as the most recent year. No attempt has been made to forecast to fill missing datapoints in recent years, but gaps of one or two years in the time series have been filled by interpolation.

Rolling five-year averages have been created for researchers, population and labour-force data in order to enable like-for-like comparisons with Thomson Reuters data. The average is produced from the value for the year in question, and the four years which precede it.

Indicator	Basic source
GDP	OECD Main Science and Technology Indicators
GERD	OECD Main Science and Technology Indicators
GOVERD	OECD Main Science and Technology Indicators
HERD	OECD Main Science and Technology Indicators
HERD by field of science	OECD Research and Development Statistics
National populations	OECD Main Science and Technology Indicators
PhD graduates	OECD Education and Training Database
PhD graduates by field of science	OECD Education and Training Database
R&D personnel	OECD Main Science and Technology Indicators
Researchers	OECD Main Science and Technology Indicators
Labour (work) force	OECD Main Science and Technology Indicators

In this report, OECD data are usually available for 21 countries. Coverage for the 17 OECD nations is broadly complete, but data for some countries are missing from some tables. This may be because there were no data available, or that there were so many missing data points in the data available that no meaningful attempt to interpolate could be made.

Where necessary and feasible, OECD data has been supplemented by data sourced from the UK Higher Education Statistics Agency (HESA), and the Department for Business Enterprise & Regulatory Reform's (BERR) SET Statistics.

Financial data are given in units of Million constant US$ at 2000 prices and corrected for Purchasing Power Parity (PPP). In other words, the financial data are expected to be comparable between years and countries. Where translation from Million current PPP$ to Million constant PPP$ was required, OECD's Implicit GDP Price Indices table (Annex B to MSTI) was used. Where translation from National Currency to Purchasing Power Parities (national currency per dollar) was required, OECD's Purchasing Power Parities table (Annex C to MSTI) was used.

The interpretation of OECD science and technology data is governed by the Frascati Manual, which has become the internationally recognised methodology for collecting and using R&D statistics. Some basic definitions from the Frascati Manual appear below; detail is in the Glossary.

The OECD Education and Training Database provides internationally comparable data on key aspects of education systems. It makes use of data collected by UNESCO, OECD and Eurostat. The interpretation of OECD education data is governed by the OECD publication 'Data Collection on Education Systems: Definitions, Explanations, and Instructions', which is available from the OECD here:

http://www.oecd.org/topicstatsportal/0,3398,en_2825_495609_1_1_1_1_1,00.html.

Changes in data collection by HESA (the Higher Education Statistics Agency in the UK) led to an apparent increase in the numbers of PhD awards from 2001 onwards by about 4.5% compared to previous data. More information is available in an article published by HESA at the time; see:

http://www.hesa.ac.uk/holisdocs/pubinfo/student/changes.htm

All publication and citation data are provided by Thomson Reuters. The National Science Indicators for 2007 was the specific database from which figures were taken for these analyses. Two main methods are used in analysing these data:

NSI1: Analyses based on data from the most recent (or any specific) calendar year use the Thomson Reuters NSI1 data frame, looking at the numbers of articles published and the citations they have accumulated to date;

NSI5: Analyses based on a select period are most effective if a five-year window is taken, using the Thomson Reuters NSI5 data frame. This takes the publications for a stated five-year period (e.g. NSI5 for 2007 is the five-year window 2003-2007) and the citations to those articles in the same five-year period.

Frascati Manual data definitions (see also Glossary)

GERD: Gross domestic expenditure on R&D

HERD: Higher Education R&D [expenditure]

Researchers: professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems

R&D personnel: all persons employed directly on R&D, and those providing direct services such as managers, administrators, and clerical staff

Labour force (workforce): Total number of persons available for work, whether in employment or not

Other data definitions

GOVERD is government intramural expenditure on R&D.

PUBERD: the sum of GOVERD and HERD, equating to R&D in the publicly funded sectors

Notes on data manipulation

Interpolation was achieved by adding to the lower figure the difference between available upper and lower values divided by a count of missing years.

OECD field of science categories: a single category covers both agriculture and natural sciences.

UK HERD was rebuilt by field of science using:

- HESA data on Total HEI Research Grant & Contract Income (from Resources of Higher Education, Table 4: Research Grants and Contracts Income by Institution, Cost Centre and Source). HESA cost centre codes were mapped to OECD fields of science, and agricultural sciences combined into natural sciences, and income allocated to administration and services (<1% of the total) was pro-rated across OECD fields of science.
- BERR data on HEFC R&D Expenditure by subject area (BERR Government R&D survey reproduced on the BERR's SET statistics website: Table 5.3 Higher Education Funding Councils R&D and SET expenditure by subject area: (http://www.berr.gov.uk/dius/science/science-funding/set-stats/index.html).

This has accounted for 95% of HERD on average (though only 91% in the most recent year), and the shortfall is pro-rated across OECD fields of science.

Proportions of HERD by field of science were then calculated, and these values used to split the available totals. There are data only up to 2005

The following table is adapted from Table 6.1 of the Frascati Manual. It shows the distinction between funding and performing sector in establishing the composition of GERD.

Sector of funding source	Sector of performance				Total
	Business enterprise	Private non-profit	Government	Higher education	
Business enterprise	BE-BERD, i.e. private sector R&D financed by companies	BE-PNPERD	BE-GOVERD	BE-HERD, e.g. industrial research contracts to universities	Total domestic performance financed by the business enterprise sector
Government	GOV-BERD, i.e. Government R&D contracts and grants to industry			GOV-HERD e.g. contracts from Government departments	Total domestic performance financed by the government sector
Public general university funds (GUF)				GUF, i.e. from DfES via HEFCs	Total domestic performance financed by public general university funds (GUF)
Higher education				HE-HERD, i.e. from own funds incl. endowments	Total domestic performance financed by the higher education sector
Private non-profit (PNP)				PNP-HERD	Total domestic performance financed by the private non-profit sector
Abroad				HERD other	Total domestic performance financed by abroad
Total	Total performed in the business enterprise sector	Total performed in the private non-profit sector	Total performed in the government sector	Total performed in the higher education sector	
	BERD	**PNPERD**	**GOVERD**	**HERD**	
			< - PUBERD (OST category) - >		
	< - - - - GERD - - - - >				

