evidence

Department for
Business, Innovation, and Skills

International comparative performance of the UK research base

September 2009

Using DBIS PSA target metrics for Research or Private Study

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Summary

This is our sixth report on the performance of the UK research base. The UK exhibits strong relative international performance in terms of sustainable achievement and productivity and 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 trail 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 other countries, notably Brazil and Iran. The influence of the former SE Asian 'tiger' economies is now less evident than formerly and the performance of Japan has continued to decline in many areas of former strength.

Theme 1 – Bibliometrics

- Output has fallen slightly to 7.9 % of world papers, which is associated with changes to the database.

The UK published 91,723 papers indexed by Thomson Reuters in 2008. Its share of world publications is down from 9.3% in 1999 to 7.9% in 2008 but there are similar changes for other leading countries. The USA dropped from 34% to 29% of world share over the period. Much change is due to China's four-fold growth in ten years to over 110,000 papers in 2008. Iran, Brazil and South Korea increased their share. By subject category, UK output share is 2nd behind the USA in clinical, health, environmental, mathematics and the social sciences, 3rd in biological sciences and engineering, 5th in mathematics and 6th in physical sciences. The UK is strong on publication productivity with 2.26 indexed papers per researcher

- Citations have risen to 11.8% share of world.

The UK's share of world citations has risen to 11.8% in 2008 despite the drop in share of publications. Changes in volume have not affected the indices of quality. Share for G8 countries other than Germany has dropped and China's share for the most recent year remains below 5% of world. UK share of world citations is 2nd only to the USA in clinical sciences (12.7%), health sciences (13.8%), biological sciences (12.4%), environmental (13.6%), social sciences (13.2%) and business (13.7%). It is ranked 3rd in mathematics (9.7%), ahead of France but behind Germany, and engineering (7.7%), behind the USA and China. It is ranked 5th in physical sciences (9.1%). With 13.4 citations per researcher, the UK is ranked 3rd on citation productivity behind Switzerland and the Netherlands. Counting frequency of presence in the top three by citation volume in the main fields, the UK is in the top three in seven out of the nine areas and second only to the USA. Japan and France have now dropped out of this indicator while China is the key new entrant.

- Citation impact has improved and is highly competitive with the USA. The UK has 14.4% of the top 1% of most highly-cited papers.

The UK's average citation impact (1.50) has improved by 14% on the recent past, compared to an improvement of 8% in last year's report. It is 2nd in the G8, ahead of the USA but overtaken by Germany. The comparator group is led by Switzerland (1.83), Denmark and the Netherlands. China's impact seems to be stabilising at around 0.7 world average. The UK maintains high impact across subject areas. It is ahead of the USA in clinical sciences, health sciences, biological sciences, and environmental sciences. In mathematics, the UK has overtaken the USA but has been passed by Germany. In physical sciences and engineering, the UK is marginally 3rd to the USA and Germany. In social sciences, improved coverage has dampened impact volatility and the UK's position improves despite the shift to more non-Anglophone journals.

The UK has 12,776 papers among the world's most highly-cited 1% for 1999-2008 with an average impact of 153.2 citations per paper. Its share (14.4%) compares favourably to the UK average of around 7.9% of world papers and 11.8% of world citations. The UK's contribution is about 25% of the EU total.

Theme 2 - Collaboration

- Collaboration is increasing and diversifying. The UK has increased share with many dynamic and expanding economies and has a high gain from small European partners.

UK publications with a non-UK co-author have increased from 23,800 (33% of total output) in 1999 to 43,000 (47%) in 2007. The volume of co-authorship with every member of the DBIS comparator group has increased, typically by a factor of 2-3 but fourfold in the case of China and six-fold with Iran. Impact gain is less on average now than historically, probably because of diversification. Papers with the USA, Germany and France have impact 50% higher than the UK research base average. For Brazil, impact is 1.3 times UK average but the greatest returns on collaboration come from smaller European partners: Switzerland, Denmark and Belgium.

Theme 3 – Research postgraduate training

- The UK has a rising PhD output volume. Its share is similar to its output share but has fallen slightly.

PhD output has risen from around 11,000 in 1999 to over 16,000 in 2006. The UK remains 3rd in the G8 and the comparator group, with an 8.3% share behind the USA and Germany. The USA shows a steep recent rise from 2004 but its share is down on 1999. In natural sciences, UK PhD output share is falling but at 9.4% remains above the general average. In social sciences UK PhD output has increased by 50% since 1999. With 271 PhDs per million population, the UK is on a rising trajectory to match Germany in 4th place. Relative to the existing researcher population, the UK has increased its productivity ahead of comparator group average.

Theme 4 – Research workforce

- Workforce research capacity is below average and falling.

Previous reports have suggested that UK availability of highly skilled people compared to population and employment is poorer than competitors, but OECD researcher definitions may engage more with a technology-based than a knowledge-based economy.

The ratio of UK researchers to total population has fallen by 2% while comparator group average is rising by 9%. UK researcher density is only about 0.7 of comparator group average and the gap between the UK and France and Germany is growing. The UK was 15th in the comparator group on availability of researchers in the workforce and its index fell by 4% in 2007. The UK has about 325,000 total R&D personnel compared to about 175,000 of these who are researchers. The relative availability of R&D personnel in the UK has risen by 4% on the recent past, but the comparator group average has risen by 7%. Researchers are now scarcer relative to R&D personnel: the UK has seen a drop from 0.55 to 0.53 researchers for every R&D worker.

Theme 5 – Output productivity

- The UK has an exceptionally high level of output productivity.

The UK is 1st in the G8 on publication productivity with almost 32 papers recorded for every $Bn GDP. It has improved its share of papers compared to its share of GDP by 6%. On citations per unit GDP, the UK has fallen by 5% against comparator group average but remains 1st in the G8. With 2.51 papers per $million GERD, the UK is not only 1st in the G8 but has risen from 4th to 3rd in the comparator group as a whole. The UK is 1st in the G8 and 3rd overall in the comparator group although its share of citations relative to its share of PUBERD has fallen by 8% for 2007. The UK (1.35 cites per HERD) has dropped from 2nd to 3rd in the comparator group, behind the Netherlands (1.52) and Belgium (1.42) while few other countries exceed 1.0.

The UK currently produces 9.3% of comparator group PhDs compared to 6.6% of comparator group HERD and has been consistently more productive. It is gaining on Germany in the G8 and with 2.01 PhDs per $million HERD has moved up from 5th to 4th place in the comparator group.

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 sixth report with these indicators and has undergone several changes. In 2005, we introduced data covering the Arts and Humanities. In 2008, the information content, analysis, commentary and overall structure were modified so that the main themes better reflected the areas which had been found to be most useful and of greatest interest to readers and users and tables and charts were simplified to make the indicators clearer, with explicit statements about outcomes for the UK. This year, the data content has been developed so that the mapping between journals and the report subject categories is at a finer level, with some shifts between subjects as a consequence. Thomson Reuters' bibliometric data content is also expanded for all countries with significant additional data in social sciences and technology.

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 DBIS 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 the technologically 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), now part of DBIS) 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 DBIS 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 DBIS 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 DBIS 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 are grouped by publication similarity amongst the underlying disciplines into ten main areas (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

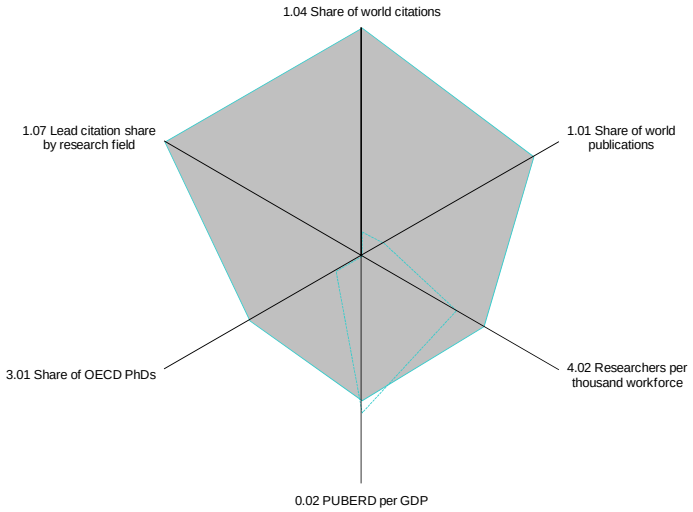
Indicator number	Description of performance indicator	Level of disaggregation	Primary data sources
THEME 1	Bibliometric outputs		
1.01	Number and share of world papers	System	Thomson Reuters NSI 2008
1.02	Number and share of world papers in ten main research areas	Main research field	Thomson Reuters NSI 2008
1.03	Papers relative to researchers	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
1.04	Number and share of world citations	System	Thomson Reuters NSI 200
1.05	Number and share of world citations in ten main research areas	Main research field	Thomson Reuters NSI 2008
1.06	Citations relative to researchers	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
1.07	Rank on citation volume in nine main research areas - frequency of occurrence in top 3 nations	System	Thomson Reuters NSI 2008
1.08	Proportion and share of uncited papers	System	Thomson Reuters NSI 2008
1.09	Citation impact (citations per paper) relative to world baselines	System	Thomson Reuters NSI 2008
1.10	Citation impact relative to world baselines in ten main research fields	Main research field	Thomson Reuters NSI 2008
1.11	Variation and consistency of research strength	System	Thomson Reuters NSI 2008
1.12	Papers in top 1% by citation count	System	Thomson Reuters NSI 2008
THEME 2	Collaboration		
2.01	UK co-authorship for select partner countries relative to total UK co-authorship	System	Thomson Reuters NSI 2008

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 2008
THEME 3	Postgraduate research training		
3.01	Number and share of OECD PhD awards	System	OECD MSTI 2009-1
3.02	Number and share of OECD PhD awards in five main research areas	OECD field of science	OECD RDS 2009-1
3.03	PhDs awarded relative to population	System	OECD MSTI 2009-1
3.04	PhDs awarded relative to researchers	System	OECD MSTI 2009-1
THEME 4	Research workforce		
4.01	Researchers relative to population	System	OECD MSTI 2009-1
4.02	Researchers relative to workforce	System	OECD MSTI 2009-1
4.03	R&D personnel relative to population	System	OECD MSTI 2009-1
4.04	R&D personnel relative to workforce	System	OECD MSTI 2009-1
4.05	Researchers relative to R&D personnel	System	OECD MSTI 2009-1
THEME 5	Output productivity		
5.01	Papers relative to GDP	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
5.02	Citations relative to GDP	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
5.03	Papers relative to GERD	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
5.04	Citations relative to GERD	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
5.05	Citations relative to PUBERD (GOVERD + HERD)	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1
5.06	Citations relative to HERD	System	Thomson Reuters NSI 2008; OECD MSTI 2009-1

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 2008-1
5.08	PhDs awarded relative to HERD	System	OECD MSTI 2009-1
5.09	PhDs awarded relative to HERD in five main research areas	OECD field of science	OECD RDS 2008-1

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 DBIS comparator group average. The shaded area - the 'footprint' - can be compared directly with the lighter 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 DBIS 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 changing somewhat. It has declining values for researchers per thousand workforce and PUBERD per GDP but its PhD output is now rising sharply. It will continue to be a strong performer across the board, because of its sheer size, and achieves maximum performance in share of world citations and lead citation share by field. It is now clearly 2nd to the EU in share of world papers. Other nations continue to challenge the USA in terms of efficiency and effectiveness. Its weakest performance is in public expenditure on R&D as a proportion of GDP where it ranks only 14th of 22 countries.

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 0.0) and researchers per workforce (indicator 4.02, where data are occasionally patchy) following the EU's eastwards growth into less research-intensive economies. This effect is balanced, however, by the research dynamism of Poland and others.

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 competitively with the USA in an increasing number of areas, 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, but the concentration of researchers within its workforce (indicator 4.02) is low by comparison with competitor countries.

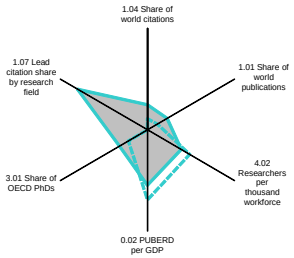
Germany, with its substantial research base, continues to display a well-balanced overall performance – strong PhD output with good share of papers and citations. Each of our reports has confirmed that Germany is the major research competitor for the UK in Europe. In some areas, these two form a lead sub-group with the USA, but those are joined by China in other areas.

Japan has seen a marked decline in performance on a range of indicators. Its value for researchers per thousand workforce (indicator 4.02) has declined, but its public expenditure on R&D as a proportion of GDP is increasing and may restore its profile. France's performance once again tracks group average values closely. Switzerland retains a strong average bibliometric performance in many fields but in the Research Footprint® presentation its relatively small research capacity becomes clear.

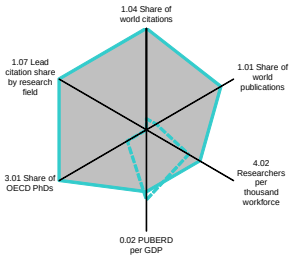
China's Research Footprint® does not yet really reflect the exceptional growth in the size of its research base, with increasing share of papers and citations. It now has a presence in lead citation share by field (indicator 1.07) but on citation impact it appears to be plateauing at a level below world average. Its exceptional volume growth may be diluting higher impact activity, but diversification into more research fields may create fresh impetus.

Research Footprints® for UK, G8 countries (except Russia) and the EU27

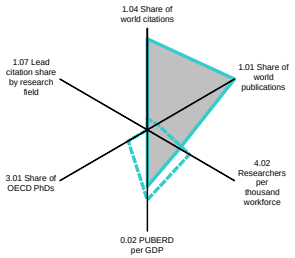
UK



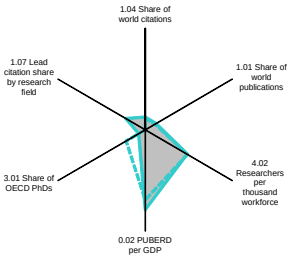
USA



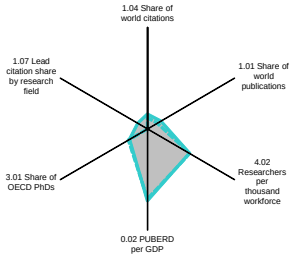
EUROPEAN UNION



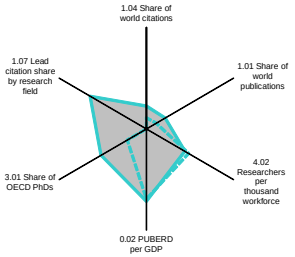
CANADA



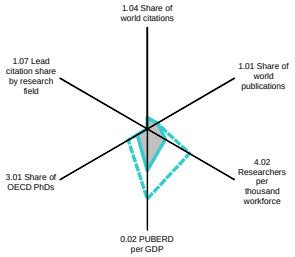
FRANCE



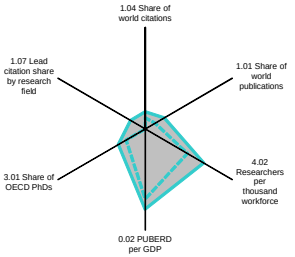
GERMANY



ITALY

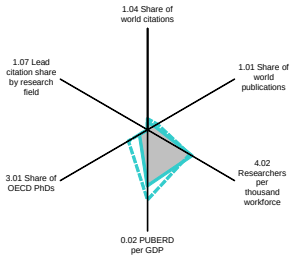


JAPAN

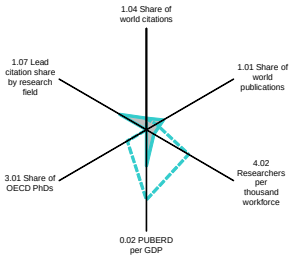


Research Footprints® for other leading comparator nations

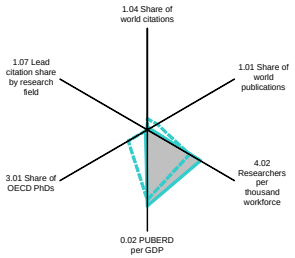
AUSTRALIA



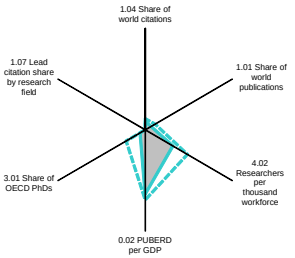
CHINA



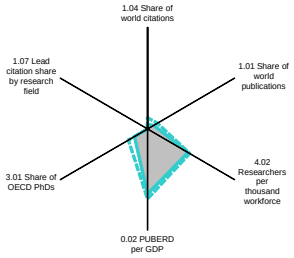
DENMARK



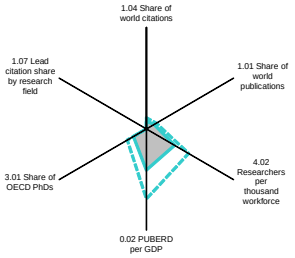
NETHERLANDS



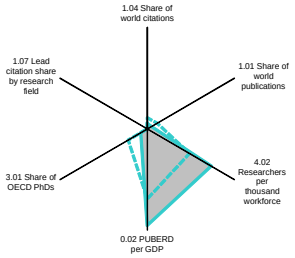
SOUTH KOREA



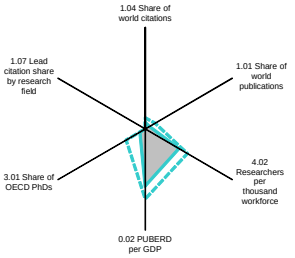
SPAIN



SWEDEN



SWITZERLAND



Thematic commentary

There has been a global increase in the volume of papers indexed by Thomson Reuters in 2008 compared with prior years. This growth has been focused outside the G8 nations and increases the proportion of non-Anglophone content. The consequence is that there are exceptional increases in relative volume for Brazil, India, China and Iran. By contrast, G8 and EU countries exhibit a relative decrease. The UK's volume growth is over 10%, which should improve the information content of other indicators.

Theme 1 – Bibliometric outputs

In 2009 the UK published 91,723 papers indexed by Thomson Reuters. The UK's share of world publications is down from 9.3% in 1999 to 7.9% in 2008 and similar change for other leading countries is evident. The UK remains ahead of Germany, which also drops share, while France maintains its share. The USA has dropped from 34% to 29% of world share over the period but remains the clear leader. Much of the change is due to China's four-fold growth in ten years to over 110,000 papers in 2008. Revised data indicates it now overtakes the major EU states in 2006, but its rate of increase is slowing. Japan gains little benefit from data changes and continues its recent decline. Elsewhere, Iran is now up to near 1% of world output, from 0.13% in 1999, while Brazil and South Korea double their share to 2.4% and 2.8%. (Indicator 1.01)

Bibliometric data cover ten main subject areas. In clinical sciences, UK volume output increased in 2008 to 32,800 papers. UK share has fallen from 9.5% to 8.7% but it remains ranked 2nd in the world behind the USA. Changes in health sciences' data emphasise UK strength where output (2nd to the USA) increased in 2008 to 10.6% share of world total. UK output in biological sciences grew by 2,000 papers in 2008, or about 9% compared to the recent past, but comparator group output increased faster and UK share of world output dropped from 8.4% to 7.6%. Nonetheless, the UK remains 3rd in this subject area, behind the USA and Japan and just ahead of China and Germany. The UK has a 9.5% share of world output in environmental sciences and output rose in 2008 by over 20% compared to the recent past. It remains 2nd behind the USA. In mathematics, the UK increased output to 5,930 papers in 2008, up by 32% compared to the recent past and remains at 5th, behind the USA, France, Germany and China. Its share of world output dropped from 7.3% to 6.8%. In physical sciences, UK output increased by about 12% compared to its recent average, but this is less than the comparator group average of over 20%. The UK retains its 6th rank just behind France. The UK's engineering output has increased but again by less than the average for the comparator group so its share of world has dropped to 6.3% from 7.3% recently, but it has gone up in rank overtaking Japan to be 3rd behind the USA and China. Database coverage of the social sciences is much improved. There is a substantial increase in UK output of about 24% in 2008 compared to the recent average and in line with general world trends. The UK's share of indexed articles remains in excess of 12% of world total and it is ranked 2nd behind the USA. In business, UK output increased by 29% and it remains ranked 2nd to the USA but world coverage has changed and UK share of world total drops to 13.1% from a 14.8% recent average. Despite the coverage change the UK also remains about 3 times the comparator group average in volume.

In clinical sciences Iran (30% recent increase to 0.66% share), Brazil (+30%, 2.16%) and India (+15%, 1.58%) also contribute to the global shift in activity. Some smaller S E Asian nations continue to grow but not as strongly as in earlier analyses. In health sciences, China and India both have very strong growth and Iran has almost doubled its health research output in just two years. Iran also doubled biological science output over two years and is now ahead of Singapore and just behind South Africa. China's biology growth is also exceptional, even compared to its strong overall expansion, taking it to 23,000 papers in 2008 compared to 4,600 in 2000. China's mathematics growth may have plateaued with a relatively small increase on 2007. Iran, India and Brazil are the only other nations with significantly increased share. The USA now only just leads in physical science output: its world share is less than 20% whereas China's share is up to 18%. India and Brazil have almost doubled output in the ten years, but Iran has seen a ten-fold increase in physical science outputs and a five-fold increase in share to 1.3%. Iran's engineering output has now grown to 1.6% of world, greater than Belgium or Sweden and not far short of Russia (1.8%). China's growth is a major factor in changing world output and share. China is now at 13% but still well

behind the USA, with a clear lead at 24.5% of world total. There is some indication that China's growth may now be slowing a little as it shifts investment into other areas. India has less than 4% of world total while Taiwan and S Korea are both around 5%. (Indicator 1.02)

The UK is very publication productive and has maintained a strong position (2.26 papers per researcher), 4th overall behind Switzerland (3.37) and the Netherlands (2.81). It is effectively 1st in the G8 group and well ahead of Germany (1.38), France (1.34) and the USA (1.06) where productivity is now less than half that of the UK. (Indicator 1.03)

Because citation count is inevitably lower for recent publications, it is share rather than volume of citations which is the key index to monitor. Despite a drop to 7.9% share of world publications (Indicator 1.01), the UK's share of world citations has risen to 11.8% in 2008. The share is in line with previous years, which suggests that the UK's increased volume of publications has not been made at the expense of quality. The UK's rise is matched by that of Germany, but that of other G8 countries has dropped and China's share for the most recent year remains below 5% of world. (Indicator 1.04)

UK share of world citations in clinical sciences has risen to 12.7% and its lead over the comparator group average has increased. It is ranked 2nd behind the USA. UK performance in health sciences has improved to 13.8% of world and it remains 2nd ranked to the USA and well ahead of other G8 economies UK share of world citations in biological sciences, an area of historic strength, has risen to 12.4% from 11.7% in the recent past and it remains 2nd behind the USA. The UK and Germany are moving further away from other G8 nations while China's share has remained around 4% for the last three years and its trajectory seems to have slowed. Brazil, however, has doubled its share from 0.8% in 1999 to 1.6% in 2008. UK share of world citations in environmental sciences has improved to 13.6% in 2008 and is again 2nd behind the USA. In mathematics, UK share has risen to 9.7% in 2008; its rank is unchanged ahead of France but behind Germany. Iran has reached 1.7% of world cites, its highest share in any subject. The UK's share of world citations in physical sciences has improved to 9.1% from 8.5% in the recent past. Although its rank is unchanged it seems certain to pass Japan in the next year but the USA, China and Germany look likely to establish a leading group separated from other major research economies. UK share of world citations in engineering has been sustained and its rank remains 2nd behind the USA in the G8 and 3rd overall in the comparator group. UK share in social sciences has risen to 13.2% in 2008 from 12.2% in the recent past and it remains 2nd behind the USA. The change in data coverage is reflected in Germany's much improved position with a citation volume similar to that of Canada, but the UK profile is rising despite the more diverse non-Anglophone journal coverage. By contrast, in business, the UK share of world citations fell from 15.3% to 13.7% in 2008 but it remains 2nd behind the USA. The UK's rank position in humanities is 2nd behind the USA with Canada in 3rd place. The database has had a strong Anglophone bias, which is now changing, but the UK still performs powerfully. (Indicator 1.05)

The UK (13.4 citations per researcher, an index of effectiveness) is ranked 3rd behind Switzerland (24.2) and the Netherlands (18.6). This is a marked rise over last year's report, perhaps driven by recent research assessment. The citation count per researcher is rising slowly for the G8 nations, but France (6.87), the USA (6.91) and Germany (7.82) remain well behind the UK. (Indicator 1.06)

Counting frequency of presence in the top three by citation volume in the main fields (excepting humanities), the UK is in the top three in seven out of the nine areas. The USA is first by volume in all areas. Japan and France have now dropped out entirely and Canada places only twice while the main gainer is China which is in the top three in mathematics, physical sciences and engineering. (Indicator 1.07)

Share of uncited papers has fallen for the UK from 35% to 32% while its total output has risen, so the increase in volume has not resulted in more marginal output. Only the USA and the Scandinavian countries have had a smaller proportion of uncited papers. The UK has a low share of the world total of uncited papers (7.0% compared to 7.9% of total outputs) placing it 2nd in the G8, just behind the USA. Only India (48%) and Iran (53%) have a higher percentage of uncited papers than China (47%). (Indicator 1.08)

The most frequently used index of research performance is that of impact, measured as citations per paper. Citations accumulate, so the index is normalised (rebased) relative to world average. The UK has a higher citation impact (1.50) than it did in 2007 and has improved by 14% on the recent past, compared to an improvement of 8% in last year's report. This is more than the comparator group average. The comparator group is led by

Switzerland (1.83), Denmark (1.70) and the Netherlands (1.55) but the UK has improved its ranking to 5th overall. The UK has been consistently in 2nd in the G8 and has now moved ahead of the USA (1.48) but remains 2nd because it has been overtaken by Germany (1.52). China's impact seems to be stabilising at around 0.7 of world average. (Indicator 1.09)

The UK maintains high impact across subject areas, where account is also taken of discipline-specific citation rates. In clinical sciences, UK rank in the G8 has improved. Its average impact (1.46) is now 2nd to Canada and ahead of the USA. In health sciences, the UK has sustained a G8 lead position and improved its overall rank. In biological sciences, the UK has steadily improved in performance (impact 1999 = 1.24, 2008 = 1.62) and is now ranked 1st in the G8 and 2nd to Switzerland (1.68) in the comparator group. The UK seems to be increasing its lead over the USA which is 4th behind Singapore (1.57). In environmental sciences, the UK has moved into a clear 1st in the G8 (impact = 1.43, up from 1.11 in 1999). Germany and France, which leapt up last year, have fallen back but the USA seems to have halted its decline. In mathematics, the UK (recent impact = 1.30, 2008 = 1.43) has overtaken the USA (1.24), but has been passed by Germany (1.28, 1.50) to remain 2nd in the G8. China appeared in last year's report to be competitive with G8 nations but this year it is clear that while it does now have similar impact to Canada and Japan, those two nations are trailing the rest of the G8. Iran has improved in impact from 0.66 in 1999 to 1.07 in 2008, similar to Singapore and close to comparator group average. In physical sciences, Germany (1.67) and the USA (1.65) have gained slightly to move the UK (1.63) to 3rd. The differences are obviously marginal. The Netherlands (1.67) and Denmark (1.64) have impact virtually identical with these three while Switzerland (1.85) leads. China has a substantial presence but has yet to show a clear improvement in performance. In engineering, the UK has steady improvement and is 3rd in the G8, just behind Germany. China's impact rose above world average in 2007 and only dipped slightly in 2008. That puts it on a rising trajectory that will take it past France in the near future. Iran also performs well, passing India to reach an impact of 1.05 in 2007, dipping in 2008 but not by as much as China. This takes these countries past both S Korea and Taiwan in engineering research performance. In social sciences, much improved coverage has dampened impact volatility seen in earlier reports. The UK's overall position is not hugely changed by this data enrichment but despite the shift to more non-Anglophone journals it improves on rank within the comparator group, which has been consistently led by Denmark (1.67) with the USA (1.25) in 2nd. In business, the UK has a sustained performance and remains in 3rd rank in the G8. While its position has improved on these data, it is in fact slightly behind last year's report on older data. On revised humanities data, with a greater journal spread, the UK position has moved back on last year's report. (Indicator 1.10)

For variety and consistency of research strength, high UK impact is matched with a consistency across disciplines, placing the country in the upper, right-hand part of the charted data. Its impact improves between early (1999-2003) and late (2004-2008) periods and gains in diversity. The USA has fallen back on diversity at much the same level of performance, as has France. Germany has improved slightly but the Netherlands has a marked gain in consistency. China has also moved up as its research diversity improves with diversifying investment. Japan has suffered in performance more than its gain in evenness, suggesting a drop in peak areas. (Indicator 1.11)

Some publications have exceptional citation rates compared to others in their field. The UK has 12,776 papers among the world's most highly-cited 1% for 1999-2008 with an average impact of 153.2 citations per paper. It lies 2nd in the G8 by volume (where the USA is 1st with 51,831) and 3rd by impact (where Japan is 1st at 157.2). The UK increased its share, at 14.4% compared to the UK average of around 7.9% of world sources (Indicator 1.01) which reflects its competitive excellence. The USA remains just the leader on volume compared to the EU (50,451). Although China now has a baseline output greater than all but the USA, its share of highly cited papers is less than that of most of the G8. (Indicator 1.12)

Theme 2 - Collaboration

Collaboration is increasing globally. It affects most countries, all research disciplines and is perceived to have an influence not only on the transfer of knowledge and know-how but on the potential quality of the research that is done. The UK has a well-established global presence and has been seen as an important collaborator for many countries by contributing significantly to the quality of its partnerships. 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.