GERD

OECD Indicators were created from the following source files, fields and criteria:

Indicator element	OECD source filename	Fields and criteria
HERD by OECD Field of Science	RDS2007-1 Table 18. Higher education intramural expenditure on R&D – HERD – by field of science	MEASURE=Million constant $ 2000 prices and PPPs
GERD	MSTI2008-1 Indicator 3. GERD – (Million 2000 dollars – constant prices and PPPs	
Researchers	MSTI2008-1 Indicator 7. Total researchers (FTE)	
R&D personnel	MSTI2008-1 Indicator 9. Total R&D personnel (FTE)	
HERD	MSTI2008-1 Indicator 47. HERD – (Million 2000 dollars – constant prices and PPPs	
GOVERD	MSTI2008-1 Indicator 54. GOVERD – (Million 2000 dollars – constant prices and PPPs	
GDP	MSTI2008-1 Indicator A.2. Gross Domestic Product (Million Current PPP$)	Converted to Million 2000 dollars – constant prices and PPPs using MSTI2008-1 Indicator B. Implicit GDP Price Indices (2000 = 1)
Population	MSTI2008-1 Indicator E. Total Population (Thousands)	
Labour force	MSTI2008-1 Indicator H. Labour Force (Thousands)	
PhDs awarded	OECD Education and Training Database: Number of graduates by field of study, level of education, programme orientation, duration of programme and sex	Country=[ALL]; Year=[ALL]; Level of education=60: Advanced research programmes; Programme destination=900000: Total; Programme duration; Programme Orientation=900000: All educational programmes; Field of study=[ALL]; Gender=90: Total males + females
PhDs awarded by OECD Field of Science	As above	As above

International comparisons and data coverage

There are 25 countries (the DIUS comparator group) covered in this report in addition to the UK. Where reference is made to comparator group, it is these 26 countries (or the subset for which data are available) that are being referred to.

The DIUS comparator group is spread by geography and type, and is thus of value for comparison with any national research base.

The combined output of the selected countries in the DIUS comparator group accounts for more than 95% of the world's relatively highly cited papers over the last 20 years. Highly cited papers are, in this context, those that have been identified by Thomson Reuters as the most cited 1% by field and year of publication. The group covers similar proportions of total world outputs.

The EU group was introduced in the 2004 report to summarise research activity in Europe, because of increased interest in the development of the European Research Area. The EU is not included in the aggregate statistics for the DIUS comparator group. The EU bibliometric data generally reflect true aggregate figures and do not duplicate activity that is collaborative between member states. This is not always true, however, of the OECD data where some countries' data are missing from some variables.

The DIUS group includes the full G8, a combination of some larger and OECD countries from different continents with research bases both similar and contrasting in structure to the UK, and a spread of smaller nations with active and rapidly growing research bases with specific strengths.

Country groups

Some countries would form the normal core of any international reference set. These are major economies with a strong and diverse research base. They include countries with university-based research systems very similar to that of the UK and others with systems that are based more strongly on research institutes outside universities. Additional performance factors related to research system can thereby be examined.

European countries provide a fuller regional economic context. Those in the DIUS group include medium to large research economies, have active and well established research bases and interact substantially with the UK. Figures for EU (now EU27) have, where possible, been taken directly from OECD's figures (rather than summed from country totals), some of which may be based upon OECD Secretariat estimates.

Country group	Country name	Short code
G8	UK	UK
	USA	USA
	Canada	CAN
	France	FRA
	Germany	GER
	Italy	ITA
	Japan	JAP
G8/E Europe	Russia	RUS
Other W Europe	Belgium	BEL
	Denmark	DEN
	Finland	FIN
	Netherlands	NED
	Spain	ESP
	Sweden	SWE
	Switzerland	SUI
Other E Europe	Poland	POL
Other Europe	EU27 group	EU
Other World	Australia	AUS
	Brazil	BRA
	China	CHI
	India	IND
	Iran	IRA
	Israel	ISR
	Singapore	SGP
	South Africa	SAF
	South Korea	SKO
	Taiwan	TWN

Social and economic change in the former Soviet Union and among recent accession countries to the EU suggests that monitoring research developments in this area will extend information gained from the core European analysis. It should be noted, however, that post-Soviet economic changes produce anomalous indicators where GDP estimates change rapidly.

A spread of leading research economies in other continents provides a broad overview of the UK's relative international standing. Recently, the rapidly evolving research performance of China has made it central to any international research comparison. India is developing more slowly but is likely to become a key focus within a few years.

Finally, smaller research economies are active in specific 'niche' areas often related to key technologies of economic significance. The countries of interest in the DIUS comparator group are likely to change from time to time. Those initially included continue to show rapid recent growth and a significant increase in research impact.

Reference benchmarks

Two baselines have been created as reference benchmarks, and they are used for each indicator and field. The first reference benchmark is the global total or average. The second reference benchmark is the total or average for the DIUS comparator group. Within the report, the specific benchmark that has been used is specified. (The relevant one depends on the availability of data for each indicator.)

Note that summed bibliometric data for the DIUS comparator group may appear to exceed world totals because of joint publications between countries. This is discussed in a methodological note (below).

International data coverage

Finance and workforce data may be limited for some countries and some subject areas, particularly in the social sciences and in the arts and humanities.

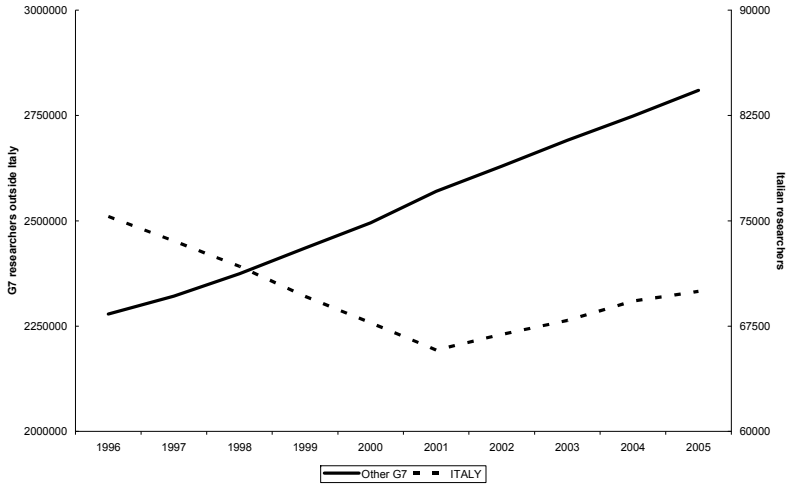
Work carried out for the Economic and Social Research Council (ESRC) highlighted some deficits and some inconsistencies with regard to postgraduate training data for some smaller countries. Data for the G8 appear generally sound.

Bibliometric data are generally available for all countries. For the social sciences, while some larger fields appear to be reasonably well covered internationally, there are other specific disciplines in which there are clear deficits for non-Anglophone countries. This means that comparisons between the USA, UK and Canada may be sound, but the relative position of, for example, France and Germany would be less certain.

The research base varies in structure between countries (as noted above) and there are also differences – possibly but not necessarily as a consequence – in research culture and thus in activities such as publication and citation behaviour. We comment below on some possible factors that arise from this.

Labour productivity in Italy

In Italy, the numbers of researchers employed within the workforce was reduced during the 1990s, whereas there was steady growth in the numbers of researchers in other countries during the same period. The numbers of Italian researchers began to grow again after 2000, but at a slower rate than elsewhere.



The consequence of these changes is that the OECD data show a significant relative decline in the year-on-year Italian researcher workforce compared to other leading research economies. Indices of labour productivity in relation to the research base are disrupted by this change, because the prior intellectual capital of the research base led to continued publications and citations.

Output per researcher (Indicator 1.03) and citations per researcher (Indicator 1.06) should be interpreted with these changes in mind. Apparently increased labour productivity for Italy is driven more by the relative decline in the size of the researcher workforce than any increase in the numbers of papers or citations. By contrast, research training capacity responded immediately to the reduced supervisor-researcher numbers and PhDs per researcher (Indicator 3.04) show a stable profile over the same period.

Subject disaggregation

Three principal levels of subject disaggregation are used in this report: System (i.e. country level); OECD; and UK-SUoA. The subject disaggregation is nested and hierarchical. 'System' breaks down into five 'OECD' categories, some of which are then broken down into the 10 'SUoAs'.

Mapping data at a subject level

Research data can be grouped at a system level (total national papers, total science and arts expenditure) or at levels of detail described as fields, subjects or disciplines. A balance needs to be struck between a coarse level of analysis and too fine a level, both of which can obscure information.

For analyses of output performance patterns, the UK's SUoAs (see below) can be used, but it is also feasible to use finer levels of discrimination. *Evidence* Ltd has developed a number of methodologies for mapping data from different sources to a common set of categories.

System (Country)

System refers to the country as a whole. This gives a national overview of research activity and performance.

System is often the only available level because data are not attributed to any specific subject category. It is not entirely satisfactory because of the innate cultural differences between major research fields. The relative size of different fields may swamp important differences between fields within countries.

OECD categories

OECD coarse-level categories are broad fields used for categorising much of the OECD database. This provides a satisfactory separation between major parts of the research base, but still obscures some performance detail.

For this DIUS report we have combined the OECD data for natural and agricultural sciences. The category for agriculture is useful for measuring the specific economic activity in this sector, but it is of much less significance as a separate grouping for research base analyses.

The five OECD categories used here are:

- 1 Medical Sciences
- 2 Natural and Agricultural Sciences
- 3 Engineering and Technology
- 4 Social Sciences
- 5 Humanities [including Arts where data permits]

Units of Assessment

Units of Assessment (UoAs) are the 68 subject categories established in the UK for the cyclical Research Assessment Exercises (RAE) up to 2001 (no public data yet exist for the 2008 RAE UoAs). A list of these categories is available from the HERO website at:

http://www.hero.ac.uk/rae/Pubs/4_01/section4.htm

These categories are generally too fine and numerous for international comparisons, other than those focussing on a single discipline.

SUoAs (Super-UoAs)

SUoAs are grouped Unit of Assessment (UoA) subject categories. This usefully separates some of the major sub-divisions within the OECD categories, such as biological, physical and environmental sciences within the OECD Natural Science and Agricultural Sciences category.

The groups are based on an analysis of similarity of journal usage by researchers submitting to the UK RAE in 1996 and 2001. Some of the groups are substantially larger than others and might be identified as 'major' fields, but this designation refers to size only rather than policy significance.

The 10 SUoA categories used here are:

- Clinical (major) = OECD category 1

- Health and medically-related subjects = OECD 1
- Biological sciences (major) = OECD 2
- Environment = OECD 2
- Mathematics = OECD 2
- Physical sciences (major) = OECD 2
- Engineering (major) = OECD 3
- Social science (major) = OECD 4
- Business = OECD 4
- Humanities, languages and arts = OECD 5

Economic and social research

The application of some research indicators to the economic and social sciences is justifiably disputed, as we note elsewhere.

Several studies for the ESRC confirm that bibliometrics must be used with caution in this area. Thomson Reuters' economic and social coverage has not historically been balanced in the same way as natural science disciplines. A lower language diversity results in a deficit in coverage for some large European research economies. This balance is changing but, for the present, the indicators must be treated with some caution.

The bias towards Anglophone journals may affect the UK in two ways: it is relatively less well covered than the USA, so the database has less utility; but more 'average' material may be covered than for other European competitors, so its net indexed impact may be reduced.

It is also noteworthy that a higher proportion of the material cited by articles in social science journals is not covered by the Thomson Reuters databases, than would be true for natural science journals.

Although the defects of existing bibliometrics are familiar to social science researchers, many of them make extensive use of journal, article and citation information in reaching judgements about research quality. However, they do so in an 'expert' fashion alongside other data and it is not possible readily to translate their approach into systematic evaluation.

The use of journal articles as a preferred output mode for economic and social research appears to be increasing, as judged by RAE data and survey outcomes. Bibliometrics are likely to be of increasing importance and bibliographic databases and indices are likely to be of increasing value to social scientists over the next few years.

Humanities, languages and arts

New indicators appropriate to the different research paradigms in these disciplines are likely to be required. While research funding and research training are clearly common to all disciplines, their relation to performance is not the same in all cultures. Publication and citation behaviour also differs markedly, perhaps more so in the humanities than in the Social Sciences.