UK publications with a non-UK co-author have increased from 23,800 (33% of total output) in 1999 to 43,000 (47%) in 2007. The volume of co-authorship with every member of the DBIS comparator group has increased, typically by a factor of 2-3 but fourfold in the case of China and six-fold with Iran. Most collaboration is with the G8. USA collaboration is constant as a proportion of UK volume. Collaboration has increased for China (now almost 2,500 papers per year) and India (about 800 papers per year). With Brazil, co-authorship has risen from 400 to 900 papers per year and with Iran has grown from 65 papers in 1999 to 385 papers in 2008, now almost as much as with Singapore. (Indicator 2.01)

Co-authored work tends to be highly-cited work. The analysis shows that impact gain is less on average now than historically. As the proportion of UK activity entwined with other countries rises, so lower impact work is drawn into the analysis. Nonetheless, collaboration gain is often substantial: with the USA, Germany and France papers have impact 50% higher than the UK research base average. Collaboration with China and India is of lower impact but may be important in intellectual gain. For Brazil, impact is 1.3 times UK average but the greatest returns on collaboration come from smaller European partners: Switzerland (1.8 times UK average), Denmark and Belgium. (Indicator 2.02)

Theme 3 – Research postgraduate training

Research training capacity is evaluated in terms of absolute output and relative to both population and researcher numbers in the workforce.

Output of highly-trained researchers for the UK has risen strongly in absolute terms, from around 11,000 in 1999 to over 16,000 in 2006. The UK remains 3rd in the G8 and the comparator group, with an 8.3% share (greater than share of papers – Indicator 1.01) behind the USA and Germany. The USA shows a steep recent rise from 2004 but its share is down on 1999. For most EU countries PhD output growth is numerically small so the UK's profile and growth is relatively good. A number of important countries – China, India, Brazil and Iran – supply no PhD data to OECD. (Indicator 3.01)

The subject categories for research training data are the five main OECD fields. In medical sciences, UK share is increasing, up from to 8.0% and doubling volume to 2,821 PhDs in 2006. It remains 4th behind the USA, Germany and Japan but South Korea is ranked a close 5th and rising. In natural sciences, UK PhD output has been flat since 2000 and its share is falling, down to 9.4% in 2006 from 12% in 2001. It remains ranked 3rd overall. In engineering and technology, UK output is rising up to 2,400 in 2006 but its share has declined to 7.8% although its rank position has improved because Germany's output has declined. In social sciences UK PhD output has increased by 50% since 1999 which places it 3rd to the USA and Germany. UK share has risen to 7.1%. UK PhD output in the humanities has also increased by more than 50% per year since 1999 and is now over 2,200 per year. (Indicator 3.02)

The UK, USA, Germany, and Japan award over 15,000 PhDs per year – more than twice any other country. By population, Switzerland (436 PhDs per million people), Sweden (416) and Finland (354) have double the output of the USA (184). The UK (271 PhDs per million) is on a rising trajectory to match Germany in 4th place. Relative to the existing researcher population, the UK has increased its output (Indicator 3.01) so there is growth (9%) on this index ahead of comparator group average. With a better trajectory than Germany, the UK is now placed 2nd. The USA produces 38.7 PhDs per thousand researchers compared to the UK (93.2). (Indicators 3.03, 3.04)

Theme 4 – Research workforce

Relative research capacity is measured in terms of researchers and R&D personnel, and in relation to total population and to the national workforce. Previous reports have suggested that the UK capacity in this regard – the availability of highly skilled people compared to population and employment – is poorer than the comparator group average. However, the OECD researcher definitions may engage more with a technology-based than a knowledge-based economy. Other studies suggest that the UK is stronger in this regard.

The ratio of UK researchers to total population has fallen by 2% while comparator group average is rising by 9%. UK researcher density is only about 0.7 of comparator group average and the gap between the UK and

France and Germany is becoming more evident. The density of researchers in the UK workforce is also falling. At the start of the period, the UK was 15th in the comparator group and 7th ahead only of Italy in the G8. The availability of researchers in the workforce fell by 4% in 2007 compared to the recent past and by 8% compared to group average. The relative improvement for China includes a 500,000 increase in researcher numbers between 2004 and 2007, matching total USA volume. This is three times the actual volume of UK researchers and implies enormous potential for future development. (Indicator 4.01, 4.02)

The UK has about 325,000 total R&D personnel compared to about 175,000 of these who are researchers. The relative availability of R&D personnel in the UK is rising, up by 4% but while the comparator group average has risen by 7%. The UK, France and Germany are in very similar positions and well ahead of Italy. The density of R&D personnel in the UK workforce is typical of the comparator group and stable, placing the UK 13th. The availability of R&D personnel in the workforce rose by 1% in 2007 compared to the recent past. The comparator group average, by contrast, has risen by 4% so the UK's position fell. China now has about 1.75 million R&D personnel in a workforce of over 750 million. (Indicators 4.03, 4.04)

Because UK researcher availability is falling (Indicators 4.01, 4.02) and R&D personnel density is rising (Indicators 4.03, 4.04) so researchers are scarcer relative to R&D personnel. The UK has seen a drop from 0.55 to 0.53 researchers for every R&D worker. The UK dropped behind EU competitors over the decade. China appears to have a much better position but the exceptional proportion of R&D personnel classed as researchers may be an issue of classification. (Indicator 4.05)

Theme 5 – Output productivity

The UK has consistently been reported to have an exceptionally high level of output productivity.

The UK is 1st in the G8 on publication productivity with almost 32 papers recorded for every $Bn GDP. It has maintained its position relative to the comparator group average and improved its share of papers compared to its share of GDP by 6%. While the UK position remains strong relative to France, Germany and the USA, it is now at a similar point to Canada. The UK's record on output means that falling in line with EU economies should not be seen as any threat so long as impact (Indicator 1.09) remains high. On citations per unit GDP, the UK has fallen by 5% against comparator group average. It remains 1st in the G8 but dropped to 8th in the comparator group as a whole. Both Germany and Italy have improved and only the USA has lost more share than the UK. (Indicator 5.01, 5.02)

GERD indexes research-specific investment within GDP. The UK, with 2.51 papers per $million GERD, is not only 1st in the G8 on output per unit GERD but has risen from 4th to 3rd in the comparator group as a whole. UK output relative to GERD has fallen, by less than for other countries. On citations per GERD, an index which inevitably falls over time, the UK has dropped by 5% against comparator group average. Nonetheless, it remains 1st in the G8 and 4th in the comparator group. The UK's position has fallen by less than the USA. (Indicators 5.03, 5.04)

PUBERD is public sector R&D expenditure within GERD. The UK is 1st in the G8 and 3rd overall in the comparator group. Its share of citations relative to its share of PUBERD has fallen by 8% for 2007 compared to the recent past but this is actually an improvement on 2006. The UK retains a clear lead among G8 nations and a slight decline, due to rapid UK PUBERD growth, seems to have halted. HERD is higher education R&D within PUBERD. UK share of citations relative to HERD has declined against the comparator group average by about 11% but it leads the G8. The UK (1.35 cites per HERD) has dropped from 2nd to 3rd in the comparator group, behind the Netherlands (1.52) and Belgium (1.42) while few other countries exceed 1.0. (Indicators 5.05, 5.06)

The subject categories for financial data are the five main OECD fields. HERD is expected to increase while citation counts decrease in more recent years. There has been some revision of the mapping between citation data and OECD categories. In medical sciences, the UK has improved in relative performance. It is 2nd to Russia in the G8, but Russia's HERD is anomalously low. UK rank within the comparator group has improved. In natural sciences, the UK declined marginally against the comparator group average and is now ranked 5th instead of 4th. Where data for the USA and Germany are available, the UK outperforms both. In engineering, UK change in performance is in line with the comparator group average and it has risen to lead the G8. In social sciences, the UK performs substantially

better than the comparator group average. While there may be an Anglophone bias in the data, the UK has improved against that average and is 1st in the comparator group. In humanities, the UK performance is in line with the comparator group average and it remains 1st in the comparator group. (Indicator 5.07)

The UK currently produces 9.3% of comparator group PhDs compared to 6.6% of comparator group HERD and has been consistently more productive. It is 2nd to Germany in the G8, but Germany's lead has declined. The UK (2.01 PhDs per $million HERD) has moved up from 5th to 4th place in the comparator group behind Poland (6.81, but anomalously under-funded) and South Korea (2.48) as well as Germany. The USA (1.37) remains relatively inefficient on PhD output. (Indicator 5.08)

OECD data for PhD awards and for HERD at main field category level are patchy for many countries. For the available data, the UK's rank has improved in medical sciences. In natural sciences, UK output productivity is good and rank within the comparator group has improved in line with Germany and well ahead of the USA. In engineering, UK productivity is better than comparator group average and its rank has improved. In social sciences there are data for only 6 countries. UK productivity is better than comparator group average and has risen ahead of that average, with rank improving to 2nd behind only Poland. In humanities, the UK is well above the average for the six comparator countries for which data are available. (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

Indicator identification and description

Table 1.01 Number of papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	79,630	91,273	+15%
Group average papers	39,923	49,136	+23%
UK / Group average	1.99	1.86	-7%
UK rank within Group	2	3	⇩
UK rank within G8	2	2	⇔
UK share of world	8.5	7.9	-8%

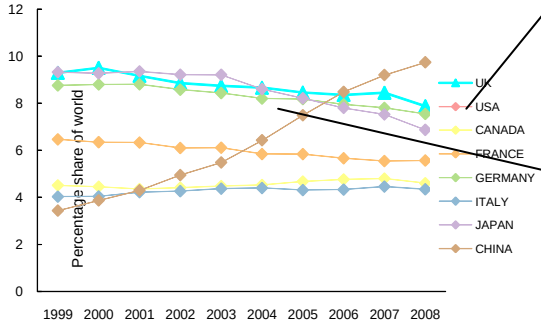
Key results for UK actual and ranked performance in latest data year and average for previous five years

Change in UK performance ranked among total comparator group and G8

Change (ratio or difference) between last year and recent

Data: Thomson Reuters. Analysis: Evidence

Chart 1.01 Share of world papers



Charts may omit USA if inclusion would distort vertical axis

Chart illustrating performance trend of UK and G8 competitors (and sometimes others) over last decade

Data: Thomson Reuters. Analysis: Evidence

Commentary

There has been an exceptional global increase in the volume of papers indexed in 2008 compared with prior years. This growth has been focussed outside the G8 nations and increases the proportion of non-Anglophone content. The consequ… are exceptional increases in relative volume for Brazil, India, Ch… contrast, almost all G8 and EU countries exhibit a marked relat… nations have increased their absolute indexed output. The UK's volume growth is over 10%, which should improve the information content of other indicators, but its share of world is down from 9.3% in 1999 to 7.9%.

The decline in share for leading countries is evident. The USA (not shown) has dropped from 34% to 29.5% of world over the period but remains a clear leader. The spectacular rise …nges. Revised … of increase is …e while France maintains its share. Japan gains little benefit from data changes and continues its recent decline. Elsewhere, Iran is now up to near 1% of world output, from 0.13% in 1999, while Brazil and South Korea double their share to 2.4% and 2.8%.

Text may include commentary on additional issues arising from data or indicators

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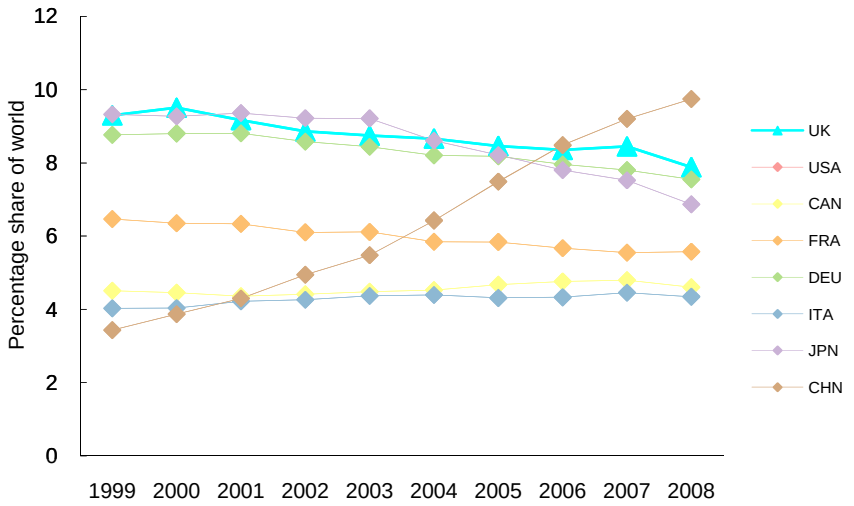
Data: Thomson Reuters. Analysis: Evidence

Chart 1.01 Share of world papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

There has been an exceptional global increase in the volume of papers indexed in 2008 compared with prior years. This growth has been focussed outside the G8 nations and increases the proportion of non-Anglophone content. The consequence is that there are exceptional increases in relative volume for Brazil, India, China and Iran. By contrast, almost all G8 and EU countries exhibit a marked relative decrease. All nations have increased their absolute indexed output. The UK's volume growth is over 10%, which should improve the information content of other indicators, but its share of world is down from 9.3% in 1999 to 7.9%.

The decline in share for leading countries is evident. The USA (not shown) has dropped from 34% to 29.5% of world over the period but remains a clear leader. The spectacular rise of China - a four-fold growth in ten years - is accentuated by database changes. Revised data indicates it now overtakes the major EU states in 2006, but its rate of increase is slowing. The UK remains ahead of Germany, which also drops share while France maintains its share. Japan gains little benefit from data changes and continues its recent decline. Elsewhere, Iran is now up to near 1% of world output, from 0.13% in 1999, while Brazil and South Korea double their share to 2.4% and 2.8%.

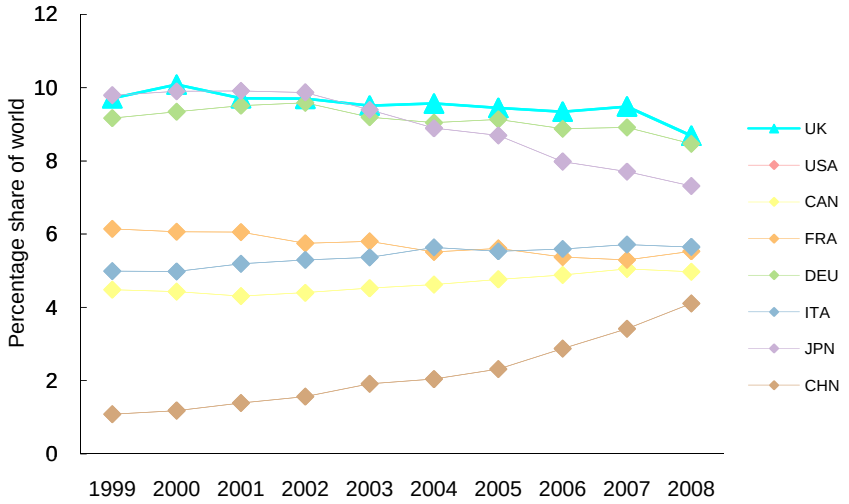
1.02.01 Number and share of world papers in ten main research areas

Table 1.02.01 Number of clinical papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	28,979	32,805	+13%
Group average papers	12,975	16,084	+24%
UK / Group average	2.23	2.04	-9%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	9.5	8.7	-8%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.01 Share of world clinical papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Amended mapping has shifted output from clinical to health sciences. The volume of UK output in clinical sciences increased in 2008 over recent years, from 29,000 to 32,800 papers. This has not kept pace with global growth, which has expanded by almost a quarter in 2008 over the average for the recent past (2003-2007). The UK's share of the world total has fallen from 9.5% recently to 8.7% but it remains ranked 2nd in the world behind the USA. Most European countries have fallen slightly in world share, while the USA dropped to 32% from around 33.5% recently.

Canada is one of the few G8 countries to sustain its share, while the UK and Germany show a marked drop in 2008. France exhibits a longer-term slight decline and Japan a more sustained fall. China's rise is substantial; it remains behind the other charted nations in this subject area but the annual rise is increasing while it plateaus in some other fields. Iran (30% recent increase to 0.66% share), Brazil (+30%, 2.16%) and India (+15%, 1.58%) also contribute to the global shift in activity. Some smaller S E Asian nations continue to grow but not as strongly as in earlier analyses.

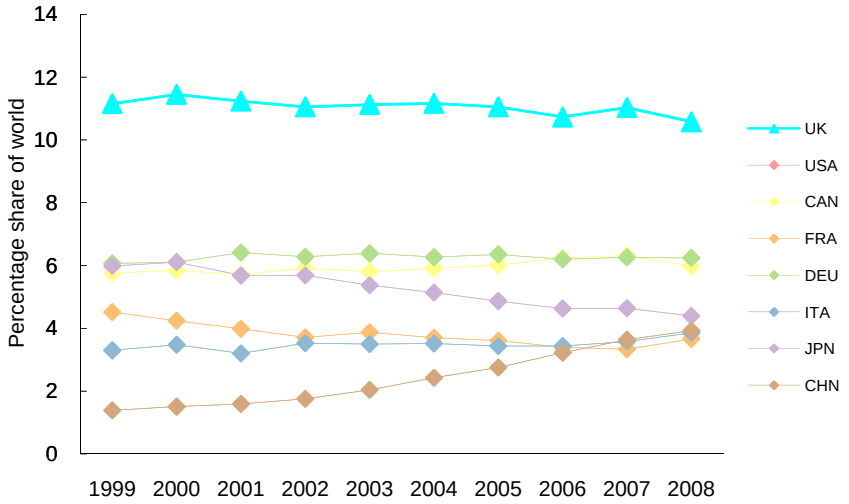
1.02.02 Number and share of world papers in ten main research areas

Table 1.02.02 Number of health & medically-related papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	11,202	14,375	+28%
Group average papers	4,297	5,820	+35%
UK / Group average	2.61	2.47	-5%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	11.0	10.6	-4%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.02 Share of world health & medically-related papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Amended mapping has shifted some output to health from clinical sciences. The changes emphasise the UK's strength in health sciences with a greater volume than shown in previous reports. Its output has increased in 2008 over the recent past by 28% but even this exceptional growth is less than the comparator group average in this important socio-economic area. Nonetheless, the UK's share of world output is well ahead of the research base average (10.6% cf 7.9%).

Growth in health sciences research is markedly patchy, with no region showing consistent growth. In the EU, France and Spain have grown while Scandinavian nations have slipped back slightly. South Korea has also expanded markedly while Singapore has not. China and India both have very strong growth and Iran has almost doubled its health research output in just two years.

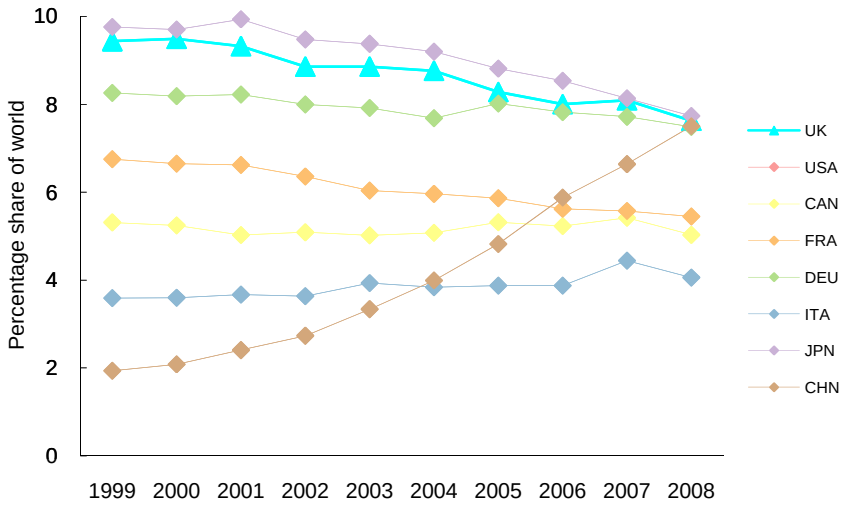
1.02.03 Number and share of world papers in ten main research areas

Table 1.02.03 Number of biological sciences papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	21,376	23,406	+9%
Group average papers	11,026	13,215	+20%
UK / Group average	1.94	1.77	-9%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of world	8.4	7.6	-9%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.03 Share of world biological sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK's output in biological sciences grew by 2,000 papers, or about 9% in 2008 compared to the recent past. However, comparator group output increased faster and the UK's share of world output dropped from 8.4% to 7.6%. Nonetheless, the UK remains 3rd in this subject area, behind the USA and Japan and just ahead of China and Germany. Iran also doubled its output over two years (to 2,205 papers in 2008) and is now ahead of Singapore (1,406) and just behind South Africa (2,401).

China's growth in this area is exceptional, even compared to its strong overall expansion. The curve is extraordinary, taking it from half of Italy's volume to rank 4th in ten years. The increase in share in successive years has been + 0.6% of world total, then + 0.75%, + 0.9%, + 0.65%, and + 0.85% to 23,000 papers in 2008 compared to 4,600 in 2000. It overtook India in 2002 and now has twice that country's volume. The combined EU share of world has dropped to 33% from 36% over the decade.

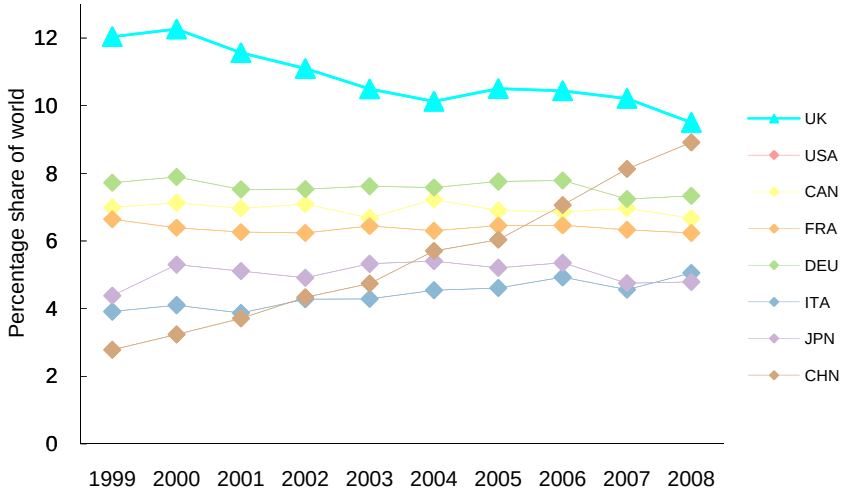
1.02.04 Number and share of world papers in ten main research areas

Table 1.02.04 Number of environment papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	8,879	10,763	+21%
Group average papers	3,826	5,060	+32%
UK / Group average	2.32	2.13	-8%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	10.4	9.5	-8%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.04 Share of world environment papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK has an above average share of output in environmental sciences where it has had a strong historical position. Its output rose in 2008 by over 20% compared to the recent past but its share of world output has been falling, down to 9.5% from 10.4% as other nations have expanded their research activity. Nonetheless, the UK remains 2nd by rank behind the USA. European activity is sustained in this area, around 40% of world total.

The graph makes clear the effect of China's growth in reducing the relative share of other, established nations. China has shot past the rest of the charted nations and is now at 8.9% just behind the UK in output share. This is three times its share of output in 1999. While other growing nations are also increasing their environmental research activity, most are doing so at around 10% absolute volume per year.

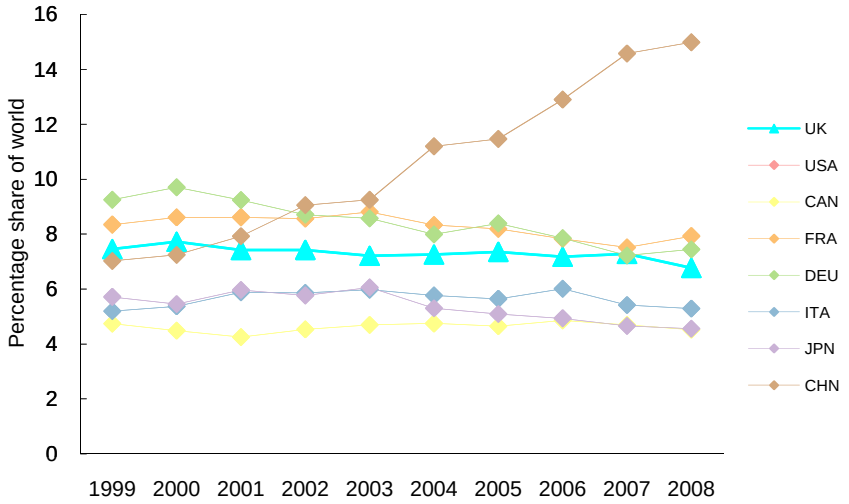
1.02.05 Number and share of world papers in ten main research areas

Table 1.02.05 Number of mathematics papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	4,488	5,930	+32%
Group average papers	2,704	3,752	+39%
UK / Group average	1.66	1.58	-5%
UK rank within Group	5	5	⇔
UK rank within G8	4	4	⇔
UK share of world	7.3	6.8	-7%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.05 Share of world mathematics papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Amended mapping has shifted some output to mathematics from other sciences. The UK shows a major increase in output to 5,930 papers in 2008, up by 32% compared to the recent past. This is not much less than the comparator group average growth. The UK's rank remains at 5th, behind the USA, France, Germany and China. Its share of world output dropped from 7.3% to 6.8%.

The growth of China is this area has been strong, although it had a high initial base and other subjects have grown relatively more. It may now be reaching a plateau with a much smaller increase on 2007 than in previous years. Iran, India and Brazil are the only other nations with significantly increased share but the comparator group average has increased showing broad world expansion in the mathematical sciences.

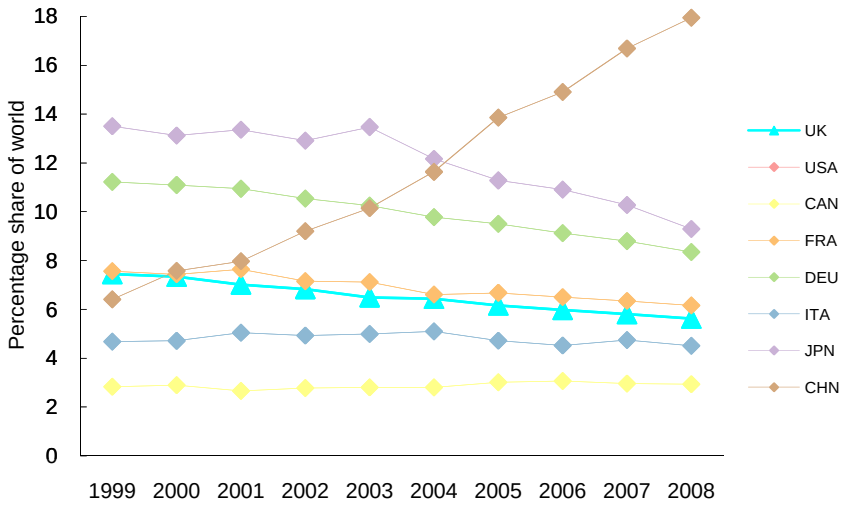
1.02.06 Number and share of world papers in ten main research areas

Table 1.02.06 Number of physical sciences papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	23,241	26,025	+12%
Group average papers	16,468	19,994	+21%
UK / Group average	1.41	1.30	-8%
UK rank within Group	6	6	⇔
UK rank within G8	5	5	⇔
UK share of world	6.2	5.6	-9%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.06 Share of world physical sciences papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK's share of papers in physical sciences has increased by 2,500, about 12%, compared to recent average. This is less than the comparator group average of over 20% but the UK retains its 6th rank just behind France as the G8 have generally fallen compared to world. Although the USA still leads, its world share is now less than 20% whereas China's share is up to 18% and has increased by over 1% of world average each year. On this trajectory it will overtake the USA next year.

The graph makes clear the effect of China's growth in reducing the relative share of other, established nations. China, with a well developed base in physical sciences, started the decade ahead of some G8 countries. With a four-fold growth, it has now shot past the rest and is 2nd behind the USA. India and Brazil have almost doubled their output in the ten years, but Iran has seen a ten-fold increase in physical science outputs and a five-fold increase in share to 1.3%.

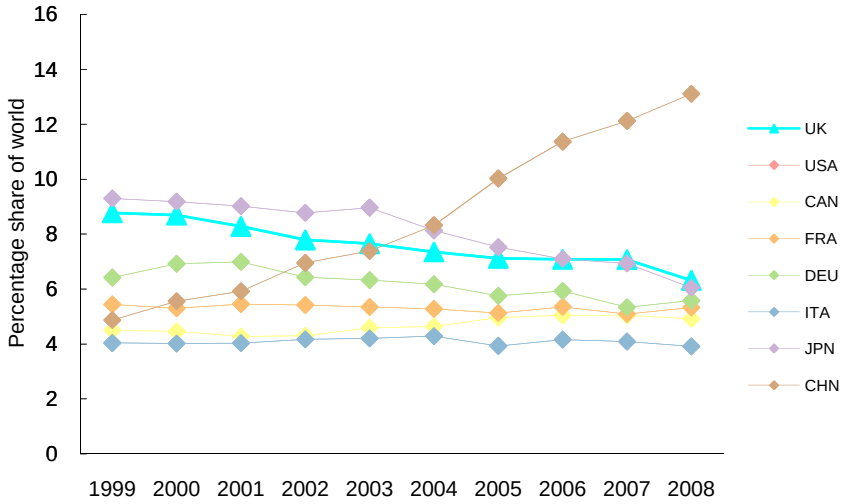
1.02.07 Number and share of world papers in ten main research areas

Table 1.02.07 Number of engineering papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	14,820	15,784	+7%
Group average papers	8,429	10,253	+22%
UK / Group average	1.76	1.54	-12%
UK rank within Group	4	3	⇧
UK rank within G8	3	2	⇧
UK share of world	7.3	6.3	-13%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.07 Share of world engineering papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK's engineering output has increased (+950 papers, +7%) by rather less than the average for the comparator group (+22%). Its share of world has dropped to 6.3% from 7.3% recently, but it has gone up in rank overtaking Japan to be 3rd behind the USA and China. Iran's engineering output has now grown to 1.58% of world, larger than Belgium or Sweden and not far short of Russia (1.8%). The smaller Asian economies are larger but have grown much less recently.

China's growth is a major factor in changing world output and share. China is now at 13% but still well behind the USA with a clear lead at 24.5% of world total. There is some indication that the rapid growth earlier in the decade may now be slowing a little, though still considerable, as China shifts investment into other areas. India has less than 4% of world total while Taiwan and S Korea are both around 5%, similar in volume to some G8 economies.