Background data are being gathered by relevant agencies to support the development of new indicators and the Arts and Humanities Research Council (AHRC) will be exploring the options that arise. Their staff are in regular contact with the DIUS on this.

In the interim, where the data allow, the existing indicators have been extended to capture information about humanities research. Data on the language disciplines and on the visual and performing arts are very sparse, but have been included where available.

The international databases are often much weaker on humanities and arts research activity. Many countries make no returns in this area and others, with significant research bases, supply data only in some years. This further reduces the capacity for analysis.

It is acknowledged that indicators in this report have been developed principally for use in evaluating natural science research. Their relationship to 'research performance' in arts and humanities is only partly understood. This presentation is, therefore, one that should stimulate the wider debate on measuring research in the humanities but should not be taken to provide any grounded or authoritative measure of the UK's recent standing.

Time frames

This report uses analyses of:

- Current performance, in the latest year (or five-year period) for which data are available.
- Comparisons of recent performance with an average for the previous five-year period.
- Trends in performance over the last 10 years.

The emphasis in performance analysis indicators is on the current position of absolute and relative indicators for one or a group of countries.

Current performance can only be fully understood, however, if it is also set against recent and longer-term trends.

Some data series only make more sense in a longer time context because of missing values or exceptional year-to-year variation.

Time windows

Five-year windows address annual activity fluctuations within subjects, smooth out marked annual changes in inputs and outputs, help to compensate for missing values in a data series and present a more readily understood profile of research performance.

Thomson Reuters data make use of overlapping five-year windows for appropriate comparisons of e.g. citation counts across time. Because citation counts are less on average for more recent years a direct comparison between two years is sometimes meaningless. If the citations that accumulate over a fixed period of years are used then this provides a sensible reference point between publications from different years or periods.

Thomson Reuters recommends using a five-year (NSI5, National Science Indicators over five years) period for papers and the citations that are attributed to them. Thus the NSI5 for 1998 is the set of papers published in the years 1994-1998 and the citations to those papers that had accumulated by the end of 1998. The NSI5 for 1999 will overlap with the last four years of papers and include the next later year, with the citations that accumulate for those papers to the end of 1999.

Evidence groups data into five-year windows using the same convention. The average annual performance for a five-year window labelled 2007 will be the average for the years over the period 2003-2007.

Moving five-year windows also help to overcome the problems of missing years in OECD data.

Current performance

The last calendar year (2007) has been used for many of the indicators.

In some instances there are as yet no data for the last year, so the most recent year for which data are available is used instead. This is usually 2006, but sometimes 2005.

Where five-year windows are employed, the current performance is usually based on data for 2007 or the 2007 ‘window’ which covers the average performance for 2003-2007.

Recent performance

When ‘recent’ performance is calculated, this is done using the latest available data. Because some data from earlier years will be revised later, this means that the ‘recent’ value in a later report may differ from the calculation for the same value given in an earlier report.

If ‘recent’ data are changed then rankings may be revised as a consequence. Thus, the UK may in one report be ranked 10th recently and currently, yet in the next report be said to have improved from 12th to 10th. This will be because either the UK or another country’s data has changed so that the UK’s relative position for past years has fallen.

Current performance is usually compared with the average performance in recent years.

For this report, recent usually means the previous five years. If the current data refer to 2007 then the recent data refer to the average for 2002-2006.

For five-year windows, the window used for the recent comparator is specified in the particular analysis.

Longer-term patterns

Trends are important where year on year variation can only properly be interpreted in the context of the longer term. Different forms of trend analysis may require annual data or rolling five-year windows. Each can help to establish, first, whether the current snapshot is a good reflection of performance and, second, whether any projection can be made of likely future performance.

Lags between inputs and outputs

The timing (or phase) relationships between different types of data are important for Science and Engineering Base (SEB) indicators. For example, inputs precede outputs. A specific project grant will precede the publications that report on the project outcomes by some years.

A three-year lag has sometimes been inferred in UK policy studies, mostly because this fits with a long established three-year project structure where funding is allocated in year 1 for activity that starts immediately and begins to show substantive results in year 2 leading to articles being written in year 3 and later. Publication may occur 12-18 months after an article is written.

The time lag between input and output may vary between indicators and change over time and there may be other, less transparent, links to elucidate. There is therefore no simple, universal time lag that could readily be applied to this indicator system.

We could also consider not three- or five-year lags but a longer term. For example, we could explore patterns at institutional level over 10-year or even longer periods that take into account investment through capital as well as recurrent spend. The practicalities of such consideration would be a challenge.

Furthermore, there is no evidence either that all national systems have the same time lags or that these differ. We do know that there are differences in citation behaviour between countries (we discuss this in more detail below), which sometimes lead to a 'spike' in relative UK citations soon after publication at the same time as a relative 'trough' in Japanese citations. Later analyses shows the Japanese tend to pick up but at a slower rate while some UK papers may peak early.

To summarise, no time lag has been applied to the secondary indicators because we have no clear and uniform basis on which to make general assumptions. Output data are therefore compared with input data for the same year, although these inputs cannot have funded these outputs. More specific analyses with different time lags may be used in a future indicator cycle, but this will depend on exploring alternative scenarios to throw light on this aspect of research performance.

Bibliometrics

Bibliometrics are important in indexing research performance. Bibliometric data have particular characteristics of which the user should be aware, and these are considered here.

The data come from Thomson Reuters databases, a single source collated to the same standard and therefore providing a level of comparability not found in other data. The data are also valuable because they can readily be disaggregated by field, by year and for most countries.

Journal papers (publications, sources) report research work. Papers refer to or 'cite' earlier work relevant to the material being reported. New papers are cited in their turn.

Papers that accumulate more citations are thought of as having greater significance or influence in their field. Citation counts are therefore recognised as a measure of impact, which can be used to index the excellence of the research from a particular group, institution or country.

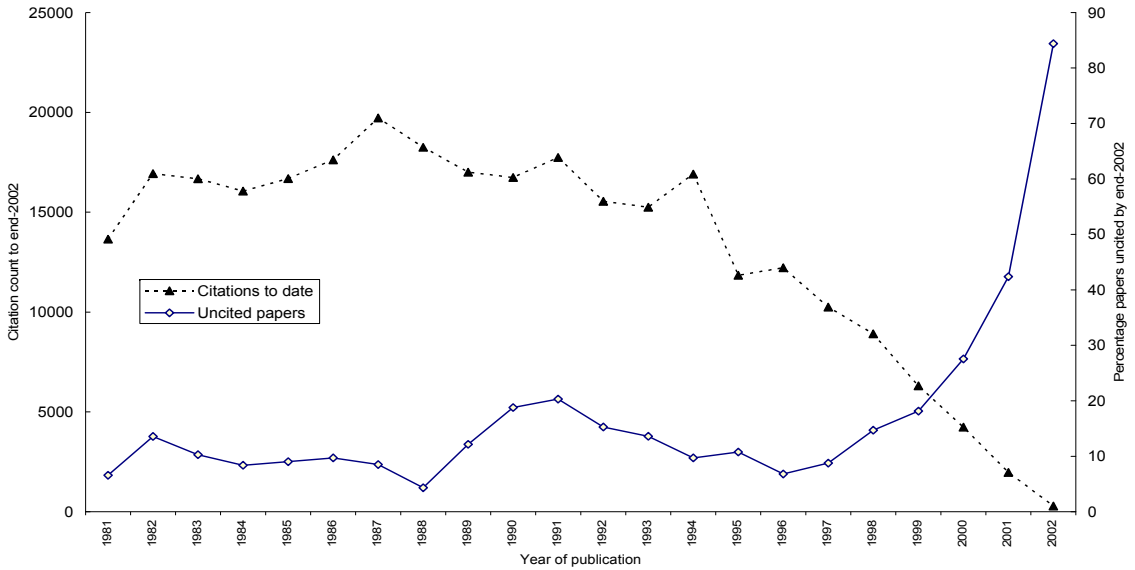
Most impact measures use average citation counts from groups of papers, because some individual papers may have unusual or misleading citation profiles. These are diluted in larger samples.

Time factors

Citations accumulate over time. Older papers therefore have, on average, more citations than more recent work. The following Figure shows the pattern of citation accumulation for a set of 30 journals in Geological Sciences. Papers less than eight years old are, on average, still accumulating additional citations. Only for older sources has the citation count plateaued.

Papers are also more likely to be cited over time. The Figure shows that the percentage of papers that have never been cited drops over about five years. Beyond five years, some 10% or more of papers remain uncited.

Citation accumulation for papers in Geological Sciences



Account must be taken of these time factors in comparing current research with historical patterns. For these reasons, it is sometimes more appropriate to use a fixed five-year window of papers and citations to compare two periods than to look at the longer term profile of citations and of uncitedness for a recent year and an historical year.

Discipline factors

Citation rates vary between disciplines and fields. On the whole, citations accumulate more rapidly and plateau at a higher level in Biological Sciences than Physical Sciences, and Natural Sciences generally cite at a higher rate than Social Sciences.

There is no intention that the indicators reported here should be used for disciplinary comparisons within countries. Account must be taken of disciplinary factors in comparing impact indices. For example, a direct comparison of citations per paper between Biochemistry and Economics is inappropriate and would be misleading. The world average in a given field, however, can provide a useful reference point for comparisons between countries. It is more informative if the values for each country within any discipline are normalised, or REBASED against a world average for that field. Rebased impact factors in this report refer to a world average index of 1.0 for that field.

All comparisons made in this report are “like-for-like”. Citation rates may be less informative about performance in some fields because they may be lower or citation behaviour (the reasons why people cite other work) may be poorly understood. Nonetheless, so long as we use fair comparisons, we should expect that such variations do not unbalance our conclusions. For example, UK Natural Science is compared with USA and Germany Natural Science, and UK Social Science in 2003 is compared with UK Social Science in 1998-2002. Only if behaviour within a discipline differs significantly between countries or if the data for one country is unrepresentative compared to others would the comparisons become invalid.

Bibliometric data for Social Science should always be regarded with caution. Recent analyses confirm that, while they may be both valid and useful, there are issues about national imbalances – especially at a disaggregate field level – and any publication analyses must be interpreted against the background context of other indicators and detailed commentary.

Location factors

Citations accumulate for each author on a paper and for each institution and country included in the authors’ addresses. The world total of citations is consequently less than the sum of national citations. As an example, imagine a set of four papers:

One has a German author, one has a UK author and two have both UK and German authors.

Each paper is cited twice. There are a total of eight (8) citations.

There are six UK citations: two to the UK only paper and two to each of the jointly authored papers.

The (UK + Germany) citations = 12, because there are similarly six German citations. This exceeds the actual total of 8.

While it is feasible to create an overall total for numbers of world papers and citations, from which duplication can be removed, it is onerous to do this for a changing sub-set of countries for each data analysis. De-duplication has been done for the EU27.

Data are only available for some countries in the DIUS comparator group for some analyses (e.g. data on researchers are a sub-set). Consequently, where the sum of papers or citations is calculated for the sub-set (e.g. to index citations per researcher), then the total includes duplicates for joint papers.

The value of the UK activity in relation to both the DIUS comparator group and the world total is given for indicators involving only publications data. In these cases, it will be seen that the UK is apparently smaller as a proportion of the DIUS comparator group than of the world, because of the duplication between countries. Nonetheless, this has no effect on comparative values such as rank or ratios of activity.

National factors

The volume of papers on Thomson Reuters databases for G8 countries is not disproportionate in the Natural Sciences, although there is said to be an Anglophone bias and some of these countries do not have English as a first language. The imbalance in some – if not all – the Social Sciences and in the Humanities is greater.

There is some selectivity in publication behaviour in some countries. For example, a study of Spanish Earth scientists (J Rey-Rocha, Scientometrics (2002) 55, 377) showed that they publish parochial reports in Spanish journals not indexed by Thomson Reuters. The effect of this on Spanish citation indices is not clear but it may mean that only higher impact work is indexed. If a similar pattern is true for other countries, there would then be a consistent sampling bias in favour of more citable publications for non-Anglophone countries (i.e. lower volume but higher average quality).

Citation behaviour also differs between countries. UK researchers tend to access new work and cite it more rapidly than researchers do elsewhere. This means that some high UK relative citation rates may dip later. This does not distort overall perceptions of relative national performance but it is important to be aware that this is a background component.