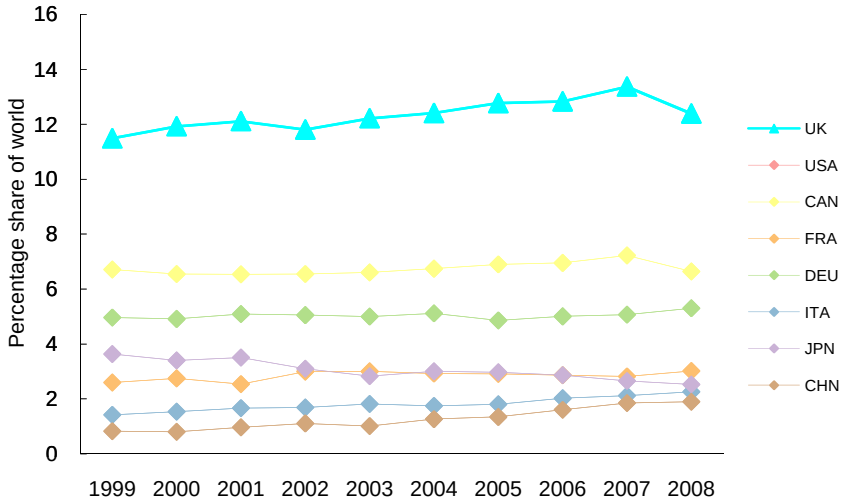
1.02.08 Number and share of world papers in ten main research areas

Table 1.02.08 Number of social science papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	6,289	7,822	+24%
Group average papers	2,018	2,568	+27%
UK / Group average	3.12	3.05	-2%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.7	12.4	-3%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.08 Share of world social science papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Database coverage of the social sciences is much improved. There is a substantial increase in UK output of about 24% in 2008 compared to the recent average and in line with general world trends. The UK's share of indexed articles remains in excess of 12% of total and it is ranked 2nd behind the USA. The USA's share has dropped by 4% to 45.8%, reflecting the more diverse regional coverage of the data.

Changes in world share have been very variable, with some EU countries such as France, Germany and Spain showing a marked increase while others such as Denmark are little changed. Brazil has increased by over 50% share to 1.5% compared to China static at 1.89%. Taiwan is also unchanged while S Korea rises by almost 50% in volume and a quarter in share. India's recorded social science output remains tiny, at fewer than 500 papers.

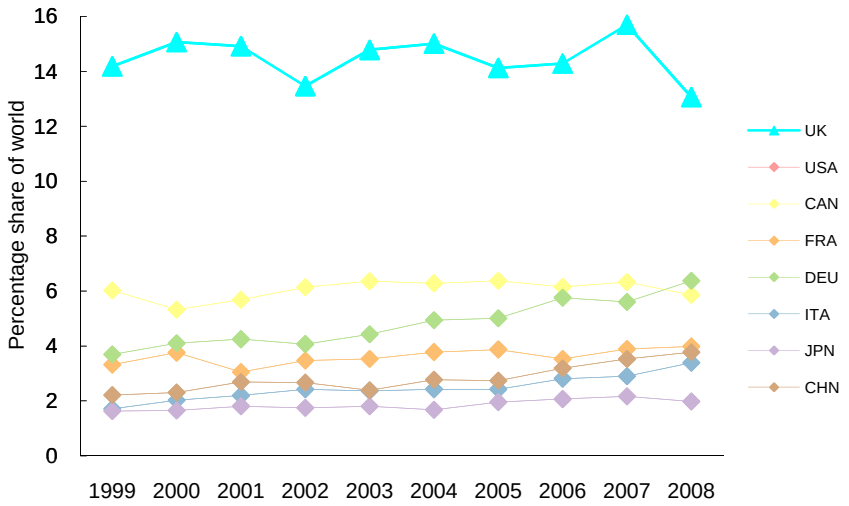
1.02.09 Number and share of world papers in ten main research areas

Table 1.02.09 Number of business papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	2,620	3,390	+29%
Group average papers	776	1,130	+46%
UK / Group average	3.37	3.00	-11%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	14.8	13.1	-12%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.09 Share of world business papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

The UK's output in business research has increased by 29% and it remains ranked 2nd to the USA but world coverage has changed and its share of world total drops to 13.1% from a 14.8% recent average. Despite the coverage change the UK also remains about 3 times the comparator group average in volume.

This is not a major area for China but its output is now greater than that of Italy and similar to that of France. Germany has seen a very big increase in recorded output this year taking it ahead of Canada, presumably a quirk of database change. Generally, EU coverage is much improved and several other countries see a rise of as much as 50% recorded volume. Total EU coverage is up to 10,800 – close to the USA's traditionally strong hold on this subject area at 11,000 papers.

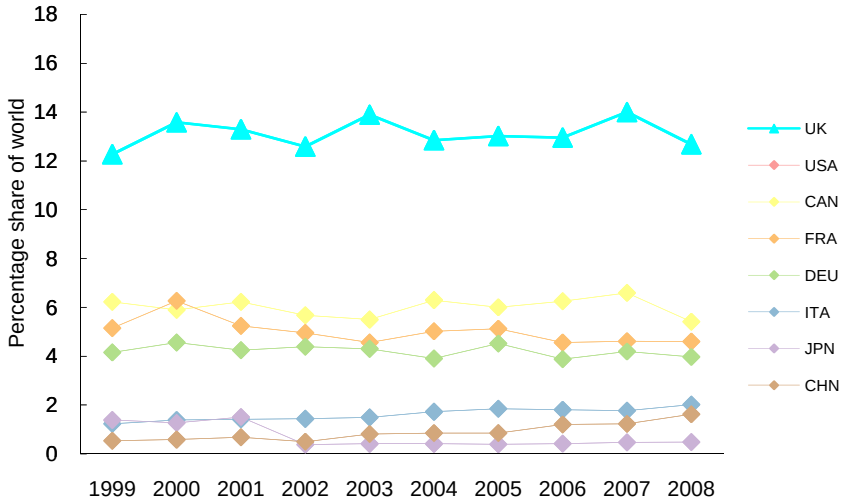
1.02.10 Number and share of world papers in ten main research areas

Table 1.02.10 Number of humanities papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK papers	2,999	3,641	+21%
Group average papers	850	1,056	+24%
UK / Group average	3.53	3.45	-2%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	13.3	12.7	-5%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.02.10 Share of world humanities papers



Data: Thomson Reuters. Analysis: Evidence

Commentary

Database coverage of the humanities is much expanded and indexed volume has increased. The UK volume indexed by Thomson Reuters now is about twice that reported last year (1,543 for 2007) while the comparator group average is trebled (up from 367). This may increase confidence in the figures. The USA is down to 37% of world output, from over 50% in 2003, and is overtaken by the EU which is up to 38%. Coverage around the world is dynamic, with Taiwan doubling volume and Singapore dropping.

The graph confirms that the general trend in humanities output is for country share to be fairly stable, despite the improved coverage, so the balance across countries has not changed dramatically although the language mix is certainly more diverse. Many countries are represented by fewer than 100 papers per year, including India, Denmark and Poland while Brazil has only 53 papers in 2008. Bibliometric indicators remain of inevitably limited value in this subject area.

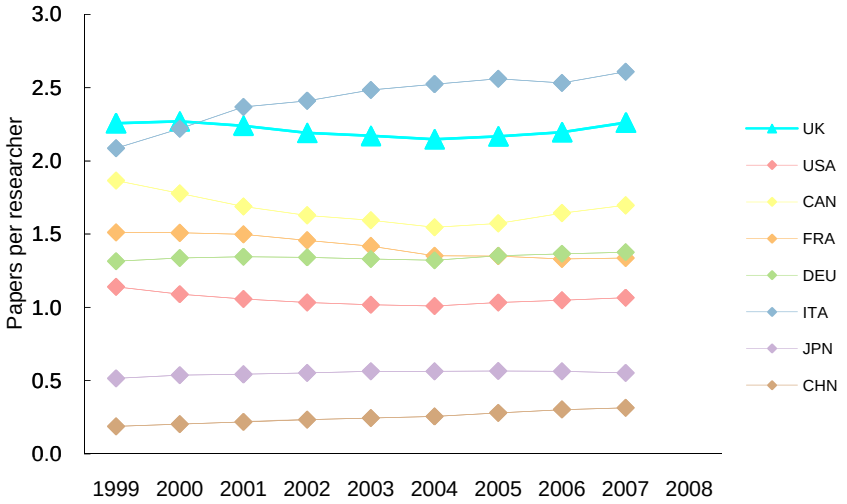
1.03 Papers relative to researchers

Table 1.03 Share of papers relative to share of researchers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK papers per researcher	2.17	2.26	+0.04
Group average papers per researcher	1.43	1.48	+0.04
UK / Group average	1.53	1.52	-0.00
UK rank within Group	4	4	⇔
UK rank within G8	2	2	⇔
UK share of papers / UK share of researchers	2.27	2.32	+0.02

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 1.03 Papers per researcher



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

The volume of papers published compared to the number of researchers behind those papers can be seen as one aspect of research competiveness. The UK has maintained a strong position on this indicator having now recovered from a slight decline earlier in the decade. It is placed 4th overall behind Switzerland (3.37 papers per researcher) and the Netherlands (2.81). [Italy is 3rd but staff data for Italy are anomalous (see Information section)].

Germany (1.38 papers per researcher), France (1.34) and the USA (1.06) are below the comparator group average. The USA's productivity is now less than half that of the UK and it ranks consistently 6th amongst the G8. EU productivity (1.40) is higher, boosted by leading countries including the UK. China's productivity has risen from 0.2 to 0.3 over the decade, where the index is affected by the very large national workforce. There are no workforce data for Brazil, India or Iran.

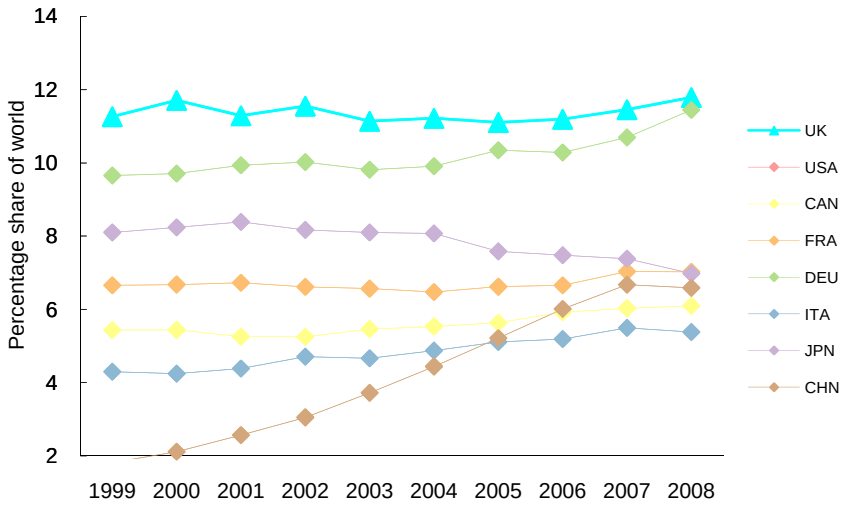
1.04 Number and share of world citations

Table 1.04 Total citations

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	729,923	59,979	-
Group average citations	321,541	26,259	-
UK / Group average	2.27	2.28	1%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	11.2	11.8	+5%

Data: Thomson Reuters. Analysis: Evidence

Chart 1.04 Share of world citations



Data: Thomson Reuters. Analysis: Evidence

Commentary

The number of citations is inevitably fewer in recent years so citation share is the critical index. Despite a drop to 7.14% share of world publications (Indicator 1.01), the UK's share of world citations has risen. It has an increase on the value for the recent five years (11.2% of world) to 11.8% in 2008. It has improved on volume for the latest year relative to the comparator group average. It therefore now has a much greater share of citations than publications. The share is in line with previous years, which may suggest that the increased volume of recorded publications for the UK has not been made at the expense of quality.

The UK's rise in share (to 11.78% of world) is matched by that of Germany (11.44%), which has been progressively edging closer to the UK since 2000. Japan's share (7.0%) and that of other G8 countries has dropped and China's share for the most recent year has fallen (to 6.6%) despite the increase in output. The USA's citation share is down from around 49% in 1999 to 43.6% in 2008. Brazil (up from 0.81% in 1999 to 1.6% in 2008), India (0.97% to 2.0%), Iran (0.09% to 0.56%), and South Africa (0.33% to 0.63%) all show a substantial relative improvement. Singapore, South Korea and Taiwan are all still above 1999 levels but 2008 shows little gain or even a slight fall on 2007.

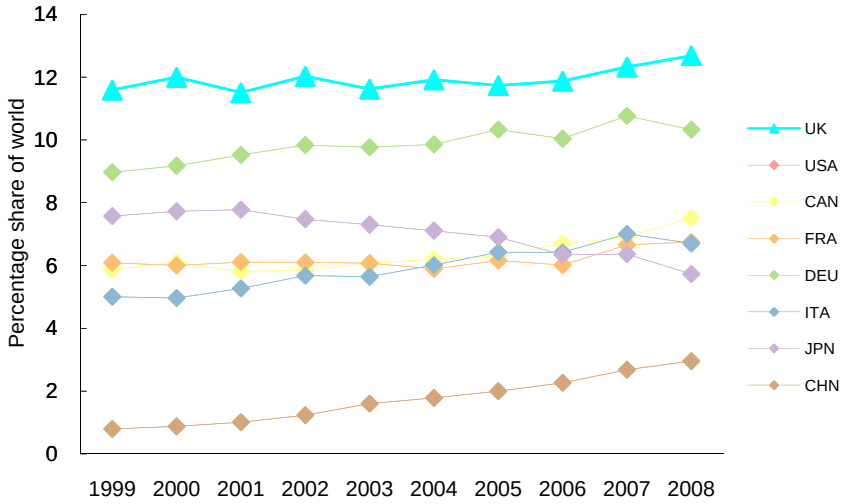
1.05.01 Number and share of world citations in ten main research areas

Table 1.05.01 Total citations to clinical papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	340,744	25,256	-
Group average citations	143,086	10,512	-
UK / Group average	2.38	2.40	+1%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	11.9	12.7	+7%

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 index. The UK's share of world citations in clinical sciences is higher in 2008 than in the recent past (12.7% cf 11.9%). The UK's lead over the comparator group average has further increased. The UK is ranked 2nd behind the USA. Germany has plateaued slightly but remains well ahead of other G8 countries although Canada has picked up markedly this year.

China's rise continues albeit at a slightly lower rate than in recent years. Japan, however, has suffered a further, possibly slightly steeper, decline. India continues to attract less than 1% of world citations in this subject area but Brazil is now up to 1.58%, which is of the same order as Denmark and Finland.

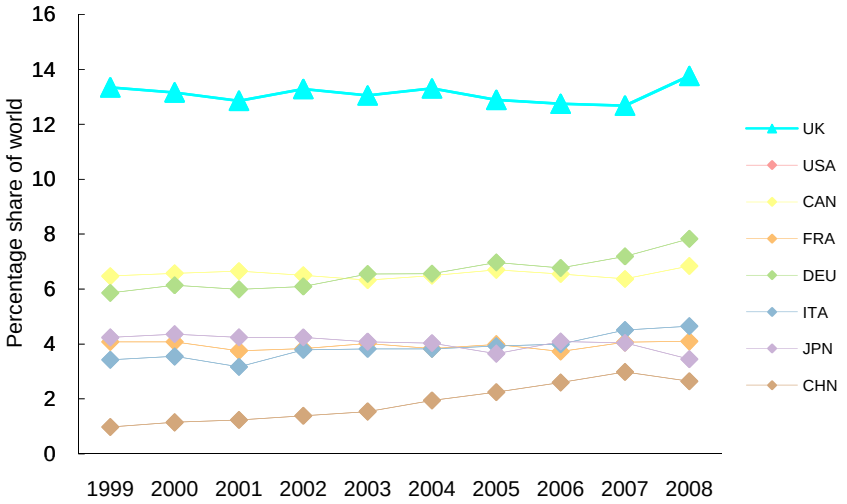
1.05.02 Number and share of world citations in ten main research areas

Table 1.05.02 Total citations to health & medically-related papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	93,927	7,947	-
Group average citations	32,867	2,746	-
UK / Group average	2.86	2.89	+1%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.9	13.8	+6%

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 index. The UK's performance is broadly maintained despite the considerable shifts in the assignment of journals to this subject area. It remains 2nd ranked to the USA and well ahead of other G8 economies with 13.8% of world citations, up from 12.9% in the recent past. The EU remains at about 40% of world citation share and the USA at about 50%. Several EU countries have increased share so the net position may indicate increased collaboration.

China has not greatly increased its citation share in health sciences over the last four years and it remains slightly below 3% of total. India has similarly levelled out at less than 1.5% whereas Brazil has doubled its share to nearly 2%. Russia's share of world cites is now the lowest in the comparator group, at less than 0.25% compared to 0.38% for Iran, up from 0.08% in 1999.

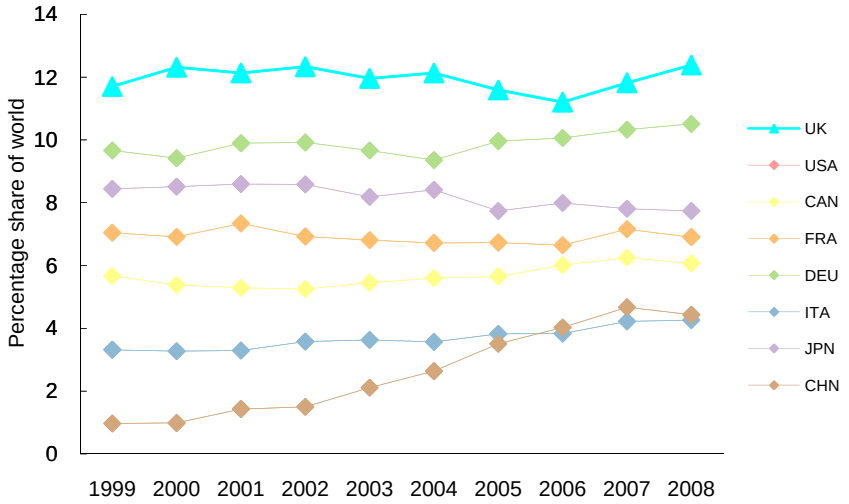
1.05.03 Number and share of world citations in ten main research areas

Table 1.05.03 Total citations to biological sciences papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	291,678	21,538	-
Group average citations	119,972	8,963	-
UK / Group average	2.43	2.40	-1%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	11.7	12.4	+5%

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 index. The UK's share of world citations in biological sciences, an area of historic strength, has risen to 12.4% from 11.7% in the recent past and it remains 2nd behind the USA. The upward shift seen in last year's report has been sustained this year. The UK and Germany are moving further away from other G8 nations.

China's share of cites has remained around 4% for the last three years and its upward trajectory seems to have slowed while India has also levelled around 1.45%. Brazil, however, has a sustained upwards trend doubling its share from 0.8% in 1999 to 1.6% in 2008. Canada has a slight drop in citation share, as does France, while Japan has now stabilised. Last year these three were essentially on the same point but have now separated.

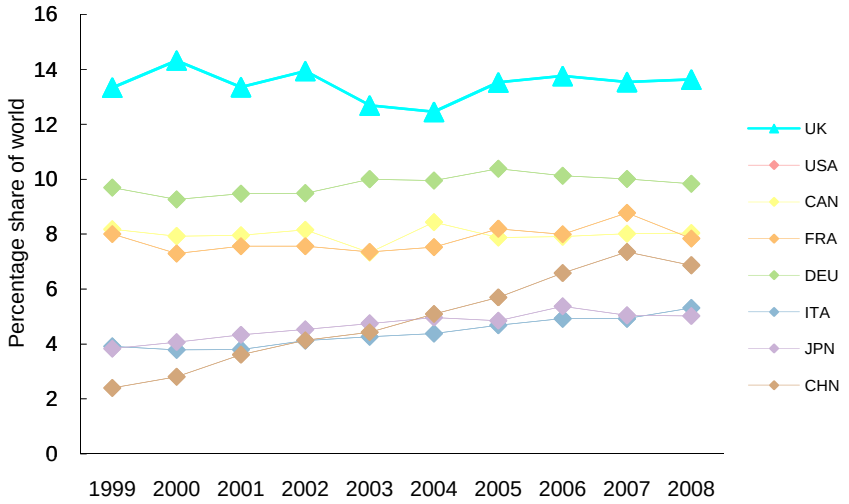
1.05.04 Number and share of world citations in ten main research areas

Table 1.05.04 Total citations to environment papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	61,296	5,459	-
Group average citations	23,986	2,099	-
UK / Group average	2.56	2.60	+2%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	13.2	13.6	+3%

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 index. The UK's share of world citations in environmental sciences has improved from 13.2% in recent years to 13.6% in 2008. It retains its position in the G8 and the comparator group as 2nd behind the USA. Germany (3rd) has maintained a roughly constant share around 10% over the decade.

Whereas France had increased its share of citations in environment research in 2007 it has now slipped back (to 7.8%). China has continued to improve its profile and despite a drop in 2008 it is now (at 6.9%) more evidently ahead of Japan (5.0%) and Italy (5.3%) across the decade as a whole. It seems likely to overtake France in the near future. Iran has seen a marked increase in its share although this remains small (1999 = 0.05%, 2008 = 0.41%) but India still has only a 1.85% citation share.

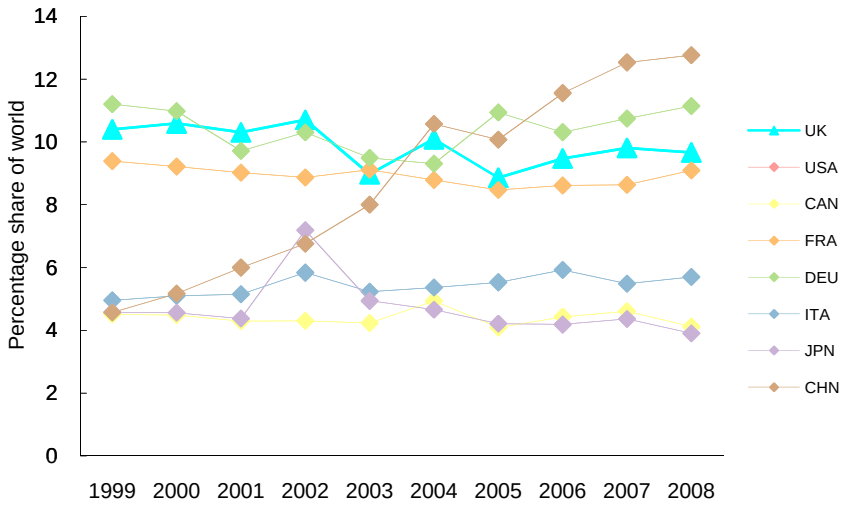
1.05.05 Number and share of world citations in ten main research areas

Table 1.05.05 Total citations to mathematics papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	21,268	1,998	-
Group average citations	10,981	975	-
UK / Group average	1.94	2.05	+6%
UK rank within Group	4	4	⇔
UK rank within G8	3	3	⇔
UK share of world	9.4	9.7	+2%

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 index. The data in this area have been recategorised. The UK's share of world citations in mathematics has risen to 9.7% in 2008 but its rank in the G8 and comparator group is unchanged ahead of France but behind Germany (11.1%, with a more sustained performance), China (12.8%) and the USA (33%).

China has sustained its lead over the G8 group (excepting the USA) seen in last year's report. India has increased its share of citations to nearly 2% but Iran has further built on last year's improvement to reach 1.7% of world cites. This is its highest citation share in any subject. Citation share for the SE Asian nations is not sustained.

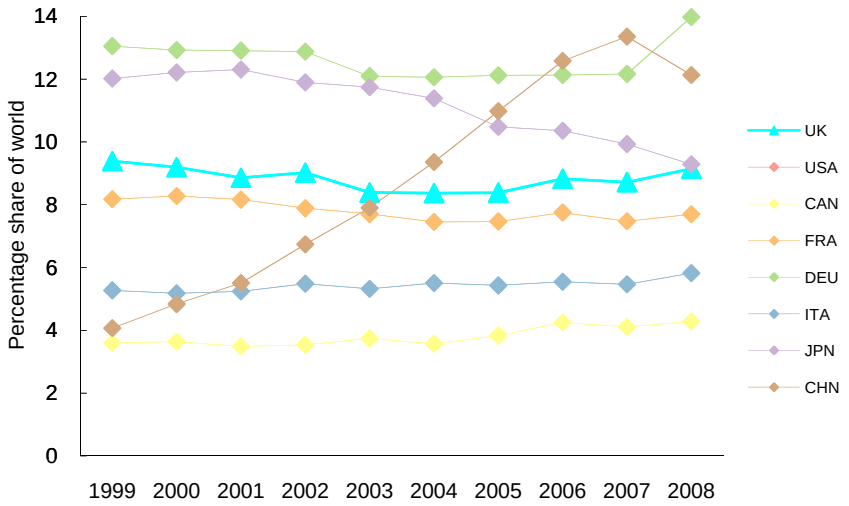
1.05.06 Number and share of world citations in ten main research areas

Table 1.05.06 Total citations to physical sciences papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	202,073	20,262	-
Group average citations	117,548	11,335	-
UK / Group average	1.72	1.79	+4%
UK rank within Group	5	5	⇔
UK rank within G8	4	4	⇔
UK share of world	8.5	9.1	+7%

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 index. The UK's share of world citations in physical sciences has improved to 9.1% from 8.5% in the recent past. Its rank is unchanged but it seems certain to pass Japan in the next year. Germany's position relative to Japan and other nations has improved substantially over previous reports (14%) but it was caught by China's rising share for 2007 although China then dropped back in 2008.

Previous reports commented on a dip in UK performance in 2003, but it is now evident that this was a blip from which there has been a sustained recovery. It seems unlikely on present figures to have a significant challenge and it will pass Japan in 2009. But it is equally clear that the USA, China and Germany look likely to establish a leading group separated from other major research economies in physical sciences. India has a significant citation share in this field (3.9%) whereas Russia's share is now below 3%.

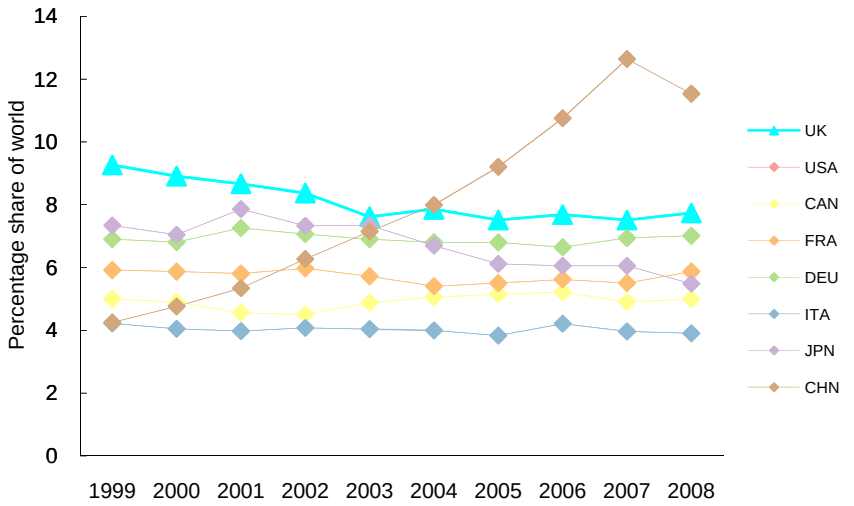
1.05.07 Number and share of world citations in ten main research areas

Table 1.05.07 Total citations to engineering papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	52,550	3,941	-
Group average citations	30,039	2,256	-
UK / Group average	1.75	1.75	-0%
UK rank within Group	3	3	⇔
UK rank within G8	2	2	⇔
UK share of world	7.6	7.7	+1%

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 index. The UK's share of world citations in engineering has been sustained and its rank remains unchanged 2nd behind the USA in the G8 and 3rd overall in the comparator group. There has generally been little change in share across nations in the decade, except for the progressive fall in share for Japan and the sustained rise for China.

China has now moved clearly ahead of all the G8 economies except the USA and retains a share in excess of 10% of world citations even with the final year dip. Japan has dropped behind France. India has sustained its share at over 3% of world citations while Iran continues to improve its position in engineering with over 1.5% (more than smaller western EU economies). Brazil too is on a rising profile.

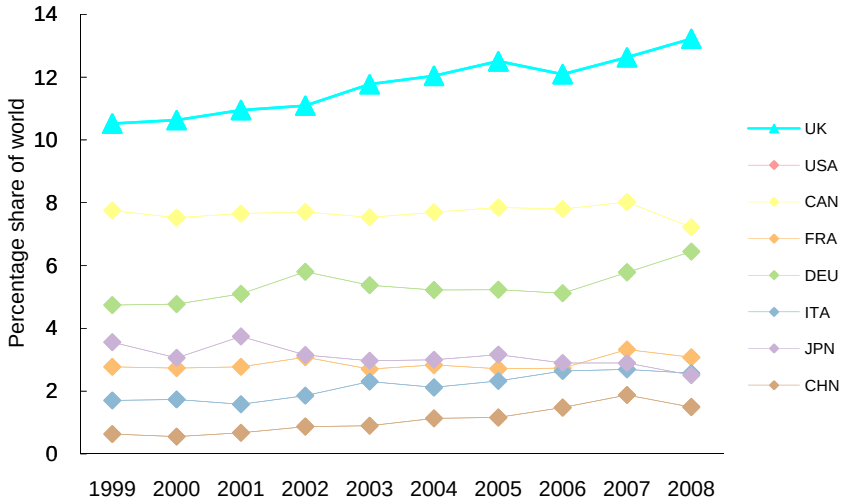
1.05.08 Number and share of world citations in ten main research areas

Table 1.05.08 Total citations to social science papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	29,787	2,400	-
Group average citations	10,907	821	-
UK / Group average	2.73	2.92	+7%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	12.2	13.2	+8%

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 index. The UK's share of world citations in social sciences has risen to 13.2% in 2008 from 12.2% in the recent past and it remains 2nd behind the USA. This change in coverage is reflected in Germany's much improved - and improving - position with a citation volume similar to that of Canada. There is also more separation between other G8 nations than before, again reflecting improved data content.