Glossary

AHRB The Arts and Humanities Research Board was established following the recommendations of the Dearing Report (1997). In 2003 the Secretary of State for Education and Skills confirmed that the new Arts and Humanities Research Council should be established by 2005.

AHRC The Arts and Humanities Research Council funds research and postgraduate study within the UK's HEIs in traditional humanities subjects, such as history, modern languages and English literature, and in the creative and performing arts. It also provides funding for museums, galleries and collections that are based in, or attached to, HEIs in England. The AHRC was established on 1 April 2005, and replaced the Arts and Humanities Research Board.

ANZSRC The Australian and New Zealand Standard Research Classification was released by the Australian Bureau of Statistics (ABS) on 31 March 2008 to update a 1998 Standard Research Classification and incorporates both 'Field of Research' codes and socio-economic objective codes. There are about 40% more research codes than the 1998 classification so as to align the classification to research currently being undertaken in Australia and New Zealand and reduce the volume of research categorised as "not elsewhere classified". The ANZSRC includes concordance tables to enable organisations to update administrative systems, and allow for analysis of data across the various versions of the classification. The ANZSRC also maps to the OECD Fields of Science and Technology classification to allow for international benchmarking.

ARC The Australian Research Council is a statutory Australian Government body established under the Australian Research Council Act 2001 and reporting to the Minister for Innovation, Industry, Science and Research. The ARC advises the Government on research matters and manages the National Competitive Grants Program. The ARC's mission is to advance Australia's research excellence to be globally competitive and deliver benefits to the community. It supports fundamental and applied research and research training through national competition across all disciplines, with the exception of clinical medicine and dentistry, and brokers partnerships between researchers and industry.

BERD Business enterprise expenditure on R&D – the total R&D performed in the business sector. Contrast with BE-GERD, which is that part of GERD funded by the business enterprise sector.

Bibliographics is used as a term for descriptive data referring to publication activity or submissions that do not provide a direct measure of performance.

Bibliometrics are measures of research activity and performance derived from databases of journal articles and of citations of those articles. There are associated secondary measures based on relative journal and article citation rates.

BSTS refers to OECD's Basic Science and Technology Statistics. These are disaggregated further than MSTI but cover fewer countries. In 2004, BSTS was succeeded by Research and Development Statistics (RDS).

Category A (Cat. A) staff are the number reported at the UoA level and are a measure of the potential research capacity of an institution. As part of the RAE, HEIs are invited to put forward for assessment those staff in a department who were involved in research. Staff are required to have a salaried contract with the institution indicating their academic duties (including teaching, research or both) and can be entered under one of a number of categories reflecting such factors as the date they joined or left the institution and their teaching/research status. Category A staff in post on a stated census date can potentially count towards a volume measure that acts as a multiplier for research funding.

Category A (Cat. A) staff selected are the number of Category A staff selected at the UoA level and is a measure of the realised research capacity of an institution. Institutions are required to decide which Category A staff potentially involved in research they will actually put forward in each category. Some institutions, aware that research funding is influenced by the relationship between quality and volume of research

activity (including staff numbers) assessed, may submit or select only a proportion of their staff for submission.

Chief Scientific Adviser (CSA, GCSA) is the head of the Government Office for Science (GO-Science) within DIUS, and provides advice to the Government on science, engineering and technology matters.

Citations are the formal references made in a journal paper or other publication to earlier work. These citations (or cites) usually indicate that the earlier work supports the publication's methods, data or claims in some way. Negative citations may also occur.

Current Contents was an early current awareness product of ISI (q.v.) which enabled researchers to keep up-to-date with new serial publications in identifiable research fields defined by journal categories. It appeared in a number of subject-based versions which covered various combinations of over 100 field categories.

DBERR The Department for Business, Enterprise and Regulatory Reform came into being in July 2007 and brings together functions from the former Department of Trade and Industry.

DELNI (formerly DENI) is the Department for Employment and Learning, a government department in the Northern Ireland Executive responsible for distributing public money for higher education in Northern Ireland. The department was originally the Department for Further and Higher Education, Training and Development..

Department for Children, Schools and Families (DCSF) emerged form the DfES as one of three new Government departments set up by the Government in June 2007. The others are the Department for Innovation, Universities and Skills (DIUS) and the Department for Business, Enterprise and Regulatory Reform (DBERR).

DfES The Department for Education and Skills, the parent body of HEFCE, was dissolved in July 2007. Its predecessors include the Department for Education and Science (DES), which was responsible both for direct university research funding via the UGC and for the Science Budget until 1993. Its responsibilities for the Higher Education research base transferred in 2007 to DIUS. Other functions transferred to DCSF.

Director-General of Science and Innovation The DG-SI is a senior member of DIUS who advises on the allocation of the UK Science Budget to the Research Councils.

DIUS The Department for Innovation, Universities and Skills came into being in June 2007 and took responsibility for Higher Education from DfES and for the Research Councils (and associated responsibilities) from DTI.

DTI The Department of Trade and Industry, in existence until June 2007, was the home of OSI and was responsible for the Research Councils, which were transferred to DIUS. Other functions transferred to DBERR.

Dual support is the system, essentially established when the Research Council apparatus was set up by the Science and Technology Act 1965, by which universities are provided, initially by the UGC and later the HEFCs, with core research funds to enable the support of the 'well-found laboratory' and then acquire funds for specific research projects through the Research Councils.

Efficiency in the context of Evidence Ltd reports is the relationship between the volume of outputs from the system and a stated volume of inputs.

Effectiveness in the context of Evidence Ltd reports is the relationship between the volume of outputs and their average quality.

ERA See Excellence in Research for Australia.

Eurostat The Statistical Office of the European Communities is situated in Luxembourg. It had a budget of €140 million in 2000. Established as a directorate of the European Community in 1959, its current task is to provide the European Union with a high-quality statistical information service at European level that enables comparisons between countries and regions.

Excellence in Research for Australia (ERA) is an initiative announced on 26 February 2008 by the Minister for Innovation, Industry, Science and Research as a new research quality and evaluation system. It will be developed by the ARC and will assess research quality in eight discipline clusters within Australia's HEIs using a combination of indicators and expert review by committees.

Expected citation rate – see Journal Average Impact factor.