The UK profile is steadily rising despite the more diverse non-Anglophone journal coverage. The EU total has risen to 33% of world citations, up from 27% in 1999 and from 28% reported in last year's report on sparser data. China's share of citations is in fact slightly less than last year and, at around 1.5%, is much less than in most subject areas.

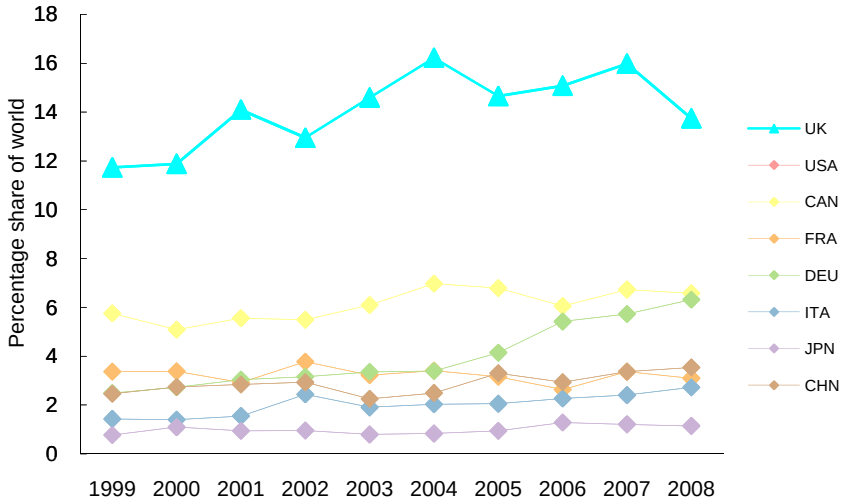
1.05.09 Number and share of world citations in ten main research areas

Table 1.05.09 Total citations to business papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	9,965	626	-
Group average citations	3,186	218	-
UK / Group average	3.13	2.88	-8%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	15.3	13.7	-10%

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 index. The UK's share of world citations in business research has fallen from 15.3% recently to 13.7% in 2008 but its rank remains 2nd behind the USA. There has been no sustained improvement for Germany which remains just behind Canada in much the same position as in last year's report.

China has a slightly greater share of world citations (3.53%) than France (3.09%) and a relatively level profile over the decade suggesting little change in output of high quality papers. The USA's share has dropped from 71% in 1999 to 56% in 2008. The EU share has risen from 26.4% to 37.3% over the same period.

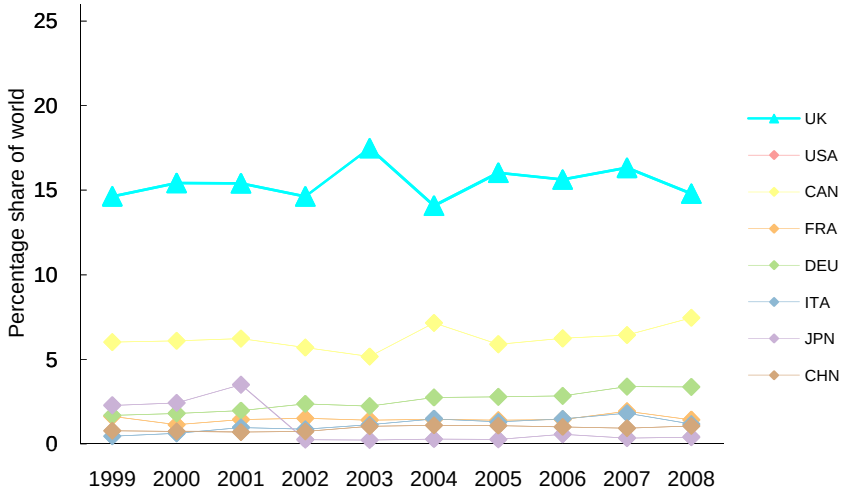
1.05.10 Number and share of world citations in ten main research areas

Table 1.05.10 Total citations to humanities papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
Citations to UK papers	4,366	405	-
Group average citations	1,167	121	-
UK / Group average	3.74	3.34	-11%
UK rank within Group	2	2	⇔
UK rank within G8	2	2	⇔
UK share of world	15.9	14.8	-7%

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 journals are only one main mode of publication. The UK's rank position is 2nd behind the USA with Canada in 3rd place. The database has had a strong Anglophone bias, which is now changing, but the UK still performs powerfully. Its share of world citations is stable at around 15%, a shift from 25% of former years but a more balanced reflection of the world data. The USA has a falling world share, down from 63% in 1999 to 47% in 2008.

The chart confirms the stable trend in UK relative performance. The EU share is up from 27% to almost 40% in 2008, the bulk of which change is due to the Netherlands, Belgium, Denmark and Spain reflecting the diverse range of humanities research now captured. Smaller countries are now better represented in the data than previously and this indicator may show some volatility in the next few years.

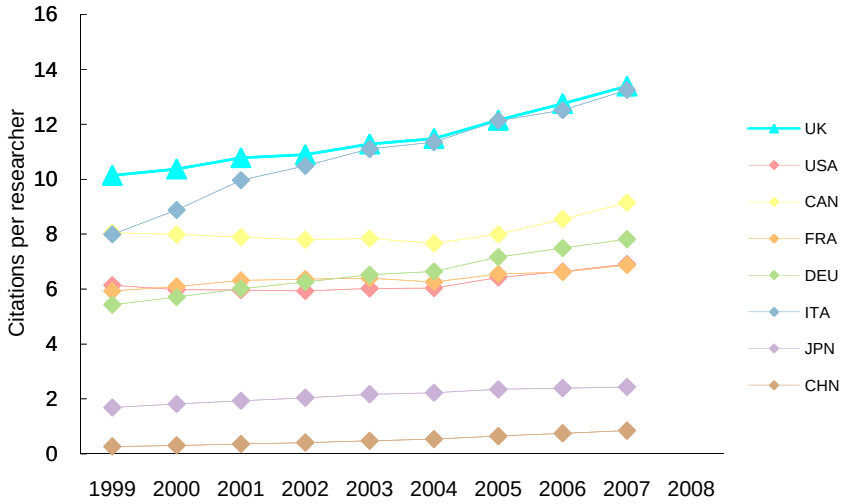
1.06 Citations relative to researchers

Table 1.06 Share of citations relative to share of researchers

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Citations per researcher	11.71	13.39	+0.14
Group average citations per researcher	6.87	8.02	+0.17
UK / Group average	1.70	1.67	-0.02
UK rank within Group	3	3	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of researchers	2.55	2.65	+0.04

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, this indicator introduces a quality – perhaps, effectiveness - element by using citations per researcher. The UK is ranked 3rd behind Switzerland (24.2 citations per researcher) and the Netherlands (18.6). Italy's value is close to the UK but as noted in indicator 1.03 is affected by anomalous 'people' data. The UK's data for 2007 also show a marked rise over last year's report for 2006, perhaps driven by recent research assessment.

The citation count per researcher is rising slowly for the G8 nations, but France (6.87 citations per researcher), the USA (6.91) and Germany (7.82) remain well behind the UK. Germany is the most improved having overtaken these two others in the decade. Nonetheless, all three and the EU average (6.81) remain behind the comparator group average (8.02).

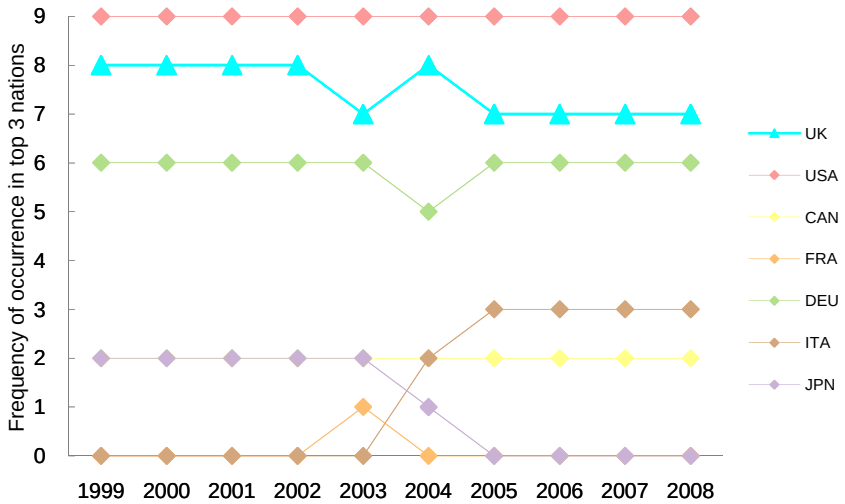
1.07 Rank on citation volume in nine main research areas - frequency of occurrence in top 3 nations

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

Frequency of occurrence in top 3 comparator group nations	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK	7.2	7.0	⇔
USA	9.0	9.0	⇔
Germany	5.8	6.0	⇔
Japan	1.5	0.0	⇩
Canada	2.0	2.0	⇔
China	2.8	3.0	⇧

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 not included in this indicator as there are uncertainties about the value of national ranked performance in relation to recently changed Humanities' data.

Seven countries account for the top three places across the nine subject areas over the ten-year period, as they did in the last report. The UK has maintained its position and is ranked in the top three for seven out of the nine areas while the USA does so for all areas. Germany has consolidated from a more variable position last year but Japan and France have now dropped out entirely and Canada places only twice. The winner is China which is in the top three in three subject areas: mathematics, physical sciences and engineering.

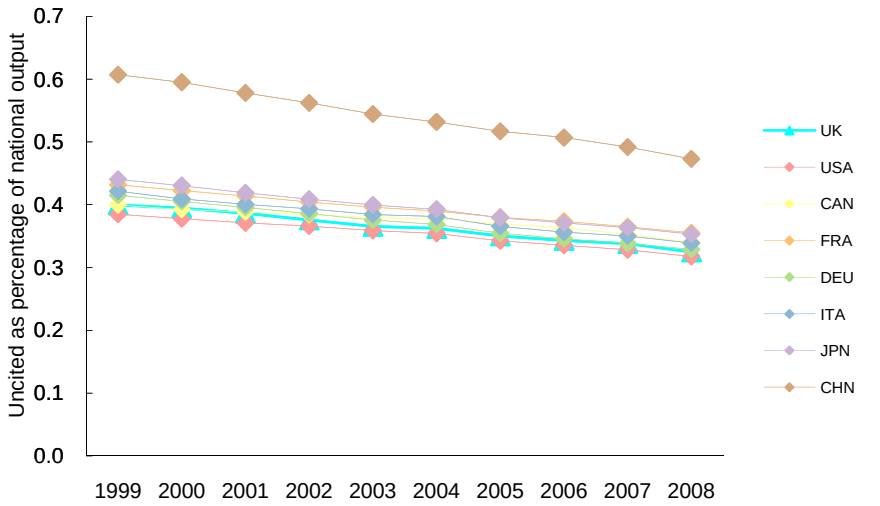
1.08 Proportion and share of uncited papers

Table 1.08 Uncited papers as share of world

	Recent 5 year value (1999-2003)	Current 5 year value (2004-2008)	Current relative to Recent
UK uncited as percentage of all papers	0.35	0.32	-8%
Group average uncited as percentage of all papers	0.38	0.36	-6%
UK / Group average	0.92	0.91	-2%
UK rank within Group	8	8	⇔
UK rank within G8	2	2	⇔
UK uncited as share of world uncited papers	0.08	0.07	-7%

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. Here we used fixed five-year windows for a like-for-like comparison. The UK's proportion of uncited papers in each sample has fallen from 35% to 32% (an 8% relative drop) while its total output has risen, so the increase in volume has not resulted in more marginal output. Only the USA and the Scandinavian countries have had a smaller proportion of uncited papers. 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.

The UK has a lower share of the world total of uncited papers (7.0% now compared to 7.6% in the recent past and compared to 7.9% of total outputs). This places it 2nd in the G8, just behind the USA. China has a much higher level of uncitedness (47%) than the G8 and other established nations. This is clearly on a falling profile, however, and China has gradually narrowed the gap with the comparator group average from 18% in 1999 to 11% now. Nonetheless, at present, only India (48%) and Iran (53%) have a higher percentage of uncited papers than China.

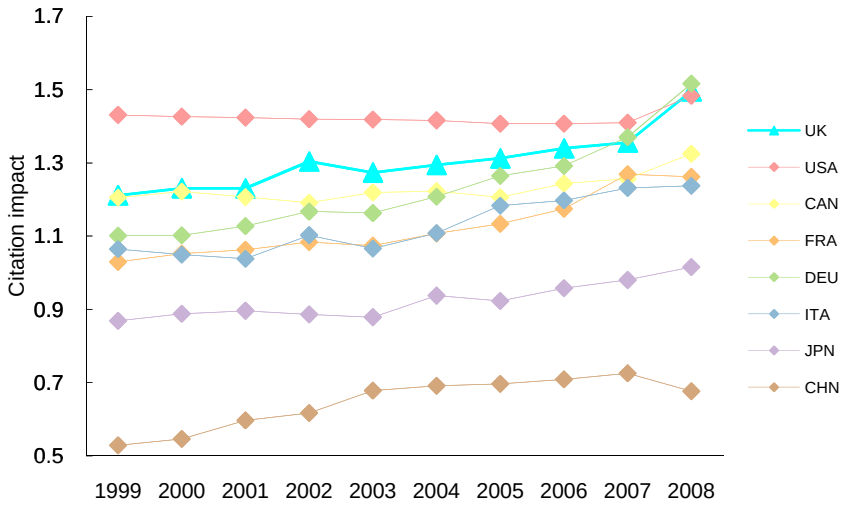
1.09 Citation impact (citations per paper) relative to world baselines

Table 1.09 Citation impact

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.32	1.50	+14%
Group average citation impact	1.05	1.13	+8%
UK / Group average	1.25	1.32	+6%
UK rank within Group	7	5	⇧
UK rank within G8	2	2	⇔

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 impact changes as citations accumulate, the index is normalised (rebased) relative to world average within year (hence, world average becomes 1.0). The UK's citation impact is higher in 2008 (1.50) than in 2007 and has improved by 14% on the recent past, compared to an 8% improvement in last year's report. This is more than the comparator group average, led by Switzerland (1.83), Denmark (1.70) and the Netherlands (1.55). The UK has improved its ranking to 5th overall and maintains a very even performance (indicator 1.11).

For most of the ten-year period, the UK has been consistently in second place in the G8 on this indicator. It has now moved ahead of the USA (1.48) but remains second because it has been overtaken by Germany (1.52). The picture this year is similar to 2007, but France and Italy have slipped back in the G8 group with a slight fall in impact despite a growth in volume. The position for China is becoming more complex. It has for several years showed a marked drop in impact in the last few years of each cycle, with a hump-shaped profile. This hump is now less evident and its overall impact seems to be stabilising at around 0.7 of world average but this may change as it diversifies into more fields of science. Database changes may also have added more modest Chinese journals.

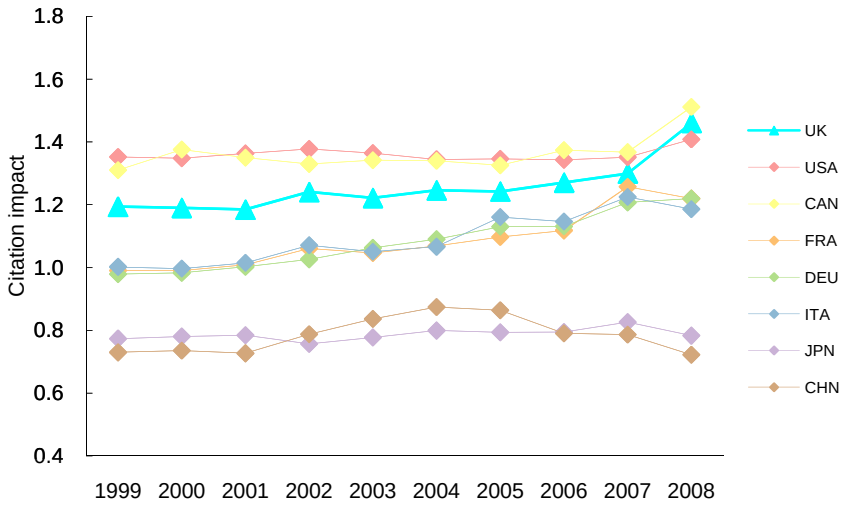
1.10.01 Citation impact relative to world baselines in ten main research fields

Table 1.10.01 Citation impact of clinical papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.26	1.46	+16%
Group average citation impact	1.04	1.13	+9%
UK / Group average	1.21	1.30	+7%
UK rank within Group	9	8	⇧
UK rank within G8	3	2	⇧

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 data in this area have been recategorised. The UK's rank within the comparator group has improved and, with average impact = 1.46, is now 2nd to Canada and ahead of the USA within the G8, with sustained impact gains over the decade. Some of the shifts in rank seen last year, e.g. for France and Poland, have not been sustained.

China's impact in clinical science has not developed. As in last year's report it is tracking Japan and well behind the G8 with impact 0.7-0.8. The world leaders are Denmark (1.65), Switzerland (1.64) and Belgium (1.6). They have sustained this lead position for several years. Last year's report noted a 'bunching' amongst EU nations. This is now less evident with recategorised data and the conclusion is therefore that collaboration is not diluting national distinctiveness.

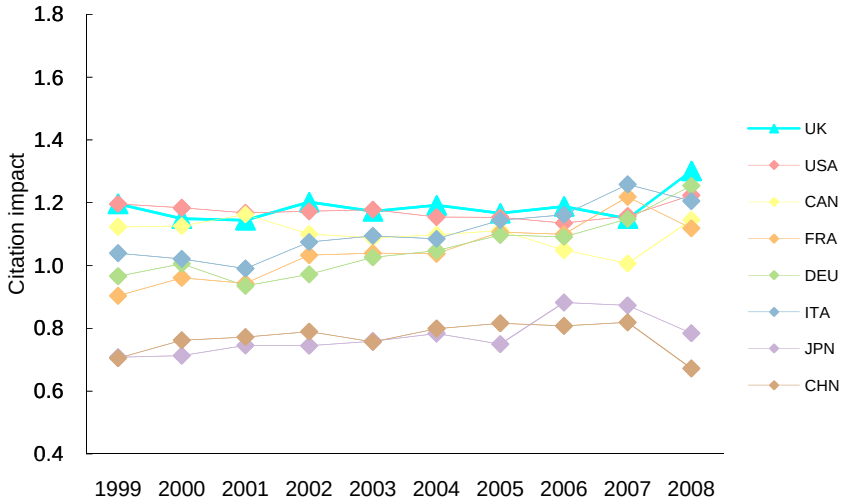
1.10.02 Citation impact relative to world baselines in ten main research fields

Table 1.10.02 Citation impact of health & medically-related papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.17	1.30	+11%
Group average citation impact	0.98	0.99	+0%
UK / Group average	1.19	1.32	+11%
UK rank within Group	5	4	⇧
UK rank within G8	1	1	⇔

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 data in this area have been recategorised. The UK has sustained a lead position in the G8 and improved its overall rank. Note that the comparator group average impact is close to world average and this is an area with less spread of performance than some fields. The charted nations are mostly in the impact range 1.15-1.3. The world leader is Switzerland (1.52).

China's impact in health sciences is not improving despite its growing volume. As in last year's report it is tracking Japan and well behind the G8 with impact 0.7-0.8. There are a number of non-EU nations with similar impact (Brazil, India, Iran, Taiwan) while the EU nations tend to be more closely aligned to the G8 lead group. This may reflect prioritisation of health research in EU programmes.

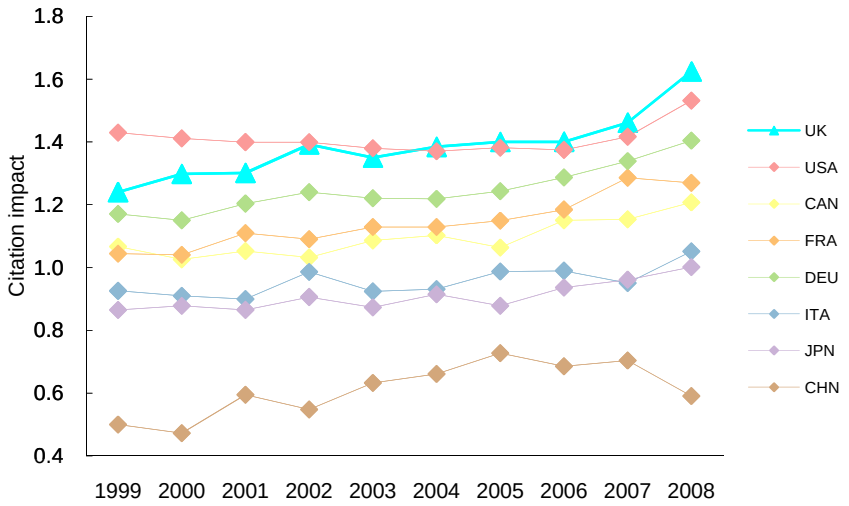
1.10.03 Citation impact relative to world baselines in ten main research fields

Table 1.10.03 Citation impact of biological sciences papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.40	1.62	+16%
Group average citation impact	0.98	1.07	+10%
UK / Group average	1.43	1.51	+6%
UK rank within Group	2	2	⇔
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 steadily improved in performance over the decade (impact 1999 = 1.24, 2008 = 1.62) and is now ranked 1st in the G8 and 2nd to Switzerland (1.68) in the comparator group. The UK moved ahead of the USA in 2006 and it has not only sustained but seems to be increasing its lead. The USA has a more steady performance over the period and its impact now (1.53) puts it 4th behind Singapore (1.57).

China's volume of papers in biological sciences is now similar to the UK, Germany and Japan but its impact is not only low in the most recent year but has improved only very slowly over the decade. Although Italy and Japan have struggled recently, they have both improved in the last year and increased their lead over China. The EU's overall position remains modest, impact climbing from 1 to 1.14 in the decade. This is just ahead of comparator group average despite strong impact for many individual European nations and reflects the diversity of performance across the region.

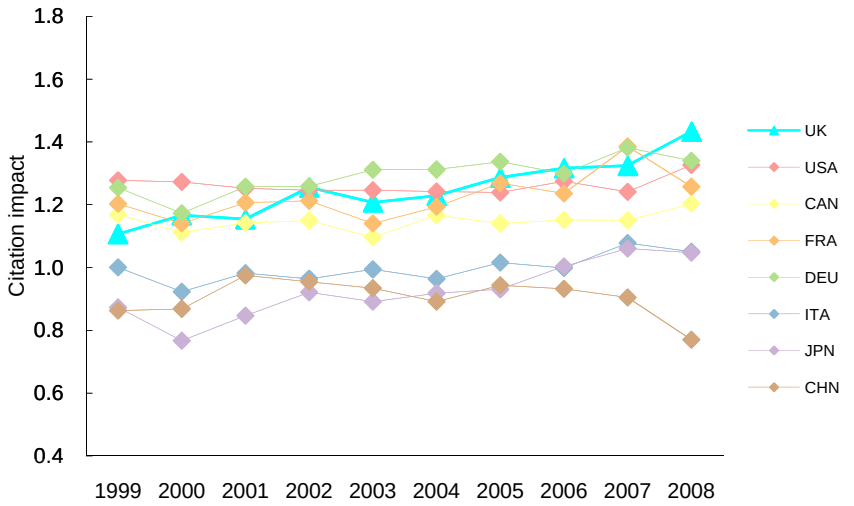
1.10.04 Citation impact relative to world baselines in ten main research fields

Table 1.10.04 Citation impact of environment papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.27	1.43	+13%
Group average citation impact	1.07	1.09	+3%
UK / Group average	1.19	1.31	+10%
UK rank within Group	8	6	⇧
UK rank within G8	2	1	⇧

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. The UK has moved into a clear 1st in the G8 with steadily improving performance across the decade. Its impact (1.43, up from 1.11 in 1999) compares to 1.61 for Switzerland, the world-leader. Germany and France, which leapt up last year, have fallen back but the USA seems to have halted its decline.

China's performance has dropped markedly in 2008 compared to its profile in last year's report. Japan, by contrast, has improved its position and is now ranked closely with Italy. Denmark (1.58), and the Netherlands (1.54) are consistently excellent performers and Sweden and Belgium are just ahead of the UK. As in biology, despite this strong European lead the average EU performance remains only just ahead of the comparator group average.

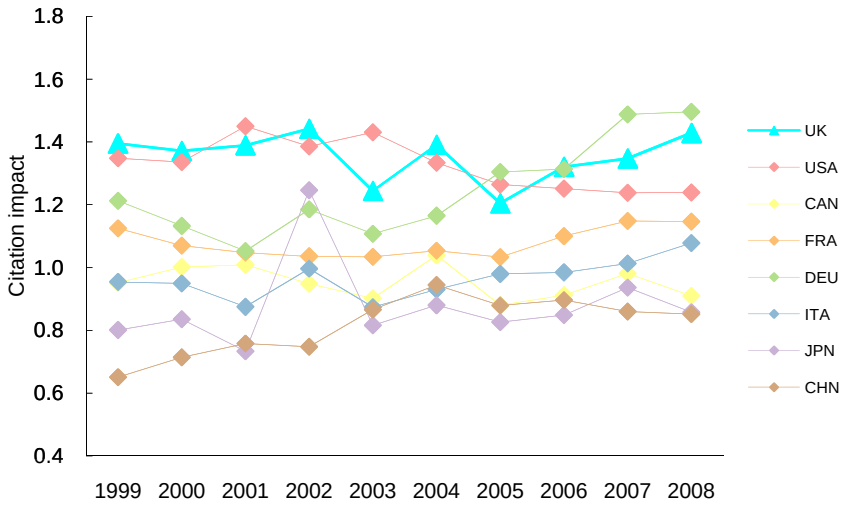
1.10.05 Citation impact relative to world baselines in ten main research fields

Table 1.10.05 Citation impact of mathematics papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.30	1.43	+10%
Group average citation impact	1.07	1.09	+2%
UK / Group average	1.22	1.31	+7%
UK rank within Group	5	4	⇧
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. The data in this area have been recategorised. Against the trend in earlier reports, the UK (impact recent = 1.30, 2008 = 1.43) is now seen to be not just competitive with but to have overtaken the USA (1.30, 1.24). Last year's report noted that the UK was gradually catching the USA, but having moved ahead it has at the same time been overtaken by Germany (1.28, 1.50) and so remains 2nd in the G8. Switzerland (1.69) leads the comparator group with Denmark (1.66).

In last year's report it was noted that some performance data might need review. China appeared in last year's report to be competitive with G8 nations but this year it is clear that while it does (at 0.85) now have similar impact to Canada (0.91) and Japan (0.86) , those two nations are trailing the rest of the G8. Japan has, however, significantly improved on last year's outcome. Note should be taken of Iran which has improved in impact (0.66 in 1999, 1.07 in 2008), similar to Singapore (1.10) and close to comparator group average. The EU current average is 1.13.

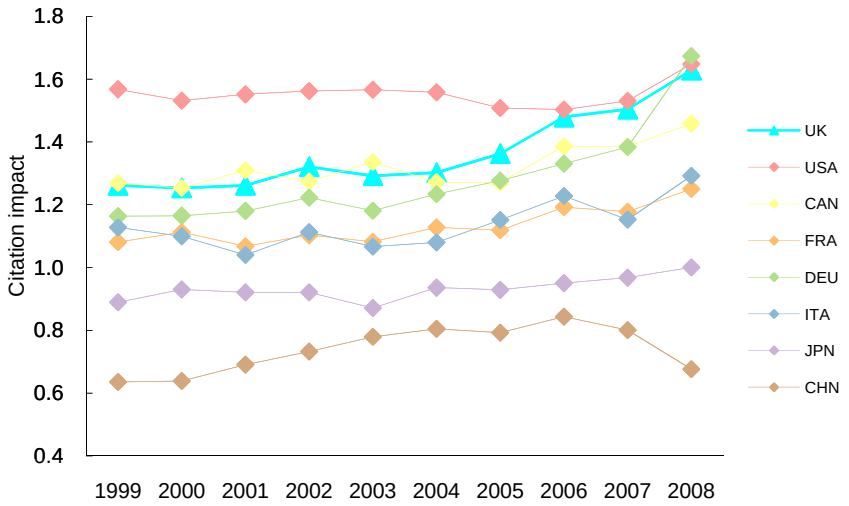
1.10.06 Citation impact relative to world baselines in ten main research fields

Table 1.10.06 Citation impact of physical sciences papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.39	1.63	+17%
Group average citation impact	1.12	1.20	+7%
UK / Group average	1.24	1.35	+9%
UK rank within Group	6	6	⇔
UK rank within G8	2	3	⇩

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 last year's report the UK had just edged ahead of the USA and Germany in physical sciences. This year, Germany (1.67) has edged ahead and the USA (1.65) has gained slightly to move the UK (1.63) to 3rd. The differences are obviously marginal. The Netherlands (1.67) and Denmark (1.64) have impact virtually identical with these three while Switzerland (1.85) leads.

The charted outcome is similar to previous reports. This is an area in which China has had a very substantial presence for some time and a volume close to the USA. Nonetheless, it is evident that it has yet to show a clear improvement in performance and its output continues to outstrip its citation growth. The EU has a better average (1.24) in this area than in some other fields indicating a more even spread of performance across nations. Outside Europe, the smaller SE Asian nations have not improved performance over the decade but S Africa has recently shown a marked impact gain.