Frascati Manual was first published as the outcome of an OECD meeting in June 1963 with national experts on R&D statistics at the Villa Falcioneri in Frascati, Italy. The result was the first official version of the Proposed Standard Practice for Surveys of Research and Development, now commonly known as the Frascati Manual. The Working Party of National Experts on Science and Technology Indicators (NESTI) has now developed a "Frascati Family" of methodological manuals, including publications on innovation (Oslo Manual), human resources (Canberra Manual) and the technological balance of payments and patents.

FTEs Full Time Equivalents. Many research and other posts are filled on a fractional basis and there are also a significant number of part-time research students. The balance of full- and part-time posts and students varies between institutions and a direct head-count may therefore be a poor indication of the actual volume of activity. To account for this, head-count numbers may be converted to full-time equivalents (e.g. two 0.5 FTE posts equate to 1.0 FTE). In other cases the actual head count may be more relevant.

G8 refers to a group of eight leading economies. This comprises the UK, USA, Canada, France, Germany, Italy Japan and Russia. The G7 is an earlier version of the same group, without Russia.

GERD is Gross Expenditure on R&D.

GO-Science The Government Office for Science, within DIUS, is headed by the Government's Chief Scientific Adviser (q.v.).

GOVERD is total R&D performed in the government sector.

HE is higher education in the broad sense.

HEFCE is the Higher Education Funding Council for England. It distributes public money for teaching and research to universities and other HE institutions.

HEFCs are the regional Higher Education Funding Councils responsible since 1992 for allocating funding for teaching and for research to UK higher education institutions. In England this is HEFCE. The equivalent organisations in the devolved administrations are SHEFC (now SFC) for Scotland, HEFCW/ELWa for Wales and DELNI for Northern Ireland.

HEFCW is the Higher Education Funding Council for Wales. It was established in May 1992 under the Further and Higher Education Act 1992 and administers funds made available by the National Assembly for Wales to support education, research and associated activities at 12 higher education institutions. Under the Education Act (1994) it is also responsible for initial teacher training in Wales.

HEIs are higher education institutions. In the UK specifically they are the universities and colleges funded for teaching and research by the regional HEFCs (see also TEOs).

HERD is total R&D performed in the higher education sector (which is very broadly defined by OECD and may in some countries cover much more than universities and colleges). That part of HERD funded by the business enterprise sector may be denoted as BE-HERD.

HESA The Higher Education Statistics Agency was established in 1993 and is the central source for HE statistics. It seeks to standardise data collection processes and formats.

Immediacy refers to an estimate of the topicality of the work in a research paper. The immediacy index for a journal would be calculated as [the number of times papers published in year X were cited in other indexed journals during the same year] / [the number of papers published in that year]

Impact is the average citation rate of the outputs for a specified source (country, organisation, author). This is a simple and direct measure of research performance since citations usually reflect acknowledgement by later authors of the value of a published item. The impact figure can be taken as a local measure of the 'worth' of publications. Impact figures can be rebased to take account of the world average figure in the field. In this way, comparisons can be made between fields that have different raw impact values to judge their effectiveness.

ISI® The former Institute for Scientific Information, was founded by Eugene Garfield in 1958 and was acquired by Thomson Business Information, a subsidiary of The Thomson Corporation in 1992. Following

restructuring, the ISI® division was combined with Derwent Information (patent information) to form Thomson Scientific® (q.v.)

Journals are the main mode of rapid output for most scientific fields. Research findings are also published in conference proceedings, reports and books and the significance of these as an output channel varies between fields. The first research journal was reputedly the Journal des Scavans, inaugurated in 1665. It was published by Denys de Sallo in Paris. By 2000 there were estimated to be about 20,000 journals carrying over one million research papers per year.

Journal Average Impact Factor (JAIF) can be calculated as the average number of citations received by the papers in a stated journal in a particular year. JAIF varies between journals: those such as 'Nature' and 'Science' tend to publish papers that receive many citations and they have a high JAIF. Publication in a journal with high impact is often seen as a mark of prestige. JAIF for any one journal varies between years because more recent years have obviously had less time to accumulate citations. See also Journal Impact Factor.

Journal Impact Factor (JIF), as with JAIF, is also calculated through a more complex algorithm by Thomson Scientific®. Journal Citation Reports, which report the JIF, is a commercial product available through Thomson Scientific®.

MSTI is the OECD's Main Science and Technology Indicators. These are at a summary level compared to RDS (BSTS), but cover more countries.

NSI refers to Thomson Scientific®'s National Science Indicator product. The NSI5 is the standard five-year grouping of bibliometric data used in the NSI1 to provide constant time windows for trend analysis, because citations accumulate over time and comparisons between years would otherwise be problematic.

OECD The Organisation for Economic Cooperation and Development is a major source of data for international R&D statistical analyses. It evolved in 1961 from the former Organisation for European Economic Co-operation which was formed to administer American and Canadian aid after World War II. It now has 30 member and 70 associate countries. Its members account for about two-thirds of global goods and services.

ONS The Office for National Statistics was created in April 1996 when the Central Statistical Office merged with the Office for Population, Censuses and Surveys. It is the government department that provides statistical and registration services. The Director of ONS is the National Statistician who is also Registrar General for England and Wales. ONS is responsible for producing economic and social statistics used by Government to create evidence-based policies and monitor performance against them. The Office builds and maintains data sources both for itself and for customers.

OSI The Office for Scientific Innovation, a rebranded OST, now within DIUS.

OST (1) The UK Government's Office of Science and Technology was created in 1992 by the amalgamation of the Cabinet Office's Science and Technology secretariat and the Science Branch of the former Department of Education and Science. In 2005, the OST was rebranded as the OSI whose work, in turn, has latterly gone into the new DIUS, effective June 2007.

OST (2) The Observatoire des Sciences et des Techniques (93, rue de Vaugirard, 75006 Paris) designs and produces R&D indicators and maintains an international database on research, constructed from multiple sources. It produces the biennial 'Science & Technology Indicators' OST runs the 'NormAdresses' project, the goal of which is to improve the way French addresses are recorded in the Web of Science database.

Output is specifically the numbers of journal articles recorded on the databases of Thomson Scientific®, but is used generically to refer to other outputs from research, including patents and highly trained people. Output volume in research journals world-wide was estimated in 2000 to be about one million research papers per year in some 20,000 titles.