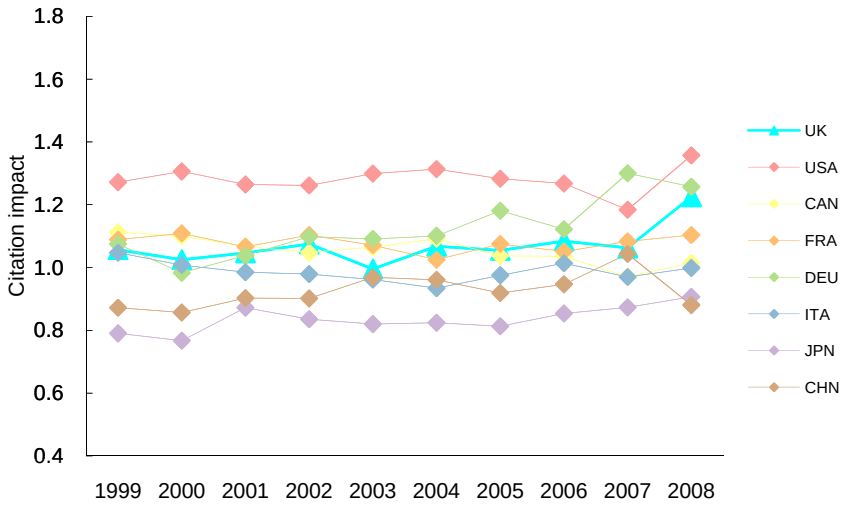
1.10.07 Citation impact relative to world baselines in ten main research fields

Table 1.10.07 Citation impact of engineering papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.05	1.22	+16%
Group average citation impact	1.03	1.04	+1%
UK / Group average	1.02	1.17	+15%
UK rank within Group	12	7	⇧
UK rank within G8	4	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. The UK has shown a steady improvement in impact since 2000 and is 3rd in the G8, just behind Germany. France has slipped back slightly compared to earlier years and Japanese engineering performance is markedly lower than in earlier analyses. Across the comparator group as a whole, the UK has moved up to 7th. The comparator group is led by Switzerland (1.68) and Denmark (1.65).

It is informative to note that in engineering, China's earliest core research area, its impact rose above world average in 2007 and only dipped slightly in 2008. That puts it on a rising trajectory that will take it past France in the near future. Iran also performs well, passing India to reach an impact of 1.05 in 2007, dipping in 2008 but not by as much as China. This takes these countries past both S Korea and Taiwan in engineering research performance.

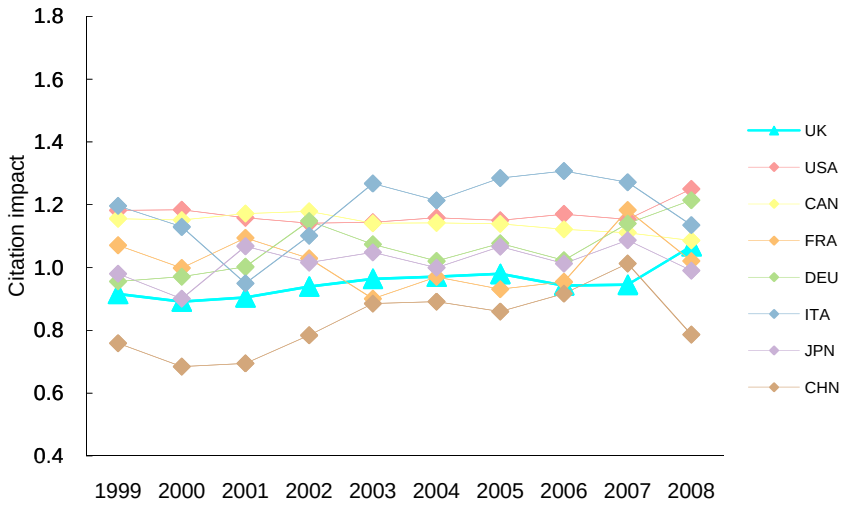
1.10.08 Citation impact relative to world baselines in ten main research fields

Table 1.10.08 Citation impact of social science papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	0.96	1.07	+11%
Group average citation impact	0.98	0.90	-8%
UK / Group average	0.98	1.19	+21%
UK rank within Group	14	9	⇧
UK rank within G8	7	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. Much improved coverage of social sciences has dampened some of the impact volatility seen in earlier reports. The UK's overall position is not hugely changed by this data enrichment but despite the shift to more non-Anglophone journals it improves on rank within the comparator group. The comparator group has been led consistently by Denmark (impact = 1.67) with the USA (1.25) in 2nd.

China appears to be performing well in an area in which it has so far had relatively little presence. Its steady climb since 2000 is evident, while the dip in impact in 2008 is of no significance. Most Asian nations have relatively weak performance on these data and India has rarely risen above 0.5 world average. Brazil, however, had a steady rise in performance to 2007, confirming the improved diversity of data coverage.

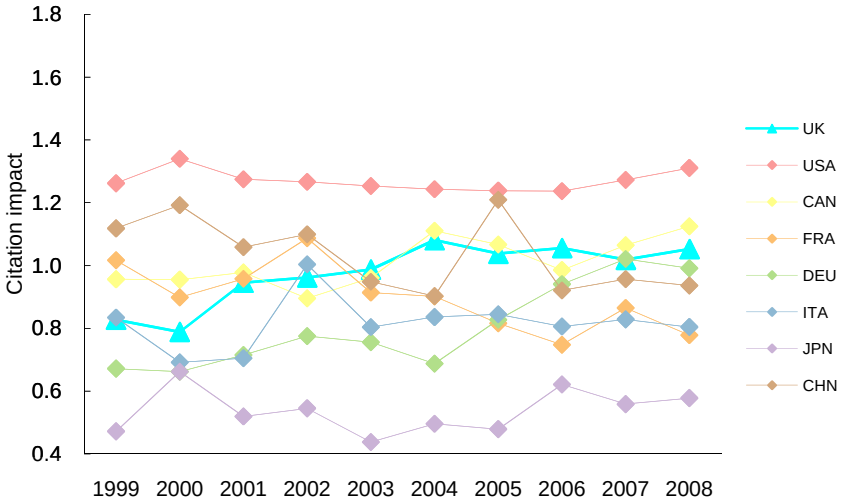
1.10.09 Citation impact relative to world baselines in ten main research fields

Table 1.10.09 Citation impact of business papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.04	1.05	+2%
Group average citation impact	0.87	0.84	-3%
UK / Group average	1.20	1.25	+5%
UK rank within Group	7	5	⇧
UK rank within G8	3	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. The USA has dominated the business and management research literature and continues to do so despite database changes. The UK has a sustained performance and remains in 3rd rank in the G8. While its position has improved on these data, it is in fact slightly behind last year's report on older data. The comparator group is led by Switzerland (impact = 1.63) and Israel (1.45).

China's impact has somewhat strangely declined over the decade. This characteristic was seen in last year's report but is more evident now because the overall China profile is lifted by the enhanced data. It appears to be producing more output but of lower quality. The profile for Germany has also changed and the enhanced data have similarly added more business research papers of lower impact for that country.

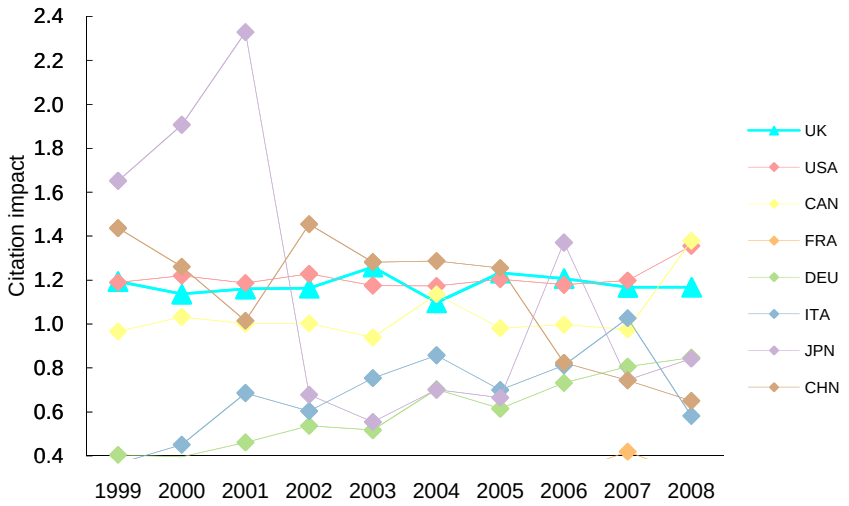
1.10.10 Citation impact relative to world baselines in ten main research fields

Table 1.10.10 Citation impact of humanities papers

	Recent average (2003-2007)	Current value (2008)	Current relative to Recent
UK citation impact	1.19	1.17	-2%
Group average citation impact	0.99	0.94	-5%
UK / Group average	1.20	1.24	+3%
UK rank within Group	8	11	⇩
UK rank within G8	1	3	⇩

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 have been reviewing the use of publication-indicators and more informed analyses are now available. On these revised data, with a greater journal spread, the UK position has moved back on last year's report.

The performance of the Anglophone nations is more consistent in the graph this year than in previous years' reports. The profile for other nations can be very erratic but the steadily rising profile for Germany and Italy is noticeable while France is effectively a non-player in this area. This tends to confirm a suggestion made last year that different cultures have moved to journals from other output modes at very different rates.

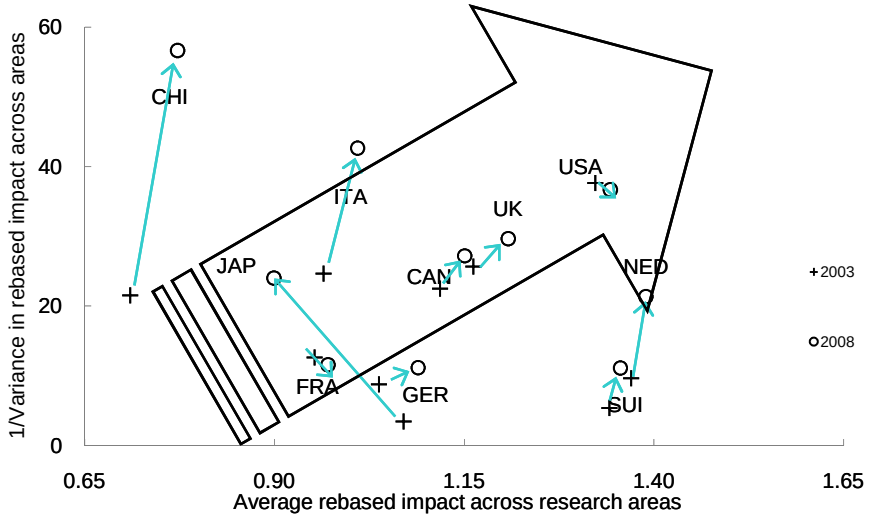
1.11 Variety and consistency of research strength

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

	Recent (1999-2003)			Current (2004-2008)			Current/ Recent
	Average	1/Variance	Avg/Var	Average	1/Variance	Avg/Var	Avg/Var
UK	1.2	25.7	29.8	1.2	29.6	35.8	+20%
USA	1.3	37.6	49.8	1.3	36.7	49.2	-1%
CAN	1.1	22.5	25.1	1.2	27.2	31.3	+24%
FRA	1.0	12.6	12.0	1.0	11.6	11.2	-7%
GER	1.0	8.8	9.1	1.1	11.1	12.1	+33%
ITA	1.0	24.7	23.8	1.0	42.6	43.0	+81%
JAP	1.1	3.4	3.7	0.9	24.0	21.6	+488%
NED	1.4	9.6	13.2	1.4	21.3	29.7	+124%
SUI	1.3	5.4	7.2	1.4	11.1	15.1	+109%
CHI	0.7	21.5	15.3	0.8	56.6	43.7	+186%

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 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 consistency across disciplines, placing the country in the upper, right-hand part of the chart. Its impact improves between early (1999-2003) and late (2004-2008) periods and gains in diversity. The USA has fallen back on diversity at much the same level of performance, as has France. Germany has improved slightly but the Netherlands has a marked gain in consistency. China has also moved up as its research diversity improves with diversifying investment. Japan has suffered in performance more than its gain in evenness, reflecting a performance drop in peak areas.

1.12 Papers in top 1% by citation count

Share of papers in top 1% by citation count

Country	Publications in top 1% world publications (pubs)	Publications as % share of world	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	993	1.12	162,925	164.07	18	17	1		Finland
Sweden	2,329	2.63	381,893	163.97	13	11	2		Sweden
Israel	1,337	1.51	214,326	160.30	16	16	3		Israel
Japan	5,376	6.08	844,878	157.16	6	5	4	1	Japan
USA	51,831	58.59	8,127,677	156.81	1	1	5	2	USA
UK	12,776	14.44	1,956,931	153.17	2	2	6	3	UK
Switzerland	3,581	4.05	544,543	152.06	10	9	7		Switzerland
Denmark	1,570	1.77	234,964	149.66	15	15	8		Denmark
Netherlands	3,789	4.28	565,140	149.15	8	8	9		Netherlands
Belgium	1,804	2.04	268,512	148.84	14	14	10		Belgium
Canada	5,508	6.23	813,873	147.76	5	6	11	4	Canada
France	6,151	6.95	908,582	147.71	4	4	12	5	France
Russia	970	1.10	141,403	145.78	19	18	13	6	Russia
Germany	9,788	11.07	1,409,761	144.03	3	3	14	7	Germany
Italy	4,218	4.77	595,829	141.26	7	7	15	8	Italy
Australia	3,131	3.54	436,503	139.41	11	10	16		Australia
Poland	758	0.86	104,949	138.46	21	20	17		Poland
Spain	2,704	3.06	363,985	134.61	12	12	18		Spain
Brazil	731	0.83	91,665	125.40	23	22	19		Brazil
South Africa	355	0.40	39,834	112.21	25	25	20		South Africa
India	894	1.01	98,170	109.81	20	21	21		India
South Korea	1,309	1.48	135,907	103.83	17	19	22		South Korea
Singapore	597	0.67	55,998	93.80	24	24	23		Singapore
Taiwan	744	0.84	68,441	91.99	22	23	24		Taiwan
China	3,750	4.24	308,362	82.23	9	13	25		China
Iran	220	0.25	8,463	38.47	26	26	26		Iran
European Union	50,451	57.03	7,418,419	147.04					European Union

Commentary

Some publications have exceptional citation rates within their field. Thomson Reuters has found that share of the most cited 1% of world papers is a useful international indicator. The data here cover the ten-year period 1999-2008; the underlying content has grown compared to previous reports. The UK has 12,776 papers among the world's most highly-cited 1% by impact with an average impact of 153.17 citations per paper. It lies second in the G8 by volume (where the USA is 1st with 51,831) and 3rd by impact (where Japan is 1st at 157.16). The UK increased its share, at 14.44% (up from 13% in 2007) compared to a recent UK average of around 8% of world sources (indicator 1.01) and reflects its competitive excellence. The USA remains only just the leader on volume compared to the EU.

Finland remains the leader on average impact (the highest average impact in the top 1% but fewer than 1,000 papers). Although China now has a baseline volume greater than all but the USA, its share of highly cited papers is less than that of most of the G8. However, Russia has suffered a marked decline in high end performance with a smaller highly-cited volume than Finland.

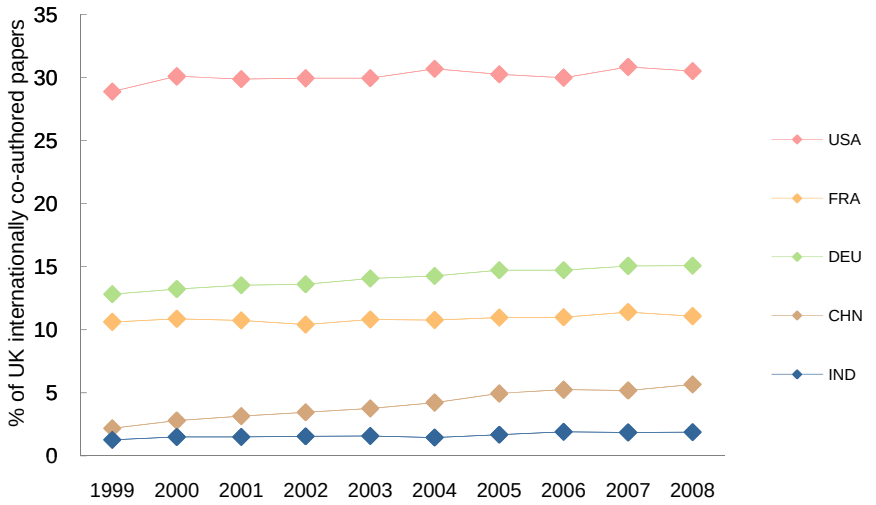
2.01 UK co-authorship for select partner countries relative to total UK co-authorship

Table 2.01 Share of UK internationally co-authored papers

	Recent average 2003-2007	Current value 2008	Current relative to Recent
USA-UK as % UK co-authored papers	30.33	30.50	+1.01
France-UK as % UK co-authored papers	10.99	11.08	+1.01
Germany-UK as % UK co-authored papers	14.56	15.07	+1.04
China-UK as % UK co-authored papers	4.67	5.66	+1.21
India-UK as % UK co-authored papers	1.70	1.89	+1.11
(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 23,800 (33% of total output) in 1999 to 43,000 (47%) in 2007, a major rise in volume and relative to total activity. The volume of co-authorship with every member of the DIUS comparator group has increased, typically by a factor of 2-3 but fourfold in the case of China and six-fold with Iran.

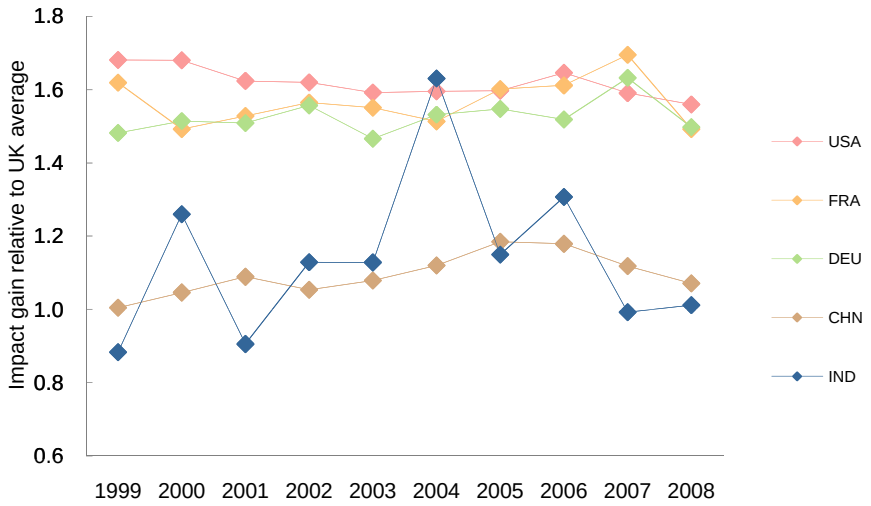
The table and chart shows that the greatest level of collaboration is with traditional research partners in the G8. Collaboration with the USA is relatively stable as a proportion of UK volume, and has grown less than for most of the comparator group. It has increased by a greater proportion for China (now almost 2,500 papers per year) and India (about 800 papers per year). Increases above average are also recorded for South Africa and for, S Korea and Taiwan. Collaboration with Brazil - which is showing rapid research growth - has risen from 400 to around 900 papers per year but with Iran has grown from 65 papers in 1999 to 385 papers in 2008, which is now almost as much as with Singapore.

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 2003-2007	Current value 2008	Current relative to Recent
RBI for USA-UK relative to RBI for UK	1.60	1.56	+0.97
RBI for France-UK relative to RBI for UK	1.59	1.49	+0.94
RBI for Germany-UK relative to RBI for UK	1.54	1.50	+0.97
RBI for China-UK relative to RBI for UK	1.14	1.07	+0.94
RBI for India-UK relative to RBI for UK	1.24	1.01	+0.82

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. The impact gain now is less on average than that historically. That is because such a high proportion of UK activity is now entwined with other countries that lower impact work is drawn into the analysis.

The gain on collaborations with all partner countries is often substantial. It is in fact higher than for previously analysed datasets because the global average has been reduced by the greater coverage. Collaboration with long-term partners such as the USA, Germany and France produces papers the impact of which is 50% higher than the UK research base average. Collaboration with China and India is of lower impact but may be more important in intellectual gain from such innovative economies. For increasingly dynamic Brazil, impact is 1.3 times UK average. But the greatest returns on collaboration come from smaller European partners: Switzerland (1.8 times UK average), Denmark (1.7) and Belgium, which have high domestic impact in areas of niche strength.

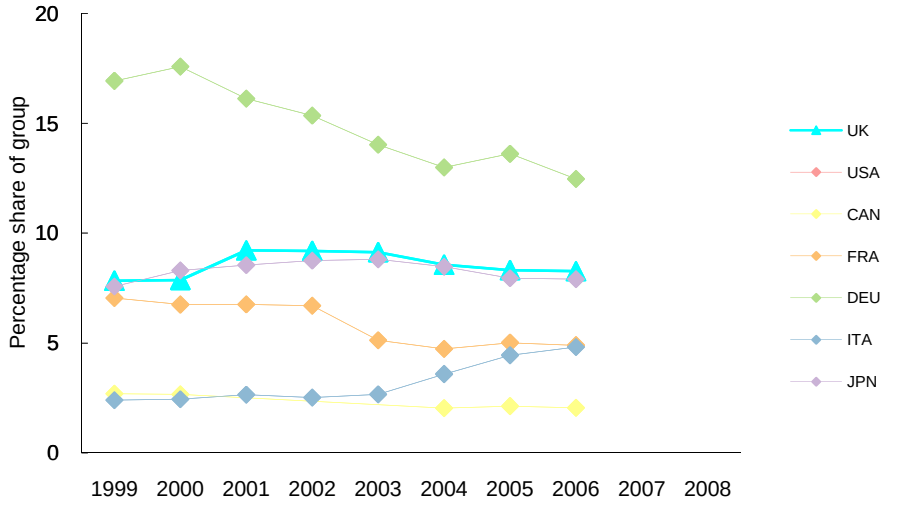
3.01 Number and share of OECD PhD awards

Table 3.01 Doctoral awards

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs	14,829	16,427	+11%
Group average PhDs	10,159	11,599	+14%
UK / Group average	1.46	1.42	-3%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	8.9	8.3	-7%

Data: OECD. Analysis: Evidence

Chart 3.01 Doctoral awards as share of group



Data: OECD. Analysis: Evidence

Commentary

The OECD data sequence remains at eight years, as in the last report, as there are no more recent data than 2006. A number of important countries – China, India, Brazil and Iran – supply no PhD data to OECD. The UK remains 3rd in the G8 and the comparator group, with an 8.3% share behind the USA (27.7%) and Germany (12.5%). Output for the UK has risen strongly in absolute terms, from around 11,000 in 1999 to over 16,000 in 2006.

The USA shows a steep recent rise from a relatively flat PhD output up to 2004, since when it has risen 20% in response to national initiatives on researcher supply. Nonetheless, its share is down on 1999. Germany has a relatively flat output, around 25,000 PhDs per year, so its share is falling against growth elsewhere. France has had some recovery from a low in 2003 but is still below 1999 totals. For most EU countries PhD output growth is numerically small so the UK's profile and growth is relatively good.

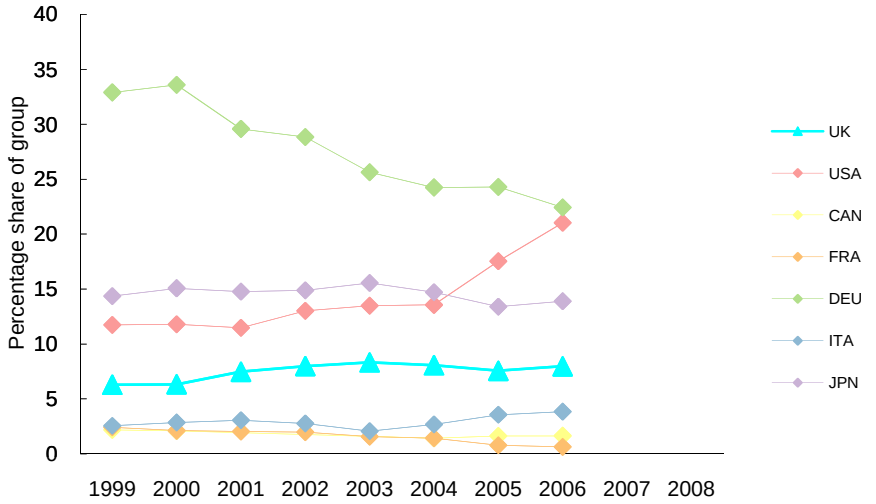
3.02.01 Number and share of OECD PhD awards in five main research areas

Table 3.02.01 Doctoral awards in medical sciences

	Recent Average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs	2,426	2,821	+16%
Group average PhDs	1,925	2,230	+16%
UK / Group average	1.26	1.26	+0%
UK rank within Group	4	4	⇔
UK rank within G8	4	4	⇔
UK share of group	7.9	8.0	+1%

Data OECD. Analysis: Evidence

Chart 3.02.01 Doctoral awards in medical sciences as share of group



Data OECD. Analysis: Evidence

Commentary

This is an indicator of the UK's share of PhDs for each of the five main OECD research categories and is a disaggregation of the data used in Indicator 3.01. Highly-skilled people are a key output of the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of comparator group allows for comparison with other input and output measures (e.g. Indicators in theme 5). The OECD Education database extends now to cover eight years in these reports, but no more recent data than for 2006. India and China are not covered.

OECD medical sciences includes clinical and health sciences. The UK is slightly increasing its share of comparator group PhDs, up from 6.3% to 8.0% in the decade and doubling volume to 2,821 PhDs in 2006. Change in share is affected by the recent rapid expansion of USA numbers, almost doubling in three years to 7,500 PhDs per year, balanced by a static output and falling share from Germany. France has little research training in this area and PhD numbers have declined to fewer than 250 per year. The UK remains 4th but South Korea is ranked a close 5th and rising.

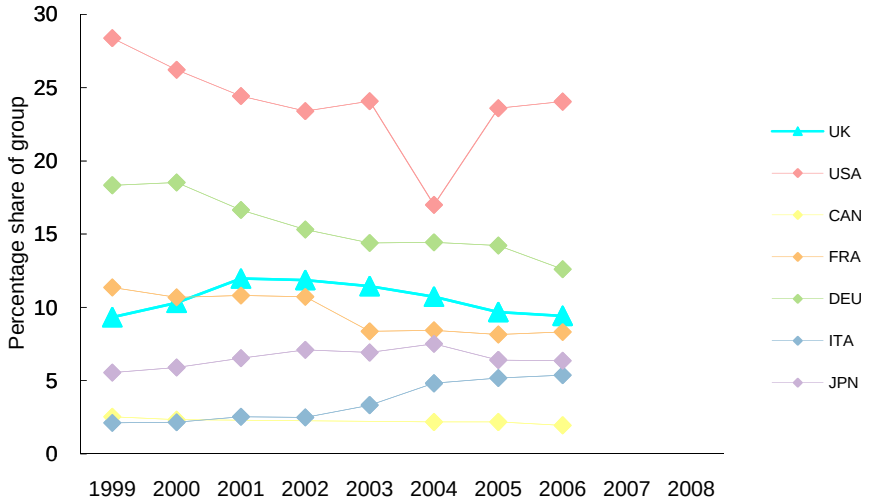
3.02.02 Number and share of OECD PhD awards in five main research areas

Table 3.02.02 Doctoral awards in natural sciences

	Recent Average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs	5,421	5,445	+0%
Group average PhDs	2,948	3,347	+14%
UK / Group average	1.84	1.63	-12%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	11.1	9.4	-15%

Data OECD. Analysis: Evidence

Chart 3.02.02 Doctoral awards in natural sciences as share of group



Data OECD. Analysis: Evidence

Commentary

This is an indicator of the UK's share of PhDs for each of the five main OECD research categories and is a disaggregation of the data used in Indicator 3.01. Highly-skilled people are a key output of the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of comparator group allows for comparison with other input and output measures (e.g. Indicators in theme 5). The OECD Education database extends now to cover eight years in these reports, but no more recent data than for 2006. India and China are not covered.

OECD natural sciences include biological, physical and environmental science, mathematics and agriculture. The UK output of PhDs in this area has been essentially flat since 2000 and its share is falling, down to 9.4% in 2006 from 12% in 2001. It remains ranked 3rd overall. Germany's output is also falling but that of other countries is rising. UK share will continue to decline and its total output will be overtaken by France in the near future unless training volume increases in these subjects.

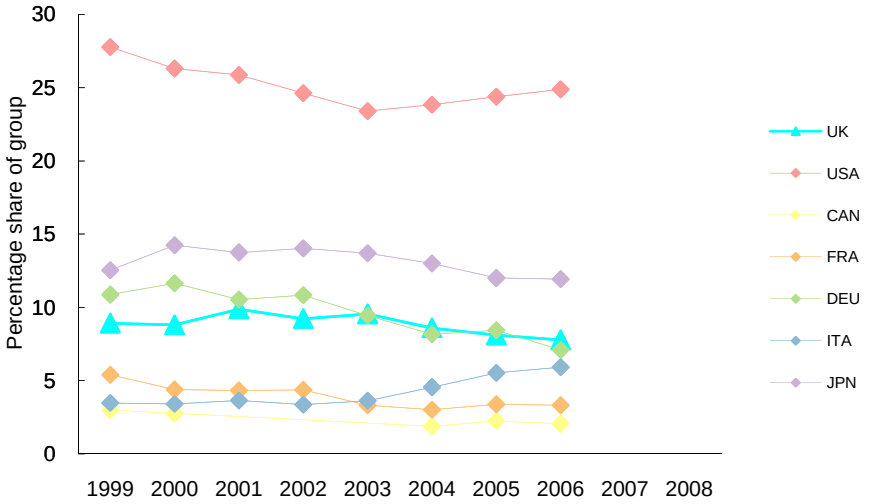
3.02.03 Number and share of OECD PhD awards in five main research areas

Table 3.02.03 Doctoral awards in engineering and technology

	Recent Average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs	2,184	2,397	+10%
Group average PhDs	1,458	1,755	+20%
UK / Group average	1.50	1.37	-9%
UK rank within Group	4	3	⇧
UK rank within G8	4	3	⇧
UK share of group	9.1	7.8	-14%

Data OECD. Analysis: Evidence

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



Data OECD. Analysis: Evidence

Commentary

This is an indicator of the UK's share of PhDs for each of the five main OECD research categories and is a disaggregation of the data used in Indicator 3.01. Highly-skilled people are a key output of the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of comparator group allows for comparison with other input and output measures (e.g. Indicators in theme 5). The OECD Education database extends now to cover eight years in these reports, but no more recent data than for 2006. India and China are not covered.

The UK has a slightly rising output of PhDs in engineering and technology, up to 2,400 in 2006 compared to fewer than 2,000 per year before 2001, but the comparator group average is rising faster so its share has declined to 7.8% from 9.1% in the recent past. The UK's rank position has improved, however, because Germany's PhD output has declined slightly and is now fewer than 2,200 per year. All shares are affected by rapid USA expansion which is up from around 5,500 five years ago to over 7,500 PhDs per year in 2006 (over 25% of world). France is also growing more quickly from a low base around 1,000 per year and South Korea looks likely to pass the UK on current data.

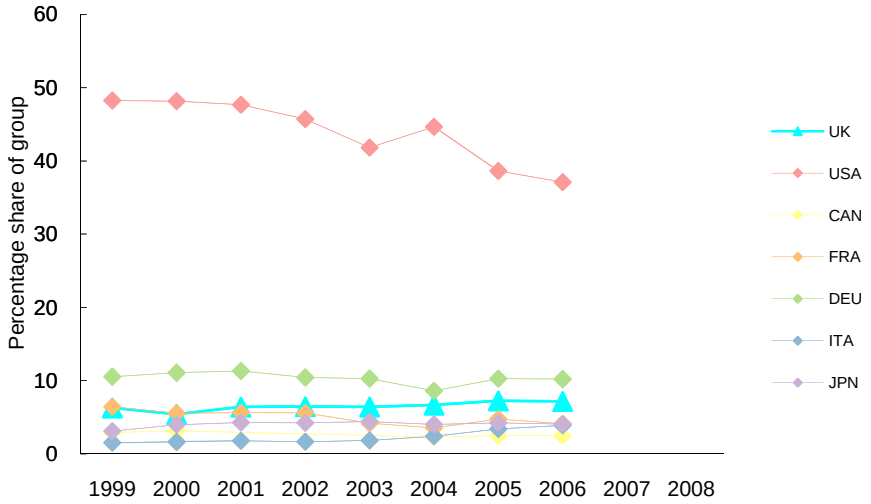
3.02.04 Number and share of OECD PhD awards in five main research areas

Table 3.02.04 Doctoral awards in social sciences

	Recent Average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs	2,814	3,561	+27%
Group average PhDs	2,571	2,851	+11%
UK / Group average	1.09	1.25	+14%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	6.6	7.1	+8%

Data OECD. Analysis: Evidence

Chart 3.02.04 Doctoral awards in social sciences as share of group



Data OECD. Analysis: Evidence

Commentary

This is an indicator of the UK's share of PhDs for each of the five main OECD research categories and is a disaggregation of the data used in Indicator 3.01. Highly-skilled people are a key output of the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of comparator group allows for comparison with other input and output measures (e.g. Indicators in theme 5). The OECD Education database extends now to cover eight years in these reports, but no more recent data than for 2006. India and China are not covered.

OECD social sciences also includes business and management. The UK's PhD output has increased by 50% since 1999 and is now around 3,500 PhDs per year. This places it 3rd to the USA (18,500, fairly constant) and Germany (5,000, rising steadily). UK share has risen to 7.1% because it is expanding output faster than the comparator group average. However, the USA dominates output in this area and the broad balance seems unlikely to change in the near future.

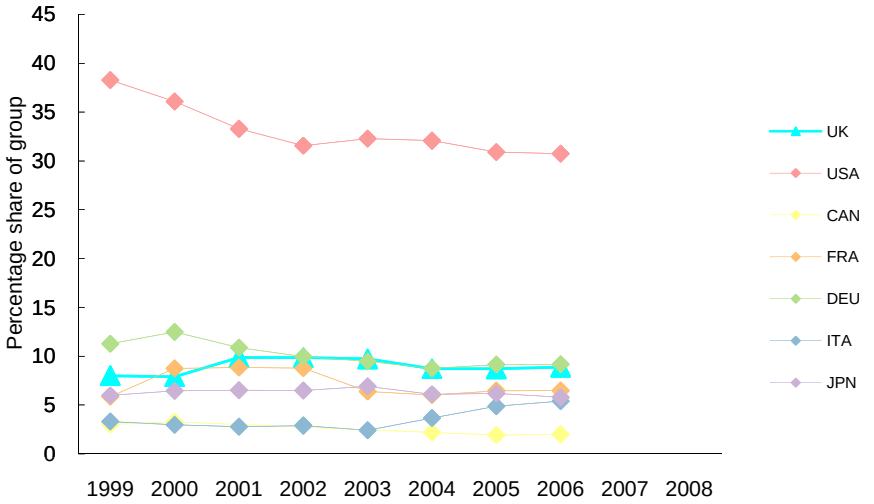
3.02.05 Number and share of OECD PhD awards in five main research areas

Table 3.02.05 Doctoral awards in humanities

	Recent Average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs	1,984	2,204	+11%
Group average PhDs	1,257	1,416	+13%
UK / Group average	1.58	1.56	-1%
UK rank within Group	3	3	⇔
UK rank within G8	3	3	⇔
UK share of group	9.4	8.9	-5%

Data OECD. Analysis: Evidence

Chart 3.02.05 Doctoral awards in humanities as share of group



Data OECD. Analysis: Evidence

Commentary

This is an indicator of the UK's share of PhDs for each of the five main OECD research categories and is a disaggregation of the data used in Indicator 3.01. Highly-skilled people are a key output of the research base and reflect the capacity to make use of knowledge. Absolute numbers indicate sustainable capacity; share of comparator group allows for comparison with other input and output measures (e.g. Indicators in theme 5). The OECD Education database extends now to cover eight years in these reports, but no more recent data than for 2006. India and China are not covered.

UK PhD output in the humanities has increased by more than 50% per year since 1999 and is now over 2,200 per year. This is a similar volume to Germany, which has had a constant output over the period. The UK's rank position remains 3rd to Germany and the USA, which produces more than one-third of the world PhDs in this area, but its share of comparator group output has fallen to 8.9% as other countries, particularly in the EU, are also investing in their humanities training.

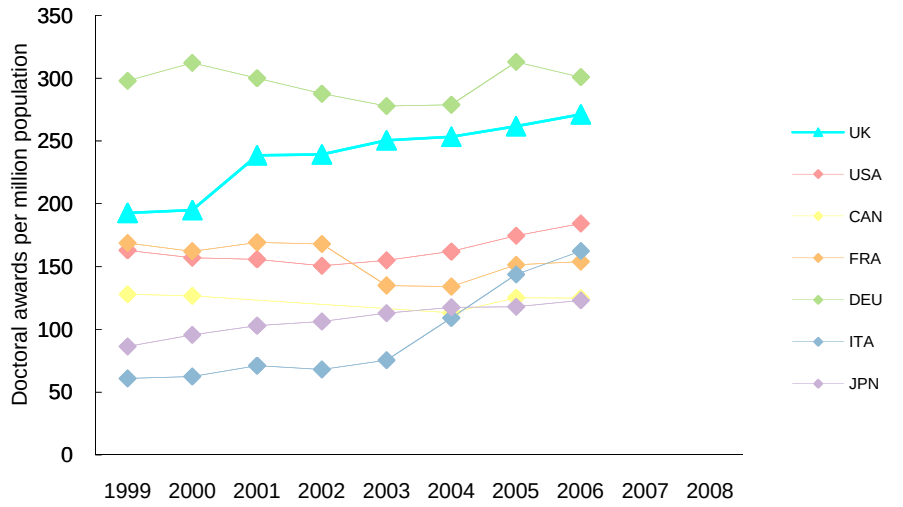
3.03 PhDs awarded relative to population

Table 3.03 Share of doctoral awards relative to share of population

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs per million population	248.72	271.13	+0.09
Group average PhDs per million population	214.05	236.52	+0.10
UK / Group average	1.16	1.15	-0.01
UK rank within Group	5	5	⇔
UK rank within G8	2	2	⇔
UK share of PhDs / UK share of population	3.95	3.80	-0.04

Data: OECD. Analysis: Evidence

Chart 3.03 Doctoral awards per million population



Data: OECD. Analysis: Evidence

Commentary

The number of PhDs awarded relative to the population as a whole is a broad measure of the relative training capacity of knowledge-skilled people. The USA, Germany, the UK and Japan all award over 15,000 PhDs per year – more than twice any other country. However, indexing this by population Switzerland (436 PhDs per million people), Sweden (416) and Finland (354) have double the output of the USA (184). In this context, the UK is increasing its absolute output and is one a rising trajectory to match Germany in 4th place.

The USA's recent increase in PhD output has improved its relative position but its relative growth is outstripped by Italy, Poland, Australia, Switzerland and South Korea. There are some striking differences between similar economies, with Canada awarding relatively half the number of PhDs as Australia, and Belgium half the number as Germany. The data deficit for the Brazil, India and China is unfortunate as this would be a valuable index of their changing knowledge capacity.

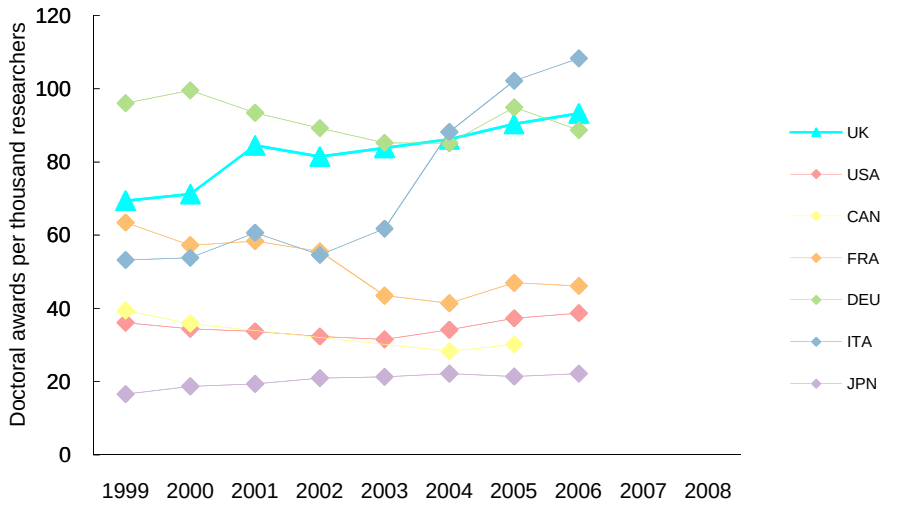
3.04 PhDs awarded relative to researchers

Table 3.04 Share of doctoral awards relative to share of researchers

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhDs per thousand researchers	85.21	93.22	+0.09
Group average PhDs per thousand researchers	56.37	58.29	+0.03
UK / Group average	1.51	1.60	+0.06
UK rank within Group	3	3	⇔
UK rank within G8	2	2	⇔
UK share of PhDs / UK share of researchers	2.77	2.83	+0.02

Data: OECD. Analysis: Evidence

Chart 3.04 Doctoral awards per thousand researchers



Data: OECD. Analysis: Evidence

Commentary

Doctoral awards relative to the existing researcher population is an indicator of the rate at which the researcher capacity is being renewed and therefore may be sustainable. The UK has increased its recent PhD output (Indicator 3.01) and there is now clear evidence of relative growth (9%) on this index. The UK has improved its position relative to comparator group average and, with a better trajectory than Germany, is now placed 2nd in the G8 and the comparator group as a whole

The USA shows some signs of improvement on this indicator but, with 38.7 PhDs per thousand researchers compared to the UK (93.2), is placed only 13th in the comparator group. In fact, as data are not available for some countries, it is trailed by only Japan (22.2) and Denmark (31.6). France has fallen back considerably since 1999 and shows no sustained recovery. The data for Italy are difficult to interpret, but may suggest some restoration of a depleted research population. There are no recent data for Switzerland, which led the comparator group.

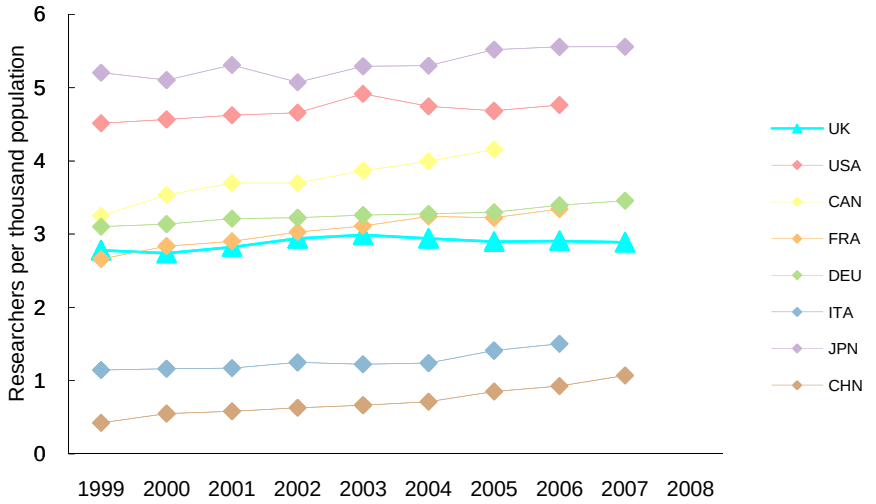
4.01 Researchers relative to population

Table 4.01 Share of researchers relative to share of population

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Researchers per thousand population	2.94	2.89	-0.02
Group average Researchers per thousand population	3.71	4.00	+0.08
UK / Group average	0.79	0.72	-0.09
UK rank within Group	16	11	⇧
UK rank within G8	7	4	⇧
UK share of researchers / UK share of population	1.41	1.89	+0.34

Data: OECD. Analysis: Evidence

Chart 4.01 Researchers per thousand population



Data: OECD. Analysis: Evidence

Commentary

The relative availability of researchers indicates the capacity of the country with regards to research and knowledge exploitation. The UK's output was relatively low at the start of the period, placing the UK 16th in the comparator group and 7th ahead only of Italy in the G8. Although its rank position appears to have improved this is only because of 2007 data deficits for some countries. In fact, the ratio of researchers to population has fallen by 2% and compared to comparator group average, which is rising, by 9%. Its researcher density is only about 0.7 of comparator group average.

The gap between the UK and its nearest EU comparators, France and Germany, is becoming increasingly evident. Canada is also on a rising trajectory. The USA has recently experienced a fall in researcher density but it is fairly stable over the decade. China has much lower researcher density than the G8 but is on a rising track and will overtake the position Italy held at the start of the decade.

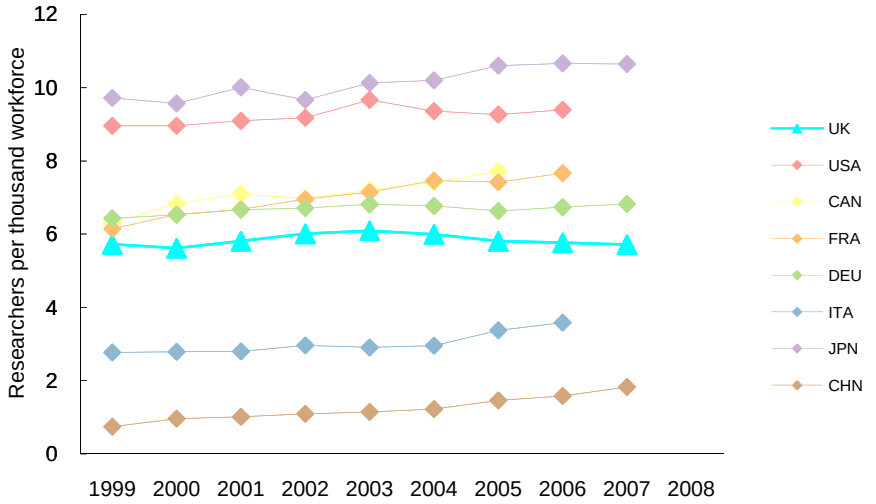
4.02 Researchers relative to workforce

Table 4.02 Share of researchers relative to share of workforce

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Researchers per thousand workforce	5.93	5.71	-0.04
Group average Researchers per thousand workforce	7.39	7.71	+0.04
UK / Group average	0.80	0.74	-0.08
UK rank within Group	15	11	⇧
UK rank within G8	7	4	⇧
UK share of researchers / UK share of workforce	1.54	2.04	+0.33

Data: OECD. Analysis: Evidence

Chart 4.02 Researchers per thousand workforce



Data: OECD. Analysis: Evidence

Commentary

The density of researchers in the UK workforce is falling. It was relatively low at the start of the period, placing the UK 15th in the comparator group and 7th ahead only of Italy in the G8. Although its rank position appears to have improved this is only because of 2007 data deficits for some countries. The availability of researchers in the workforce has fallen by 4% in 2007 compared to the recent past. The comparator group average, by contrast, is rising so the UK's position fell by 8% compared to that benchmark. The UK share of researchers compared to share to workforce appears to have gone up markedly in the last year but this is an artefact due to changes in China data.

At the start of the decade the UK was just behind France and close to Germany and Canada. France and Canada have both seen improvements in researcher availability. Although the German line has been more level, the lead over the UK is now increasing slightly. The relative improvement for China includes a 500,000 increase in researcher numbers between 2004 and 2007 bringing it level with total USA volume. This is three times the actual volume of UK researchers and implies enormous potential for future development. Numbers for South Korea and Taiwan have also risen substantially.

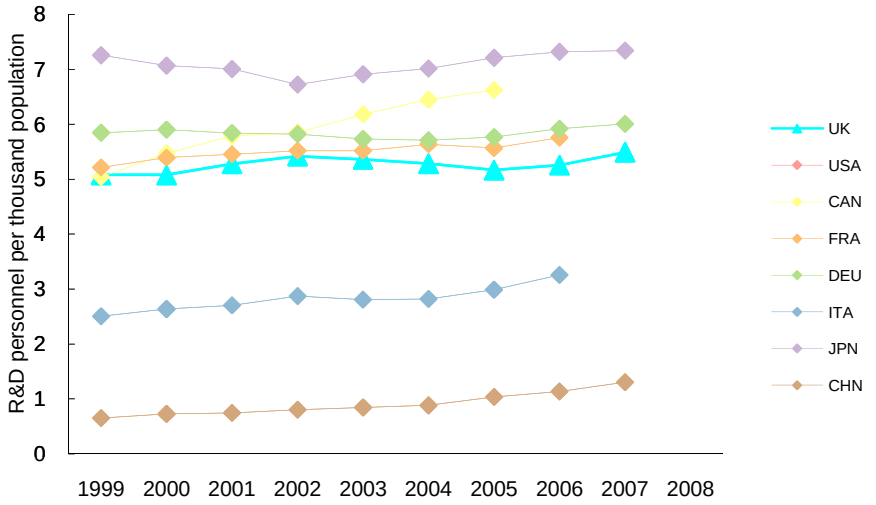
4.03 R&D personnel relative to population

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

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK R&D personnel per thousand population	5.30	5.49	+0.04
Group average R&D personnel per thousand population	5.71	6.12	+0.07
UK / Group average	0.93	0.90	-0.03
UK rank within Group	14	11	⇧
UK rank within G8	6	4	⇧
UK share of R&D Personnel / UK share of population	2.30	2.49	+0.08

Data: OECD. Analysis: Evidence

Chart 4.03 R&D personnel per thousand population



Data: OECD. Analysis: Evidence

Commentary

R&D personnel are a broader category than researchers. In round terms, the UK has about 325,000 total R&D personnel compared to about 175,000 of these who are researchers. The relative availability of R&D personnel in the UK is rising. It was less than comparator group average at the start of the period, placing the UK 14th in the comparator group and 6th ahead of Italy and Russia in the G8. The rank position for 2007 is affected by data deficits for some countries. In fact, the ratio of R&D personnel to population has risen by 4% but the comparator group average has risen by 7%.

Canada has improved noticeably over the decade and this places it well ahead of the EU members of the G8. The UK, France and Germany are in very similar positions and well ahead of Italy. There are no data for the USA. It is notable that China classifies a relatively high proportion of its R&D personnel as researchers: this may be important in arriving at an interpretation of some of these statistics.

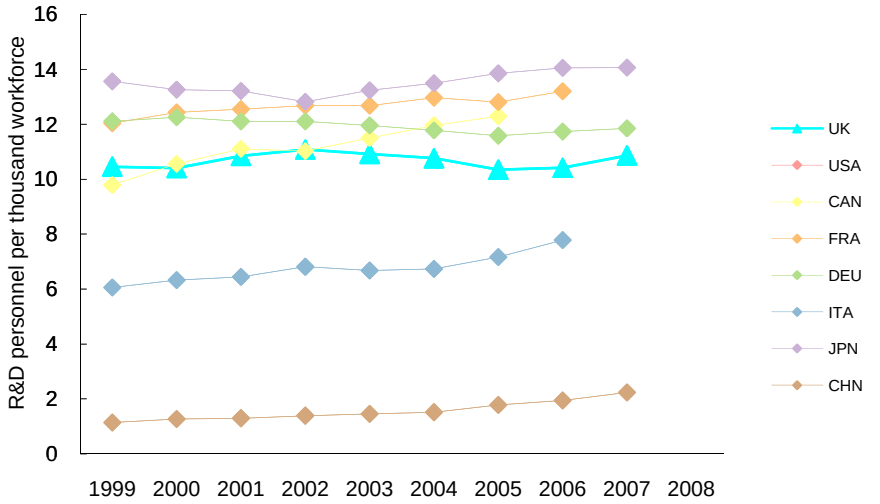
4.04 R&D personnel relative to workforce

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

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK R&D personnel per thousand workforce	10.70	10.86	+0.01
Group average R&D personnel per thousand workforce	11.42	11.87	+0.04
UK / Group average	0.94	0.91	-0.02
UK rank within Group	13	11	⇧
UK rank within G8	6	4	⇧
UK share of R&D Personnel / UK share of workforce	2.50	2.68	+0.07

Data: OECD. Analysis: Evidence

Chart 4.04 R&D personnel per thousand workforce



Data: OECD. Analysis: Evidence

Commentary

The density of R&D personnel in the UK workforce is stable. It was typical of the comparator group at the start of the period, placing the UK 13th in the comparator group but 6th ahead only of Italy and Russia in the G8. Its 2007 rank position is affected by data deficits for some countries. The availability of R&D personnel in the workforce has risen by 1% in 2007 compared to the recent past. The comparator group average, by contrast, has risen by 4% so the UK's position fell slightly compared to that benchmark.

There has been little relative change among the leading group of G8 countries in the chart (there are no R&D personnel data for the USA). Canada's position has improved relative to others and Italy has also shown signs of improvement compared to the early part of the decade. The UK has moved closer to Germany, but not by a substantial margin. France, however, has moved slightly ahead of these two. China now has about 1.75 million R&D personnel in a workforce of over 750 million.

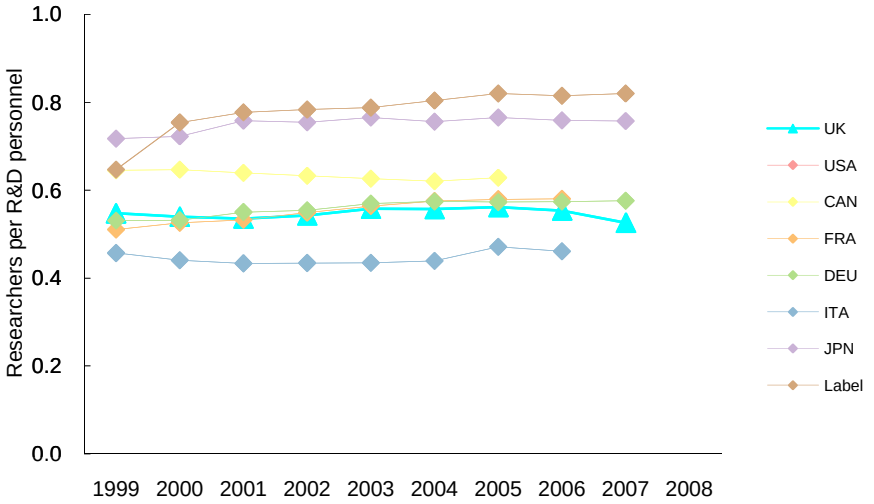
4.05 Researchers relative to R&D personnel

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

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Researchers per R&D personnel	0.55	0.53	-0.05
Group average Researchers per R&D personnel	0.66	0.66	+0.01
UK / Group average	0.84	0.79	-0.06
UK rank within Group	17	13	⇧
UK rank within G8	5	3	⇧
UK share of researchers / UK share of R&D Personnel	0.61	0.76	+0.24

Data: OECD. Analysis: Evidence

Chart 4.05 Researchers per R&D personnel



Data: OECD. Analysis: Evidence

Commentary

Researcher availability in the UK is falling (indicators 4.01 and 4.02) and R&D personnel density is rising slightly (indicators 4.03 and 4.04) so it is inevitable that researchers are now scarcer relative to R&D personnel. Roughly half of the UK R&D workforce are researchers and the UK has seen a 5% drop in this availability, from 0.55 to 0.53 researchers for every R&D worker.

The UK is in a very similar position to France and Germany but has dropped behind those countries over the decade. The UK saw a slight fall in researcher density in the late 1990s which seemed to have levelled but has now taken a further downturn. China, by contrast, appears to have risen to a much better position with a high proportion of its R&D personnel classed as researchers. However, this may be an issue of classification since the highly skilled proportion seems to have expanded at an exceptional rate.

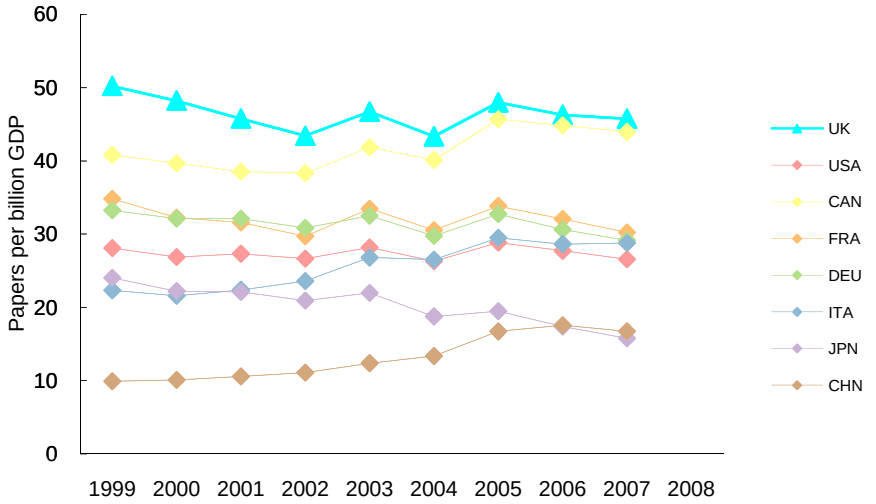
5.01 Papers relative to GDP

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	45.53	45.74	+0.00
Group average Papers per billion GDP	38.11	37.50	-0.02
UK / Group average	1.19	1.22	+0.02
UK rank within Group	7	8	⇩
UK rank within G8	1	1	⇔
UK share of sources / UK share of GDP	1.53	1.57	+0.03

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.01 Papers per billion GDP



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

The effects of inflation across all economies mean that this is almost always a falling index. The UK nonetheless has a strong position on research productivity. It is 1st in the G8 with about 45 papers recorded for every $Bn GDP. It has maintained its position relative to the comparator group average and improved its share of papers compared to its share of GDP by 3%. Note that no 2008 figure for UK, or other, GDP is yet available. This graph therefore ends at 2007 as did that in last year's report. The actual data have been revised, however, so this is an update on last year.

While the UK position remains strong relative to France, Germany and the USA, it is now at a similar point to Canada over which it had a clear lead at the start of the decade. The UK has had a remarkable record on output and falling in line with other EU research economies should not be seen as any threat so long as the impact of what is published is kept high (Indicator 1.09).

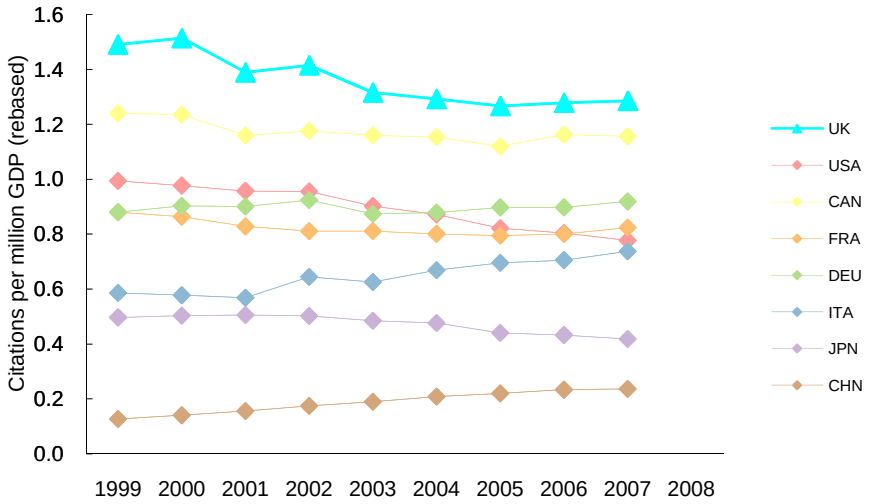
5.02 Citations relative to GDP

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	0.50	0.12	-
Group average Citations per million GDP	0.38	0.09	-
UK / Group average	1.33	1.28	-0.03
UK rank within Group	7	7	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of GDP	1.31	1.28	-0.02

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.02 Citations per million GDP



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Citation counts are always fewer for more recently published papers, so relative performance is the critical index. The UK has fallen by 3% against comparator group average. It remains 1st in the G8 and retains its rank at 7th recently and now in the comparator group as a whole. Its share of citations compared to share of GDP has fallen by 2%.

The chart shows that while the UK remains in the lead among the G8, and several other countries have shown some drop this year (on share of cites/share of GDP), it has fallen by more than Canada. Both Germany and Italy have improved their relative share. Only the USA has fallen by more than the UK. Its cites per GDP count (adjusted for inflation) was 0.99 in 1999 and is 0.74 now, a decline of one quarter. Switzerland and Belgium remain leaders but on static, not growing, activity.