PDRAs are Post-Doctoral Research Assistants, the non-permanent research workers in the transition between PhD training and full independence. They are usually employed on short–term, e.g. 3-year, research grants and contracts.

Performance-Based Research Fund is the New Zealand system, introduced in 2003 for assessing and awarding funds for research performance in

NZ tertiary education organisations (TEOs). The PBRF assessment cycle has run in 2003 and 2006 and is planned to run again in 2012.

Performance in regard to research is frequently indexed as the impact of outputs. In Evidence reports there are a wider range of performance indicators, and the ratio between research input and output as well as impact can be an important measure.

Period is used for various time windows:

the period for which Thomson Scientific® data on outputs and impact are available, 1981-current

the period to present from the first Research Selectivity Exercise in 1986

the period between RAEs, e.g. 1996 and 2001 RAEs.

PGRs are Post-Graduate Research students. Along with journal articles, they are one of the key outputs from the research base.

PNPERD is the total R&D performed in the private non-profit sector.

PPP Purchasing Power Parity states that exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries. This means that the exchange rate between two countries should equal the ratio of the two countries' price level of a fixed basket of goods and services. The simplest way to calculate PPP between two countries is to compare the price of a "standard" good that is identical across countries. Sophisticated versions of PPP look at a large number of goods and services. One of the key problems is that people in different countries consume very different sets of goods and services, making it difficult to compare purchasing power.

PSA refers to the Public Service Agreement system. This was introduced in 1998 with the intention of setting out publicly clear objectives and targets showing what Government departments aimed to achieve in terms of public service improvements.

PUBERD is the sum of GOVERD and HERD, equating to R&D performed in the publicly funded sectors.

Purchasing Power Parity, see PPP.

R&D Research and Development as defined by the OECD.

R&D personnel is defined by OECD/Frascati as all persons directly employed on R&D as well as those providing direct services such as R&D managers, administrators and clerical staff.

RAE is the Research Assessment Exercise, succeeded after 2008 by the REF.

Ranking refers to the position an institution holds relative to others in the same field. The data may be ranked according to output volume (numbers of papers produced in a given period) or impact (average of citations per paper in some given basket of publications).

RBI Rebased (or relative) Impact compares performance to a world average for that discipline and year. At a fine level this relative impact can be assessed for specific journals. Science papers tend to attract more citations than social sciences, and there are variations within science. Older papers naturally have more citations than new papers. Unless these factors are taken into account, it is not reasonable to compare citation rates. Reference to the appropriate world average allows this comparison.

Relative citation rate See Rebased Impact.

Research Assessment Exercise (RAE) is the cyclical process of assessing UK higher education research. RAE grades are used as weighting factors to determine the allocation of research resources. RAEs have taken place in 1986, 1989, 1992, 1996, 2001 and (with a revised profiling format) in 2008.

Research Footprint® is a display technique for rendering a number of related research performance indicators simultaneously with an incorporated reference benchmark.

Researchers is an OECD/Frascati definition used to denote professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.

Science Citation Index is a main Thomson Scientific® database of scientific journal publications and their citations. It can be searched electronically (see WoS).

SEB The national Science and Engineering Base (the acronym also refers to the Society for Experimental Biology).

Sector is used in the context of Evidence reports to identify particular parts of the national research base. It can be used to refer both to major sectors (Higher Education, public sector research establishment, health services, industry) and to sub-sectors (e.g. within HE: older, pre-1960 HEIs; 1960-1990 establishments; HEFC establishments).

Science and Innovation Investment Framework 2004-2014 set out the UK Government's plans to maintain a world-class research base through a strategy of increased investment and management, and to increase GERD to 2.5% of GDP by 2014.

http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm

SET refers to Science, Engineering and Technology.

Share is the fraction or percentage of, for example, outputs published by the peak compared to the UK total. It is also used for other research activity measures.

SHEFC The Scottish Higher Education Funding Council was established in June 1992 as a non-departmental public body responsible to the Scottish Executive. It was subsumed by the SFC.

Scottish Funding Council (SFC) distributes more than £1.6 billion to Scotland's colleges and universities for teaching and learning, research and other activities in support of Scottish government priorities.

Sources are the publications (papers, articles) in journals tracked by the Thomson Scientific® database.

SUoAs Super-UoAs are disciplinary groupings of cognate UoAs with similar publication profiles.

Super-UoAs See SUoAs.

Thomson Scientific® Inc, a division of Thomson Reuters Professional Division, is the world's premier source of information on journal outputs and their citations as well as patent, technical, industry codes and standards information. The division originated as the Institute for Scientific Information (ISI®), founded in 1958 under the direction of Dr Eugene Garfield, a leader in the field of citation analysis. Thomson Scientific® encompasses a number of information businesses, including Current Drugs, Delphion Research, Derwent, ResearchSoft, Techstreet, and Wila-Derwent. Thomson Scientific® provides a range of commercial information products designed to support research and research management, including 'Current Contents' and the Science and Social Science Citation Indexes. Thomson Scientific® indexes over 8,000 journals in 35 languages, which is agreed to represent most or all of the material likely to be recognised as having significant value to others for most science fields. However, the data may under-represent new and emerging fields and so disbenefit interdisciplinarity and is poorer in coverage of the Social Sciences and the Arts and Humanities.

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UoAs Units of Assessment are the disciplinary units used as subject categories for research assessment. In 1992 there were 72 UoAs, but in the 1996 and 2001 RAEs a system of 69 UoAs was used, not all of which were active on both occasions.

UK average impact is the average number of citations per paper attributable to a UK address for publications in that field. For UK HEIs, the average impact is the average of the total HEI dataset and not the average of the individual HEIs.

Web of Science (WoS) provides access to current and retrospective information from about 8,700 high-impact research journals. It includes Science Citation Index® (1900-present), Social Sciences Citation Index® (1956-present), Arts & Humanities Citation Index®

(1975-present), Index Chemicus® (1993-present), and Current Chemical Reactions® (1986-present).

Workforce (labour force) is an OECD term used to denote the total number of persons available for work, whether in employment or not.

Department for Innovation, Universities and Skills

International comparative performance of the UK research base

July 2008

Printed in the UK on recycled paper with a minimum HMSO score of 75

First published July 2008

Department for Innovation, Universities and Skills www.dius.gov.uk