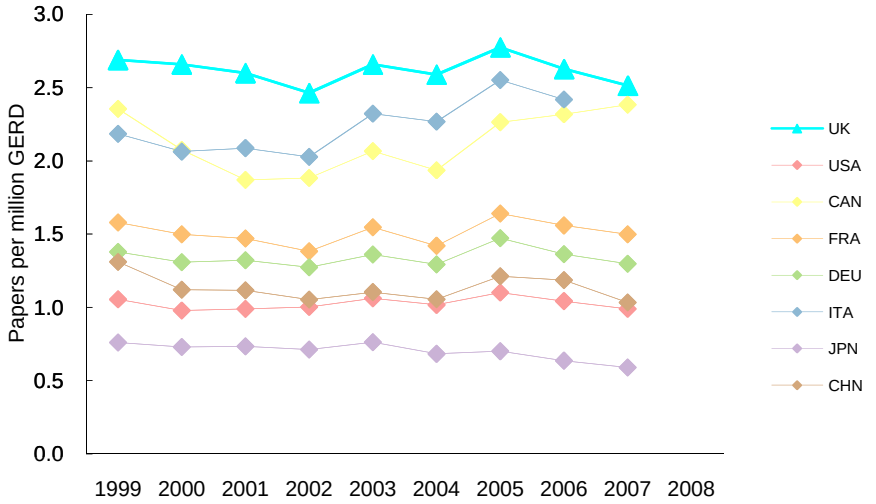
5.03 Papers relative to GERD

Table 5.03 Share of papers relative to share of GERD

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Papers per million GERD	2.62	2.51	-0.04
Group average Papers per million GERD	1.88	1.76	-0.06
UK / Group average	1.39	1.42	+0.02
UK rank within Group	4	3	⇧
UK rank within G8	1	1	⇔
UK share of sources / UK share of GERD	1.92	1.85	-0.04

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.03 Papers per million GERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

GERD is a good reflection of research-specific investment. The UK performs strongly on this indicator and is not only 1st in the G8 but has risen from 4th to 3rd in the comparator group as a whole. However, one country ahead of the UK is Poland (at 4.51 in 2007) which is productive on a notably under-funded research base. Although UK output relative to investment has fallen, it did so by more for other countries than for the UK itself. However, indexed output for some countries has risen markedly so the UK's share of sources compared to share of GERD has fallen by 4%.

Compared to most of the charted countries it is evident that the UK has retained its typically strong lead on this indicator. Canada has improved by a significant margin, however, and is now only just 2nd to the UK and Italy is also maintaining a robust performance in an environment of low research investment. Note that all the G8 countries, and China, show a falling output relative to GERD over the longer term because of inflation. Apart from Poland, only the Netherlands does better than the UK (at 2.72 cf 2.52) but Spain (2.49) is doing well.

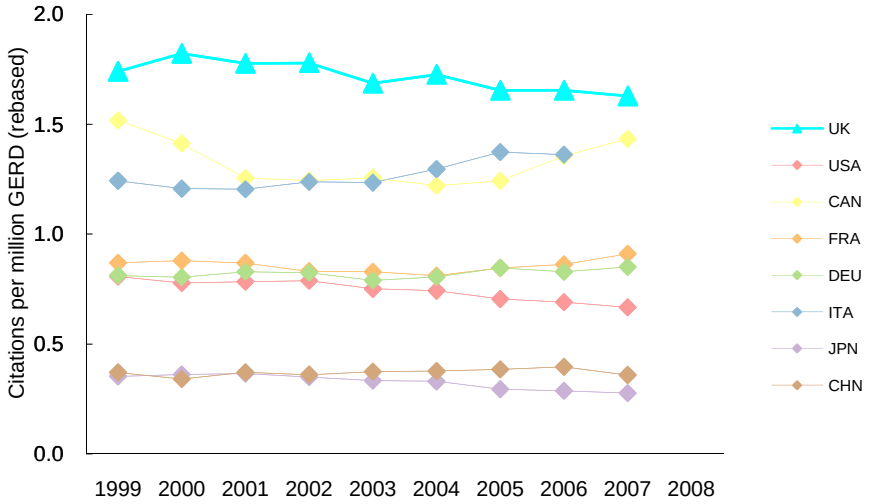
5.04 Citations relative to GERD

Table 5.04 Share of citations relative to share of GERD

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Citations per million GERD	31.82	8.03	-
Group average Citations per million GERD	18.60	4.93	-
UK / Group average	1.71	1.63	-0.05
UK rank within Group	4	4	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of GERD	1.70	1.63	-0.04

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.04 Citations per million GERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Citation counts are always fewer for more recently published papers, so relative performance is the critical index. The UK has fallen by 5% against comparator group average. Nonetheless, it remains not only 1st in the G8 but 4th in the comparator group as a whole. Its share of citations compared to share of GERD has fallen by 4%.

The chart data express relative share. The UK's position has fallen slightly but not by as much as the USA. France and Germany has kept a level profile, however, while Canada is clearly improving its position relative to the rest of the G8, although this is in part a recovery from a fall earlier in the decade.

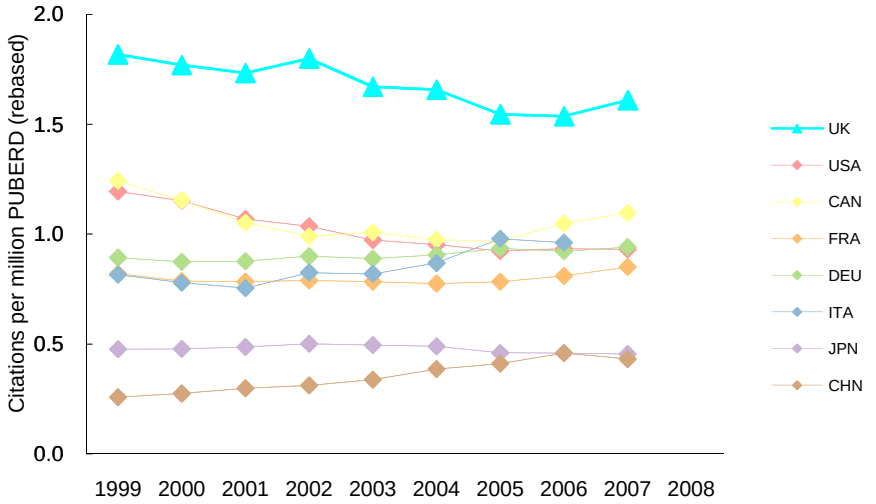
5.05 Citations relative to PUBERD (GOVERD + HERD)

Table 5.05 Share of citations relative to share of PUBERD

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Citations per million PUBERD	91.57	23.79	-
Group average Citations per million PUBERD	54.97	14.79	-
UK / Group average	1.67	1.61	-0.03
UK rank within Group	3	3	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of PUBERD	1.82	1.67	-0.08

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.05 Citations per million PUBERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Citation counts are always fewer for more recently published papers, so relative performance is the critical index. Although the UK has fallen slightly relative to the comparator group average, it remains a clear 1st in the G8 and 3rd overall in the comparator group. Its share of citations relative to its share of global public expenditure on R&D has fallen by 8% for 2007 compared to recent but this is an improvement on last year's position.

The chart confirms that the UK retains an excellent lead among G8 nations. Although its citation share relative to PUBERD has dropped it has not done so by as much as the USA. Over the decade, however, its position has deteriorated compared to key EU competitors such as France and Germany. This slight decline seems to have halted and the profile shows a definite change in trajectory this year compared to last. The decline on this indicator was, as noted previously, due to rapid UK PUBERD growth.

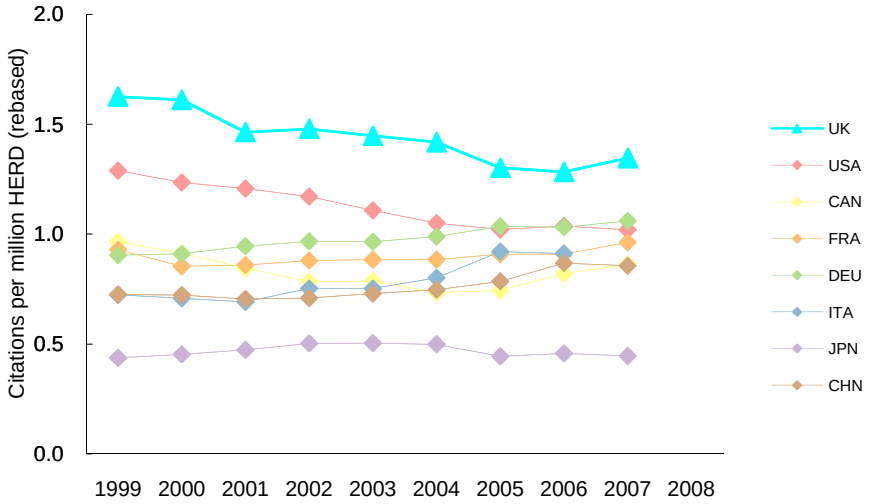
5.06 Citations relative to HERD

Table 5.06 Share of citations relative to share of HERD

	Recent average (2002-2006)	Current value (2007)	Current relative to Recent
UK Citations per million HERD	129.09	32.74	-
Group average Citations per million HERD	91.75	24.32	-
UK / Group average	1.41	1.35	-0.04
UK rank within Group	2	3	⇩
UK rank within G8	1	1	⇔
UK share of citations / UK share of HERD	1.41	1.25	-0.11

Data: Thomson Reuters & OECD. Analysis: Evidence

Chart 5.06 Citations per million HERD



Data: Thomson Reuters & OECD. Analysis: Evidence

Commentary

Citation counts are always fewer for more recently published papers, so relative performance is the critical index. This indicator focuses on research funding to the HE part of the research base. The UK share of citations relative to HERD has declined against the comparator group average by about 11% which is less than that reported last year. The UK remains in the lead in the G8 by an appreciable margin and the 2007 outcome is a gain on the previous two years.

The USA has also declined in share, by over one quarter in the decade from 1999, while France and Germany have risen over the same period. It is now evident that the profile for China is becoming similar to that of the G8, where before it still trailed those nations; its relative improvement since 1999 is similar to Germany's. The UK (1.35 cites per HERD) has dropped from 2nd to 3rd in the comparator group, behind the Netherlands (1.52) and Belgium (1.42). Denmark (1.22) has declined significantly from a clear lead to 4th behind the UK. Few other countries exceed 1.0.

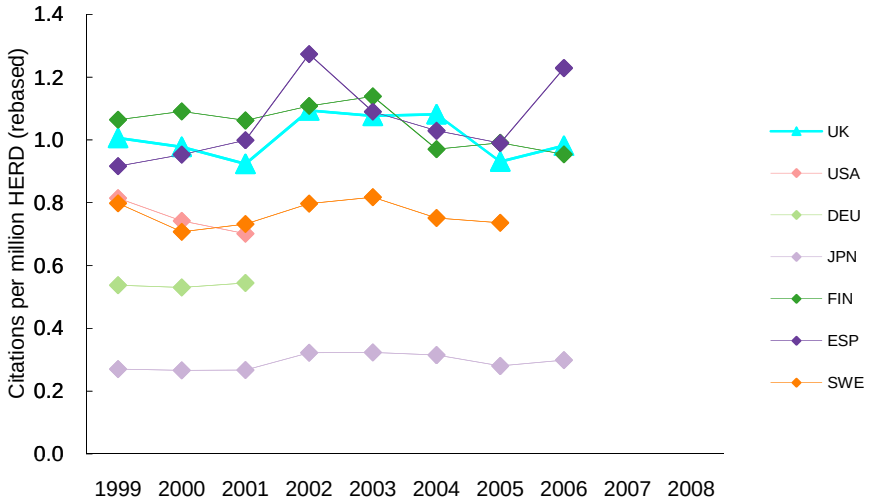
5.07.01 Citations relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million HERD in medical sciences	252.26	94.44	-0.63
Group average Citations per million HERD in medical sciences	248.59	96.25	-0.61
UK / Group average	1.01	0.98	-0.03
UK rank within Group	8	5	⇧
UK rank within G8	3	2	⇧
UK share of citations / UK share of HERD	1.02	0.98	-0.04

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 while citation counts decrease in more recent years, so this index is rebased relative to world average. The key index is national performance relative to the comparator group. The UK has improved in relative performance in 2006 compared with the recent past. It is 2nd to Russia in the G8, but Russia's HERD is anomalously low. Rank within the comparator group has also improved. The data here are changed from previous reports because of finer-scale mapping between data types, which affects all countries in the same way

The chart shows that the UK is not only keeping pace with other countries but it has improved on last year and is in a strong position on this indicator. Data for the USA cover only early years and show a declining profile. Germany also has sparse data but the index is low compared to the UK. Spain and Finland have kept pace with the UK but Finland has slipped slightly. Denmark also performs well. While Poland has a higher index than the UK, and leads the comparator group, its HERD is exceptionally low.

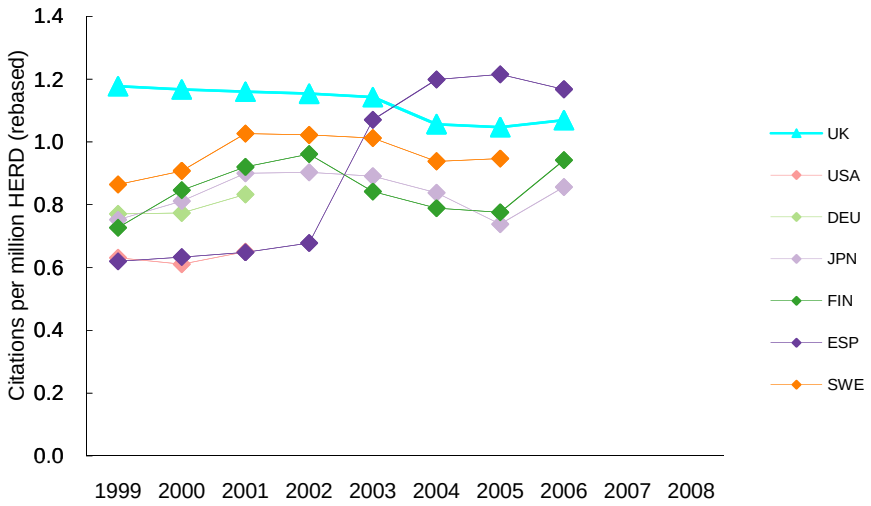
5.07.02 Citations relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million HERD in natural sciences	271.50	112.41	-0.59
Group average Citations per million HERD in natural sciences	242.24	105.13	-0.57
UK / Group average	1.12	1.07	-0.05
UK rank within Group	4	5	⇩
UK rank within G8	2	2	⇔
UK share of citations / UK share of HERD	1.11	1.07	-0.04

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 while citation counts decrease in more recent years, so this index is rebased relative to world average. The key index is national performance relative to the comparator group. HERD investment in the natural sciences is rising for most countries in the comparator group. The UK has declined slightly against the comparator group average and is now ranked 5th instead of 4th recently. Note that the UK is now shown as above average in the group where data in last year's report showed it to be below average.

The data for Spain show a disjunction in 2003 because of an abrupt reduction in reported HERD, which is now rising back up to previous levels. As it does so, Spain will fall back in line with other comparator group countries. UK performance can be seen to be rather better than other main charted countries. For early years in the period, where data for the USA and Germany are available, the UK outperforms both. The UK (2006 cites /HERD = 112) is marginally behind Denmark (113) and has only just slipped behind Poland (116). The comparator group is led by Russia with anomalously low HERD.

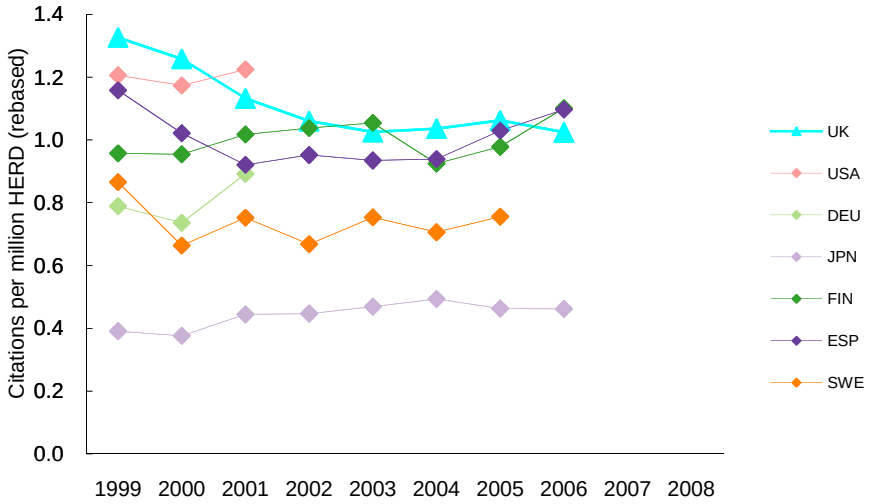
5.07.03 Citations relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million HERD in engineering and technology	70.85	28.21	-0.60
Group average Citations per million HERD in engineering and technology	66.40	27.55	-0.59
UK / Group average	1.07	1.02	-0.04
UK rank within Group	7	5	⇧
UK rank within G8	3	1	⇧
UK share of citations / UK share of HERD	1.06	1.02	-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 while citation counts decrease in more recent years, so this index is rebased relative to world average. The key index is national performance relative to the comparator group. The UK's change in performance is in line with the comparator group average. The UK leads the G8 nations for which data are available. It appears also to improve from 7th to 5th in the comparator group but this is because data are missing for the last year for Belgium and Sweden.

Citation share for other comparator group nations has increased compared with the UK. On past data, the UK outperformed Germany but not the USA on this indicator. That was because the database was itself strongly US-centric for these disciplines. The UK share of engineering data has improved recently and this produces a more informative analysis. The UK (2006 cites /HERD = 28) is marginally behind Finland (30) and has only just slipped behind Spain (30). The comparator group is led by Australia (4) and Denmark (44).

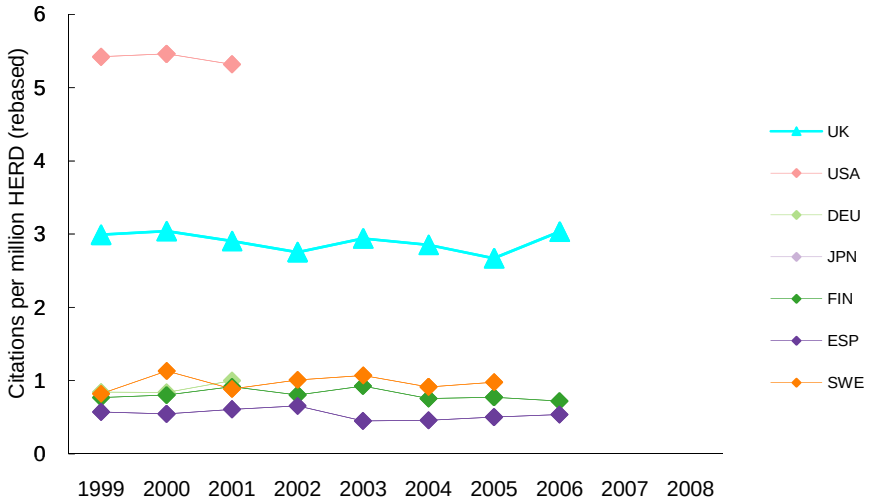
5.07.04 Citations relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million HERD in social sciences	66.89	26.48	-0.60
Group average Citations per million HERD in social sciences	23.57	8.74	-0.63
UK / Group average	2.84	3.03	+0.07
UK rank within Group	2	1	⇧
UK rank within G8	2	1	⇧
UK share of citations / UK share of HERD	2.82	3.03	+0.07

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 while citation counts decrease in more recent years, so this index is rebased relative to world average. Citations are considered to be a weak indicator of research performance in the social sciences. The UK performs substantially better than the comparator group average. While it may be argued that this is due to an Anglophone bias in the data, the UK has improved against that average and is 1st in the comparator group. The data here are changed from previous reports because of finer-scale mapping between data types, which affects all countries in the same way.

The USA data do not extend to the most recent years, but on citation data the UK position has improved relative to the USA. There is no information regarding increases in HERD. Sparse HERD data in this area further compromise the information content of this indicator.

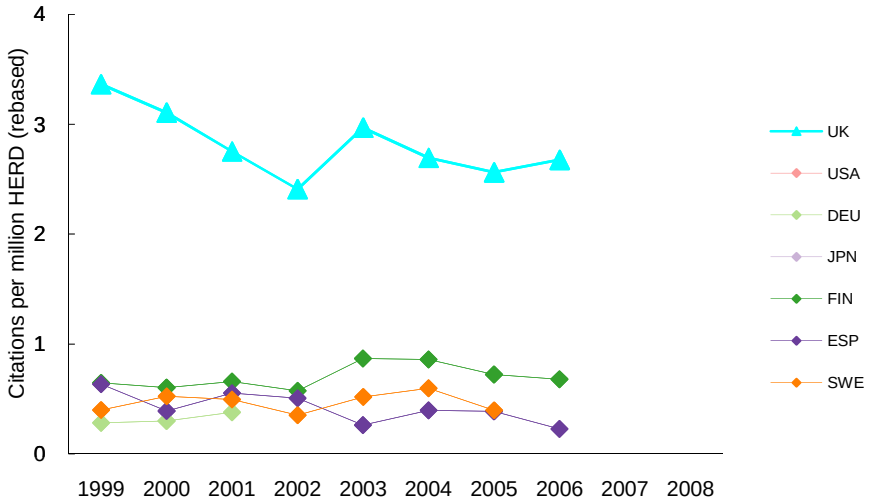
5.07.05 Citations relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK Citations per million HERD in humanities	9.32	3.40	-0.63
Group average Citations per million HERD in humanities	3.48	1.27	-0.63
UK / Group average	2.68	2.67	-0.00
UK rank within Group	1	1	⇔
UK rank within G8	1	1	⇔
UK share of citations / UK share of HERD	2.68	2.67	-0.00

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 while citation counts decrease in more recent years, so this index necessarily declines with time. Citations are also at best a rough guide of research effectiveness in the humanities. The UK performance has changed in line with the comparator group average. It remains 1st in the comparator group.

While the chart confirms the UK's strong position it provides relatively little additional information.

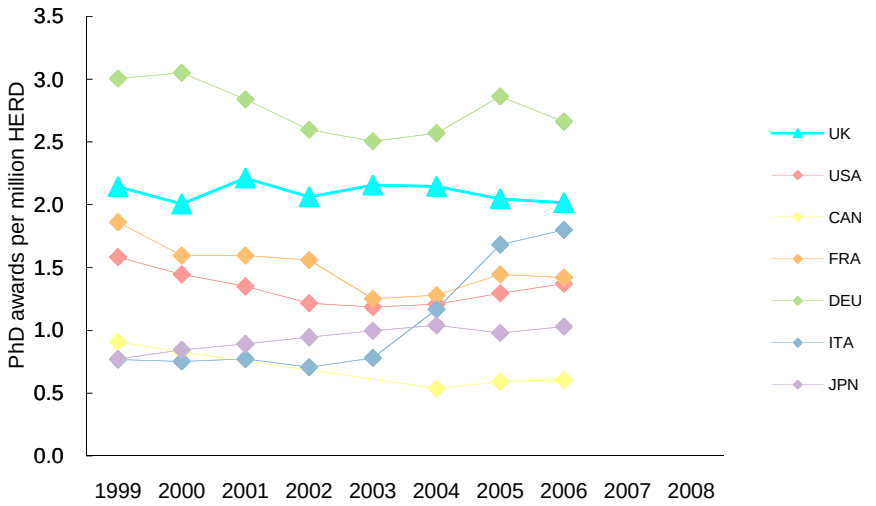
5.08 PhDs awarded relative to HERD

Table 5.08 Share of PhDs relative to share of HERD

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhD awards per million HERD	2.12	2.01	-0.05
Group average PhD awards per million HERD	1.68	1.70	+0.01
UK / Group average	1.26	1.19	-0.06
UK rank within Group	5	4	⇧
UK rank within G8	2	2	⇔
UK share of PhDs / UK share of HERD	1.57	1.41	-0.10

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 expenditure on HERD. The UK currently produces 9.3% of comparator group PhDs compared to 6.6% of comparator group HERD. It has been consistently more productive of highly-skilled people per £million HERD than the comparator group average but has declined slightly, by about 5%, compared to that average. Although it is 2nd to Germany in the G8, Germany's lead has declined during the decade while the UK's profile is relatively flat.

Highly skilled postgraduates are a key output of the research base, transferring knowledge and know-how throughout the economy. The UK (index 2007 = 2.01) exhibits a slight long-term decline but has moved up from 5th to 4th place in the comparator group behind Poland (6.81, but evidently under-funded) and South Korea (2.48) as well as Germany. The USA (1.37) seems to be on an upswing since 2002 but remains relatively inefficient on PhD output. Both Denmark and Finland have fallen back. The apparently dramatic rise for Italy is an artefact of sharply reduced HERD investment.

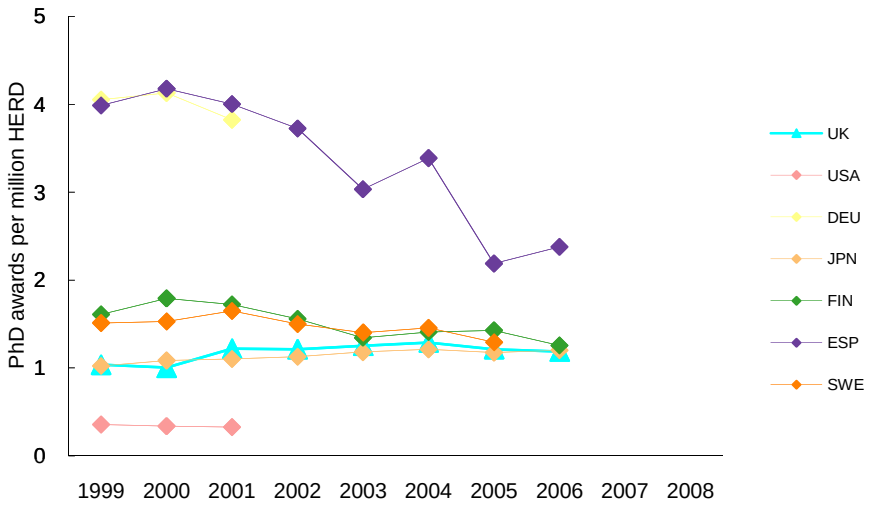
5.09.01 PhDs awarded relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhD awards per million HERD	1.24	1.19	-0.04
Group average PhD awards per million HERD	1.53	1.25	-0.18
UK / Group average	0.81	0.95	+0.17
UK rank within Group	6	5	⇧
UK rank within G8	2	2	⇔
UK share of PhDs / UK share of HERD	0.48	0.32	-0.34

Data: OECD. Analysis: Evidence

Chart 5.09.01 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

This indicator compares the number of PhDs awarded to the expenditure on R&D in the higher education sector (HERD). Data are available for both PhDs and HERD at this disaggregated level for only 10 countries in the comparator group.

While the UK's PhD productivity has been below comparator group average it has improved against that average and the UK's rank has improved. Both HERD and PhD output are higher for the UK in recent years. PhD output has nearly doubled since 1999 while HERD has risen by about 50%. This is much better than the USA for the period during which US data are available, but it is poorer than Germany.

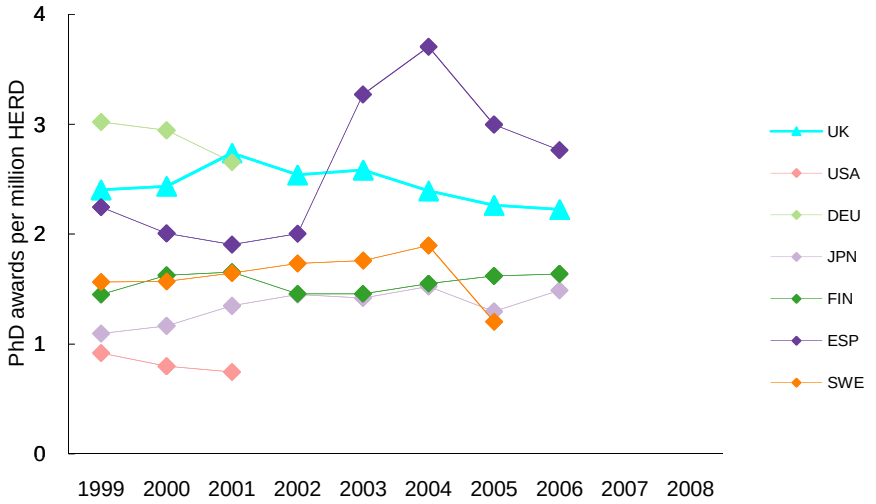
5.09.02 PhDs awarded relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhD awards per million HERD	2.50	2.22	-0.11
Group average PhD awards per million HERD	1.75	1.69	-0.03
UK / Group average	1.43	1.31	-0.08
UK rank within Group	4	3	⇧
UK rank within G8	2	1	⇧
UK share of PhDs / UK share of HERD	0.73	0.37	-0.49

Data: OECD. Analysis: Evidence

Chart 5.09.02 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

This indicator compares the number of PhDs awarded to the expenditure on R&D in the higher education sector (HERD). Data are available for both PhDs and HERD at this disaggregated level for only 10 countries in the comparator group.

UK output productivity is good on this indicator and has dropped slightly in line with comparator group average. Its rank within the comparator group has improved. UK PhD output increased by about 20% since 1999 to around 5,500 PhDs per year while HERD increased by 40%. UK performance was in line with Germany and much better than the USA for the period for which comparative data were available.

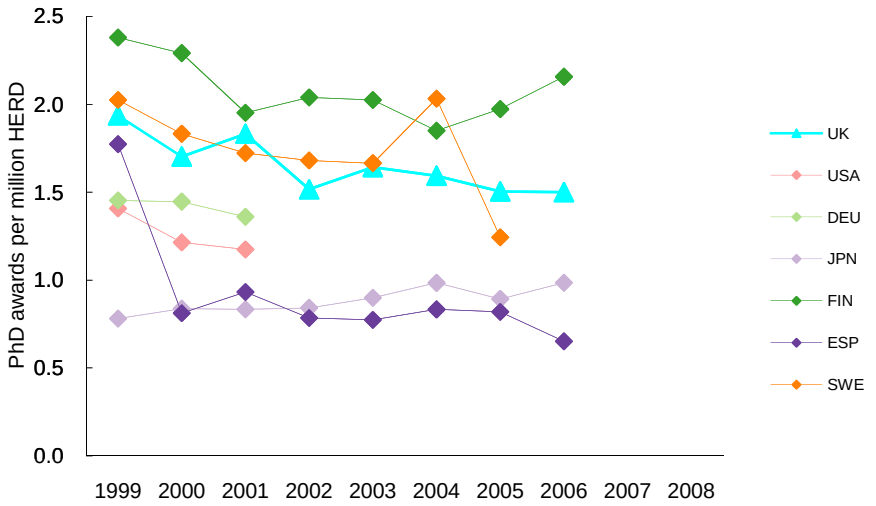
5.09.03 PhDs awarded relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhD awards per million HERD	1.62	1.50	-0.07
Group average PhD awards per million HERD	1.51	1.43	-0.05
UK / Group average	1.07	1.05	-0.02
UK rank within Group	6	4	⇧
UK rank within G8	1	1	⇔
UK share of PhDs / UK share of HERD	0.78	0.47	-0.40

Data: OECD. Analysis: Evidence

Chart 5.09.03 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

This indicator compares the number of PhDs awarded to the expenditure on R&D in the higher education sector (HERD). Data are available for both PhDs and HERD at this disaggregated level for only 10 countries in the comparator group.

UK output productivity is slightly better than comparator group average and has fallen in line with that average while its rank has improved. While HERD has increased by about 60% since 1999, PhD output has risen by only 20% to 2,400 PhDs per year. UK performance has been better than both Germany and the USA for the period for which comparative data were available.

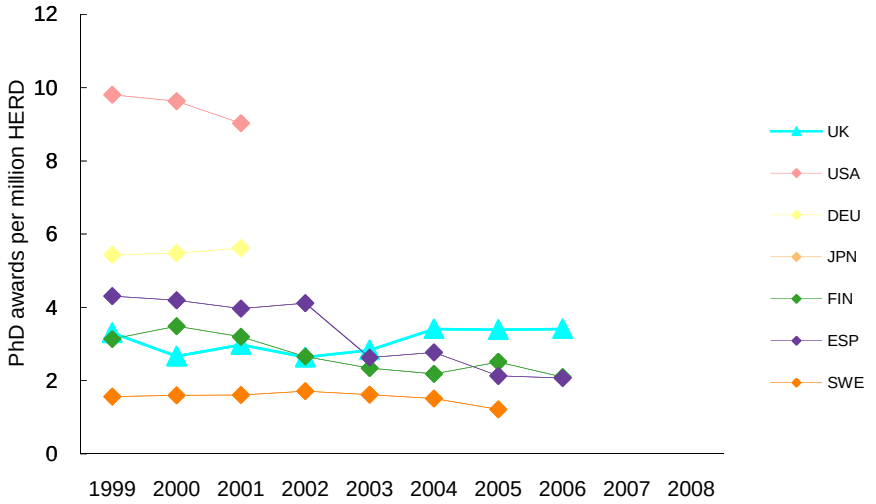
5.09.04 PhDs awarded relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhD awards per million HERD	3.05	3.41	+0.12
Group average PhD awards per million HERD	2.30	2.08	-0.09
UK / Group average	1.33	1.64	+0.23
UK rank within Group	5	2	⇧
UK rank within G8	3	1	⇧
UK share of PhDs / UK share of HERD	0.31	0.27	-0.13

Data: OECD. Analysis: Evidence

Chart 5.09.04 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

This indicator compares the number of PhDs awarded to the expenditure on R&D in the higher education sector (HERD). Data are available for both PhDs and HERD at this disaggregated level for only 6 countries in the comparator group.

UK output productivity is substantially better than comparator group average and has risen ahead of that average. The UK's rank has improved to 2nd behind only Poland (which has very low HERD). HERD has increased by about 50% since 1999, while PhD output has risen by around 60% to 3,500 PhDs per year. UK performance may appear poorer than the USA but that country is an outlier in this subject area. For the period for which data are available it had an exceptional but declining output of social science researchers.

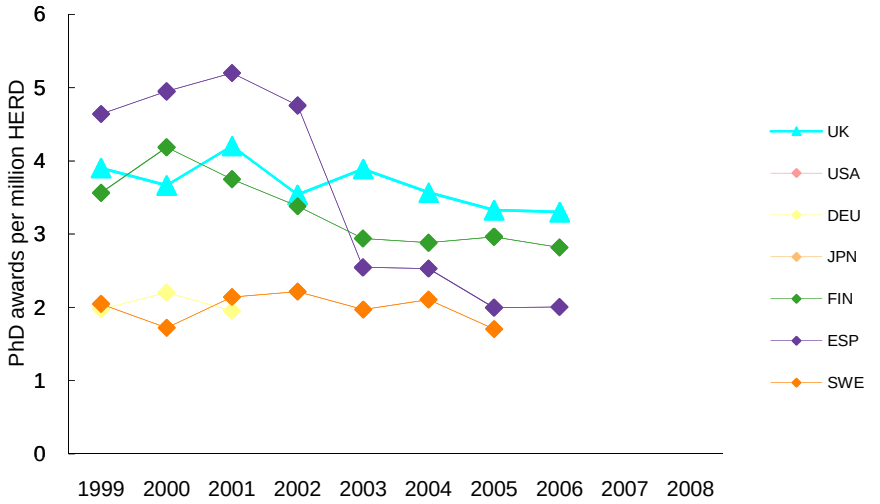
5.09.05 PhDs awarded relative to HERD in five main research areas

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

	Recent average (2001-2005)	Current value (2006)	Current relative to Recent
UK PhD awards per million HERD	3.70	3.30	-0.11
Group average PhD awards per million HERD	2.79	2.47	-0.12
UK / Group average	1.33	1.34	+0.01
UK rank within Group	2	2	⇔
UK rank within G8	1	1	⇔
UK share of PhDs / UK share of HERD	0.36	0.25	-0.31

Data: OECD. Analysis: Evidence

Chart 5.09.05 PhD awards per million HERD



Data: OECD. Analysis: Evidence

Commentary

This indicator compares the number of PhDs awarded to the expenditure on R&D in the higher education sector (HERD). Data are available for both PhDs and HERD at this disaggregated level for only 6 countries in the comparator group.

The UK is well above the average for the comparator countries for which data are available. However, the sparsity of data and the variable significance of research training in this subject area make this indicator of limited information value.

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 DBIS 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, 2009-1, first edition) and Research and Development Statistics (RDS, 2008-1, 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 2008.

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 1999 to 2008, 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 data-points 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 former 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 the Higher Education Statistics Agency (HESA) 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.html.

All publication and citation data are provided by Thomson Reuters. The National Science Indicators for 2008 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 2008 is the five-year window 2004-2008) 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 2006.

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	RDS2008-1 Table 18. Higher education intramural expenditure on R&D – HERD – by field of science	MEASURE=Million constant $ 2000 prices and PPPs
GERD	MSTI2009-1 Indicator 3. GERD – (Million 2000 dollars – constant prices and PPPs	
Researchers	MSTI2009-1 Indicator 7. Total researchers (FTE)	
R&D personnel	MSTI2009-1 Indicator 9. Total R&D personnel (FTE)	
HERD	MSTI2009-1 Indicator 47. HERD – (Million 2000 dollars – constant prices and PPPs	
GOVERD	MSTI2009-1 Indicator 54. GOVERD – (Million 2000 dollars – constant prices and PPPs	
GDP	MSTI2009-1 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	MSTI2009-1 Indicator E. Total Population (Thousands)	
Labour force	MSTI2009-1 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 DBIS 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 DBIS comparator group is spread by geography and type, and is thus of value for comparison with many national research bases.

The combined output of the selected countries in the DBIS 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 DBIS 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 DBIS 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 DBIS 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	GBR
	USA	USA
	Canada	CAN
	France	FRA
	Germany	DEU
	Italy	ITA
	Japan	JPN
G8/E Europe	Russia	RUS
Other W Europe	Belgium	BEL
	Denmark	DNK
	Finland	FIN
	Netherlands	NLD
	Spain	ESP
	Sweden	SWE
	Switzerland	CHE
Other E Europe	Poland	POL
Other Europe	EU27 group	EU
Other World	Australia	AUS
	Brazil	BRA
	China	CHN
	India	IND
	Iran	IRN
	Israel	ISR
	Singapore	SGP
	South Africa	ZAF
	South Korea	KOR
	Taiwan	ROC

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 thought 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 DBIS comparator group are likely to change from time to time. Some of those initially included now show less rapid growth while others show a significant recent 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 DBIS 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 DBIS 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.

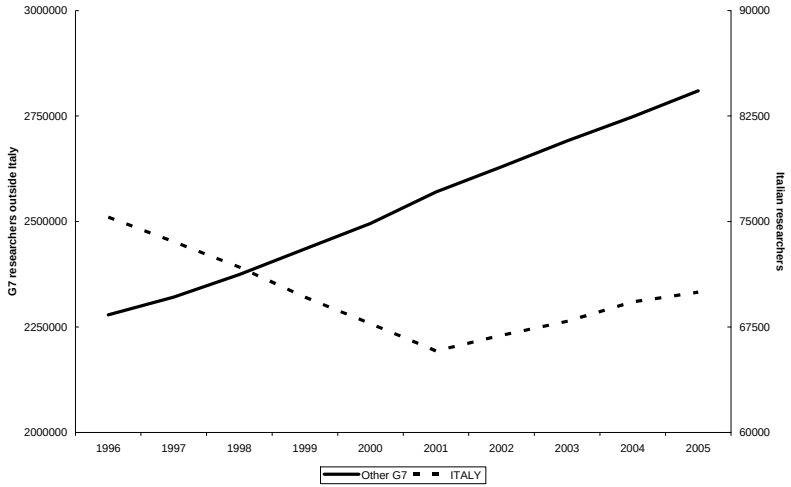
Work carried out for the Economic and Social Research Council (ESRC) highlighted some deficits and some inconsistencies with regard to postgraduate training data for some smaller countries. Data for the G8 appear generally sound.

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 varies somewhat between disciplines.

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-mapped 'faculty' main subject categories. The subject disaggregation is nested and hierarchical. 'System' breaks down into five 'OECD' categories, some of which are then broken down into the 10 main subject categories.

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 an unduly coarse level of analysis and too fine a level, both of which can obscure information.

For analyses of output performance patterns, main subject categories grouped according to UK patterns of journal usage can be employed, but it is also feasible to use finer levels of discrimination. *Evidence* 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 DBIS 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 permit]

Categorisation by literature use

Groups of subjects can be created by analysing the commonality in literature use across Units of Assessment (UoAs, 68 subject categories) established in the UK for the cyclical Research Assessment Exercises (RAE) up to 2001. These categories are generally too fine and numerous for international comparisons, other than those focussing on a single discipline.

Grouped UoA subject categories usefully separate 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 main research subject categories used here 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 main research subject categories used in this report 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 has been 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 is, however, becoming increasingly enriched both in subject depth and geographical coverage. This improved language diversity has reduced the previous deficit in coverage for some European research economies. The content will continue to change but, for the present, the indicators must continue to be treated with caution.

The historical bias towards Anglophone journals may have affected the UK in two ways: Although it is probably not as well covered as the USA, more 'average' material may have been covered than for other European competitors, so its net indexed impact may have been reduced. As coverage broadens so the true impact of the UK will be better revealed.

It is also noteworthy that a proportion of the material cited by articles in social science journals is not covered by the Thomson Reuters databases, and this is probably greater 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, 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 DBIS 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 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 2000 is the set of papers published in the years 1996-2000 and the citations to those papers that had accumulated by the end of 2000. The NSI5 for 2001 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 2001.

Evidence groups data into five-year windows using the same convention. The average annual performance for a five-year window labelled 2008 will be the average for the years over the period 2004-2008.

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

Current performance

The last calendar year (2008) 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 2007, but sometimes 2006.

Where five-year windows are employed, the current performance is usually based on data for 2008 or the 2008 ‘window’ which covers the average performance for 2004-2008.

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 2008 then the recent data refer to the average for 2003-2007.

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 show 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 depth over an extended time period 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.

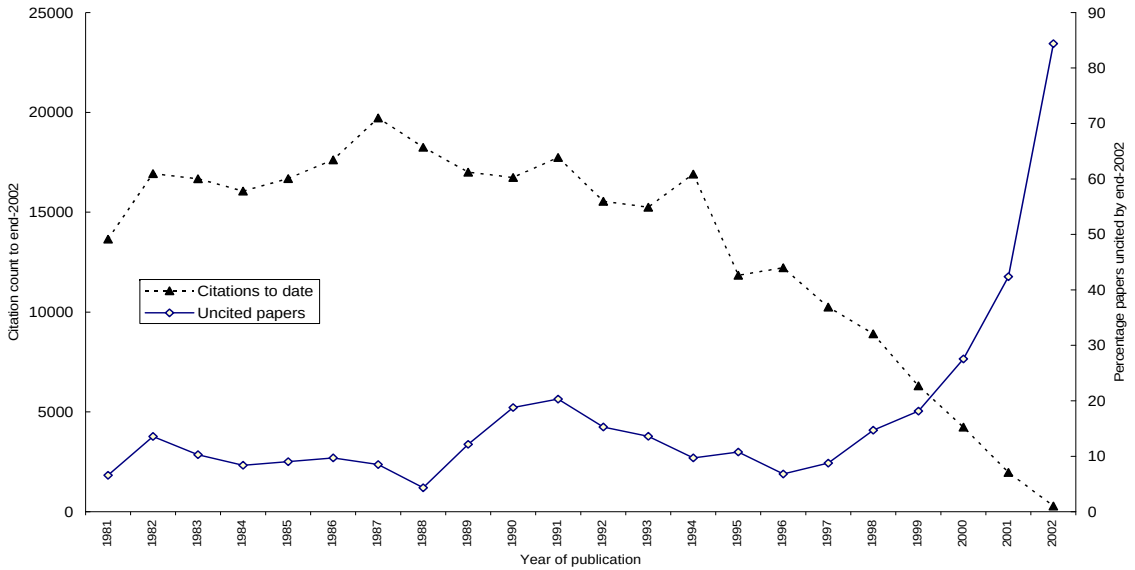
Most impact measures use average citation counts from groups of papers, because some individual papers may have unusual or misleading citation profiles. These are diluted in larger samples.

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.

Citation accumulation for papers in Geological Sciences



Beyond five years, some 10% or more of papers remain uncited.

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. New analyses suggest that recent improvements in coverage addressing problems of national imbalance have increased their validity and utility. Nonetheless, 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 DBIS 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 DBIS 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 DBIS 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 have been an historical Anglophone bias and some of these countries do not have English as a first language. Any imbalance in the Social Sciences and in the Humanities would be 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.

Recently, the Thomson Reuters databases have been expanded to include much better coverage of non-Anglophone literature within Europe, better Asian coverage with an especial emphasis on China, and much enhanced coverage of Latin America. This will change some of the historically understood dynamics in the data. This report suggest that the effect lies in the detail, where there are real variations of policy interest, but broad national trends and balances are unaffected.

Glossary

1994 Group (The) Established in 1994, the Group brings together 19 research-intensive universities that are not members of the Russell Group (q.v.). Warwick was a member of both until 2008 when it resigned its 1994 membership. The Group provides a vehicle to help members promote their common interests in higher education.

ABRC The former Advisory Board for the Research Councils, from 1972 until 1992, was responsible for advising the UK Government on the allocation of the Science Budget. It was established via the White Paper "A Framework for Government Research and Development" (July 1972, Cmnd 5046). See also, Council on Scientific Policy.

ACARD The Advisory Council for Applied Research and Development was established in 1976 to improve the interface between Government and outside organisations. It was later given wider responsibility for coordinating applied R&D, but its role was transferred to ACOST in 1987.

ACOST The Advisory Committee on Science and Technology (1965) was formed to advise the new Minister of Technology. A different body – the Advisory Council on S&T (1980) – was formed with a remit to advise the Prime Minister.

AFRC The former Agricultural and Food Research Council and its institutes were largely absorbed by the BBSRC when it was created in 1993. AFRC's predecessor until 1983 was the ARC.

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 (AHRC) would take over this role.

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 (AHRB).

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 (1) The UK Agricultural Research Council was established by Royal Charter in 1931. Its funding and responsibilities under the Agricultural Research Act, 1956 were transferred in 1965 to the Ministry of Technology.

ARC (2) 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.

BBSRC The Biotechnology and Biological Sciences Research Council receives money to fund academic research and training in biosciences. It was formed in 1994 by the merger of the former AFRC with the biotechnology division of the former SERC.

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.

Binary line The development of further and higher education in the 1960s led to the creation of a split higher education sector with the growing number of universities and the new polytechnics separated by a perceived binary line. The Further and Higher Education Act 1992 ended this distinction.

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

CACST The Central Advisory Council for Science and Technology, 1967-1970, was a Cabinet-level body established to "Advise the Government on the most effective national strategy for the use and development of our scientific and technological resources" [terms of reference, AC(67)1] and to avoid an institutional split between science and technology consequent upon the formation of the Department of Education and Science's Council for Scientific Policy and the Ministry of Technology's Advisory Council on Technology. The Council was free to set up ad hoc working parties as it saw fit. It was chaired throughout by Sir Solly Zuckerman, Chief Scientific Adviser. While the membership was drawn from the two Advisory Councils, members were appointed in a personal capacity and not as representatives of departmental or other interests.

CCLRC The former Council for the Central Laboratory of the Research Councils was formed by Royal Charter on 1 April 1995 as a non-departmental public body of the OST. CCLRC comprised three UK research institutions: the Rutherford Appleton Laboratory (RAL), Oxfordshire; the Daresbury Laboratory, Cheshire; and Chilbolton Observatory, Hampshire. On 1 April 2007 CCLRC merged with PPARC to form the Science and Technology Facilities Council (STFC).

Central Policy Review Staff (CPRS, 1970-1983) was a high-level committee which provided policy advice to government.

Centre National de la Recherche Scientifique (CNRS, National Center for Scientific Research) is a French government-funded research organization funded in 1939 and now under the administrative authority of France's Ministry of Research. Its mission is to evaluate and carry out research "capable of advancing knowledge and bringing social, cultural, and economic benefits for society" and to support research training. CNRS research units are located throughout France and employ tenured researchers. There are CNRS intramural labs(fully funded and managed by CNRS, called UPR, or unités propres de recherche) and there are joint labs: partnered with universities, other research organizations, or industry (called UMR, or unités mixtes de recherche). CNRS has six research departments and two national institutes (National Institute of Nuclear and Particle Physics, IN2P3; National Institute of Earth Sciences and Astronomy, INSU). CNRS's annual budget represents a quarter of French public spending on civilian research.

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.

CMU Originally the Coalition of Modern Universities, the CMU Universities Group was formed in 1997. Members are higher education institutions incorporated in 1992 and subsequently centrally funded by Government in the same way as traditional universities through the Higher Education Funding Councils. Although sometimes described as "new" universities, many have long histories as colleges and subsequently polytechnics.

CNRS Centre National de la Recherche Scientifique (French National Center for Scientific Research).

Committee on Future Scientific Policy (often referred to as the Barlow Committee) was set up by the Lord President of the Council in December 1945 "to consider the policies which should govern the use and development of our scientific manpower and resources during the next 10 years. To submit an interim report on very broad lines at an early date [and...] At a later date to make recommendations as to the establishment of a permanent machinery for carrying out surveys as to the best use of our scientific resources in the national interest". Sir Alan Barlow was appointed acting Chairman, with C.P. Snow as the Committee's scientific assessor.

Cooksey Review was established by the Chancellor of the Exchequer in March 2006 under the chairmanship of Sir David Cooksey to build agreement on institutional arrangements for a single fund for health research, bringing together the research budgets of the Department of Health and the Medical Research Council. http://www.hm-treasury.gov.uk/independent_reviews/cooksey_review/cookseyreview_index.cfm

Council on Scientific Policy The Advisory CSP (ACSP) emerged in January 1947 and became the CSP in 1965 with the remit to advise the Department for Education. It was originally established by the Lord President of the Council, Herbert Morrison, in the light of recommendations made in the report of the Committee on Future Scientific Policy. The ACSP assumed the mantle of the Scientific Advisory Council to the War Cabinet in respect of civil science, with a specific remit to "advise the Lord President of the Council in the exercise of his responsibility for the formulation and execution of Government science policy". Sir Henry Tizard chaired both the ACSP and the parallel Defence Research Policy Committee (DRPC) from 1947 until 1952 when he was succeeded by Sir Alexander Todd (later Lord Todd). Zuckerman also played a significant part in the creation of the CSP, was a founder member of the ACSP and served as its Deputy Chairman. The CSP's third report (1972) recognised the need to relate research more closely to national social and economic goals and to improve dialogue between research scientists and Government departments. This led to the creation and structure of a successor body, the ABRC (July 1972, Cmnd 5046, para 45).

CPRS Central Policy Review Staff.

Croham In February 1987, a committee chaired by Lord Croham published its 'Review of the University Grants Committee'. The review recommended the establishment of a formally incorporated University Grants Council with revised terms of reference and a full-time Chief Executive.

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.

CVCP The former Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, now called Universities UK.

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 (DTI). It was later absorbed into DBIS.

DBIS The Department of Business, Innovation and Skills was formed in June 2009 as an amalgamation of DBERR and DIUS.

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.

Dearing Ronald Ernest Dearing (Baron Dearing CB, 1930-2009) was Chairman and Chief Executive of the Post Office Ltd, Chancellor of the University of Nottingham (1993-2000) and the author of the Dearing Report into Higher Education. In 1998, he was made a life peer as Ronald, Lord Dearing, of Kingston upon Hull in the County of the East Riding of Yorkshire.

Dearing Report (the reports of the National Committee of Inquiry into Higher Education) was a report into the future of Higher Education in the

United Kingdom, published in 1997. The report was commissioned by the UK government and was the largest review of higher education in the UK since the Robbins Committee (q.v.) in the early 1960s. It made 93 recommendations concerning the funding, expansion, and maintenance of academic standards.

Department is used as well as Unit and Resource Centre to refer to HEI organisational entities.

Department for Children, Schools and Families (DCSF) emerged from 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).

DES See DfES.

Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) is the central, self-governing research funding organisation that promotes research at universities and other publicly financed research institutions in Germany. The DFG serves all branches of science and the humanities by funding research projects and facilitating cooperation among researchers.

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.

DFG Deutsche Forschungsgemeinschaft (German Research Foundation).

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.

Discipline, domain and field are variously used to describe subject-based categories of research. There is , however, no universal agreement on how these should be delimited or what their hierarchy might be.

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. It was absorbed into DBIS in June 2009.

Domain, see discipline.

DSIR The Department for Scientific and Industrial Research (1916-1965, when it was taken over by the new SRC) was created to address the shortage of scientific manpower and the poor organisation of research revealed by the 1914 outbreak of war.

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. DIUS and DSBERR were reunited within DBIS in June 2009.

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.

Education Reform Act (1988) established the UFC (successor to the UGC) and PCFC (successor to the NAB) as bodies responsible for policy and funding of higher education.

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.

ELWa Education and Learning in Wales was established under the Learning and Skills Act 2000 and it took over the majority of the functions of the four Training and Enterprise Councils and the Further Education Funding Council for Wales. It assumed responsibility for funding, planning and promoting all post-16 education and training in Wales with the exception of higher education.

EPSRC The Engineering and Physical Sciences Research Council is the UK's main agency for funding research and related postgraduate training in engineering and the physical sciences. It emerged from the former SERC in 1994.

ERA See Excellence in Research for Australia.

ESRC The Economic and Social Research Council is the UK's leading research funding and training agency addressing economic and social concerns. Its predecessor until 1983 was the Social Science Research Council, established in 1965.

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.

FE Further Education.

FEFC The Further Education Funding Council was created by the Further and Higher Education Act 1992 to allocate Department for Education funding to FE colleges.

Field, see discipline.

Foresight In the UK, Foresight was a Government-led process announced in the 1993 'Realising Our Potential' White Paper. The programme was managed by OST and brought together people and ideas to look beyond short planning horizons to identify potential opportunities from new science and technologies and actions to help realise those opportunities.

Framework for Government Research and Development (July 1972, Cmnd 5046).

Framework Programmes The research funded by the European Commission is organised into Framework Programmes (FPs). FP7 is the programme running in 2009.

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.

Further and Higher Education Act 1992 abolished the binary line that demarcated the university and polytechnic sectors of UK higher education, terminated the two existing funding councils (UFC and PCFC) and created new, regionally based funding councils for higher education (HEFCs).

Future of Higher Education was the 22 January 2003 White Paper by the DfES (Cm 5735), which included proposals for changes in the student financing system and the payment of fees by students to HEIs. http://www.dfes.gov.uk/hegateway/strategy/hestrategy/

G8 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 Gross Expenditure on R&D.

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

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

HE 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.

HEIF is the UK's Higher Education Innovation Fund. Initiated in 2001, it was jointly supported by the OSI, DfES and HEFCE with the aim of improving university knowledge transfer processes, sometimes referred to as a third stream (with teaching and research) of university activity. HEIF3 in 2005 was worth £238 million.

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.

Higher education – a new framework (Cm 1541) was the UK's DES White Paper of 1991.

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.

Impact Profile® citation histograms are a graphical display of the categorised distribution of normalised citation counts (citation counts rebased to take account of year and field of publication) for a set of journal articles.

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.)

Joint Infrastructure Fund was created jointly by the HEFCs, the Research Councils and the Wellcome Trust to support "infrastructure" for the UK science base. The objective was "to transform the working environment, and enhance the research capability of the UK research community by creating a flexible scheme that can respond to the real needs of the academic research community". JIF ran from 1998-2001. (See also SRIF.)

Joint Research Equipment Initiative (JREI) is an annual competition run by the Research Councils, the HEFCs and DENLI with the aim of contributing to the physical research infrastructure and to enable high-quality research to be undertaken, particularly in areas of basic and strategic priority for science and technology, such as those identified by Foresight.

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®.

JIF See Joint Infrastructure Fund and Journal Impact Factor.

JREI See Joint Research Equipment Initiative.

Keywords are terms, usually supplied by the author but sometimes added editorially, attached to journal articles which allow them to be indexed more accurately on databases.

Lambert The Lambert Review of Business-University Collaboration. Sir Richard Lambert was appointed by the Chancellor of the Exchequer in 2003 to address the shortfall of R&D investment by UK industry and the lack of strong links between industry and the research base. His committee reported in December 2003.

Leitch The Leitch Report on 'UK Skills: Prosperity for all in the global economy'. Lord Leitch was commissioned by the UK Chancellor in 2004 with a remit to "identify the UK's optimal skills mix in 2020 to maximise economic growth, productivity and social justice, and to consider the policy implications of achieving the level of change required." In his final report (5 December 2006), Leitch recommends that the UK should aim to be a world leader on skills by 2020 and in the upper quartile of OECD countries. He also makes recommendations for how that vision should be delivered.

May Baron May of Oxford, OM, AC, FRS was born in Sydney, Australia (8 January 1936) and has been Chair of Princeton University's Research Board (1977-88), UK Government Chief Scientific Adviser (1995-2000) and President of the Royal Society (2000-2005). Originally a physicist, Bob May has led major advances in population biology, the development of theoretical ecology and the study of disease and of biodiversity.

MRC The Medical Research Council was founded in 1913 (initially as a Medical Research Committee, under the provisions of the National Health Insurance Act, 1911). It promotes research into all areas of medical and related science with the aims of improving the health and quality of life of the UK public. It funds research both in universities and through its own institutes and units.

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

NAB The National Advisory Body for public sector higher education was created in 1981 to advise the former Department of Education and Science on the allocation of funding for advanced further education courses (essentially HE courses). It was succeeded by the PCFC in 1988.

National Committee of Inquiry into Higher Education (1997) See Dearing Report.

National Science Foundation (NSF) is an independent USA federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense". It has an annual budget of about $6 billion (2008)

and is the funding source for one-fifth of all federally-supported basic research conducted by US HEIs.

NDPBs are Non-Departmental Public Bodies, such as the Research Councils. They are independent legal bodies not attached to a specific Government Department but accountable to Parliament.

NCIHE See National Committee of Inquiry into Higher Education.

NERC The Natural Environment Research Council was established by the Science and Technology Act (1965) with responsibilities transferred from the Nature Conservancy and the National Oceanographic Council. It now promotes and supports research, survey, long-term environmental monitoring and related postgraduate training in terrestrial, marine and freshwater biology and Earth, atmospheric, hydrological, oceanographic and polar sciences and Earth observation. It funds research in universities and in its own institutes.

NIRNS was the National Institute for Research in Nuclear Science. In 1957 the Rutherford High Energy Laboratory (RHEL) was founded on the Chilton Site as the first NIRNS establishment.

NSF See National Science Foundation (USA).

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. It is the executive office of the UK Statistics Authority (q.v.).

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.

OSTI The Office for Scientific and Technical Information transferred from the British Library to the DES in April 1974.

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.

PBRF See Performance-Based Research Fund.

PCFC The Polytechnics and Colleges Funding Council was created by the Education Reform Act, 1988, and came into being on 1 November 1988 to replace the NAB. The Act allowed polytechnics to become corporations independent of Local Education Authority control. PCFC was merged in 1993 with the UFC to form the regional HEFCs.

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.

Peak for the UK refers in Evidence reports to those university units that were awarded a top grade (5 or 5*) in the 1996 RAE. For the USA it is the top 20% of institutions in each subject category.

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.

Peer groups is a term used in Evidence reports to refer to groupings of institutions with a similar research profile and history. Comparisons between very different universities are not particularly informative and comparisons with averages for the HE sector as a whole may also be insufficient for management purposes. A comparison [between either one similar institution or the average for a 'peer group' or sub-sector of several similar institutions] is therefore used to increase the value of performance comparisons. Inevitably, a balance has to be struck between simple and robust peer groupings and the ideal comparison that would come from a detailed but costly analysis by subject.

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.

Performance Management System was implemented under the Government Science Budget to provide a mechanism for translating the strategic priorities for the research base into specific aims and objectives for the Research Councils and the three other bodies funded by the Government: the Royal Society, Royal Academy of Engineering and British Academy. The system enables DIUS to measure better the contribution of the Science Budget to meeting the PSA target and to the UK Research Base as a whole. DIUS and the Research Councils have developed Output Frameworks to measure progress towards deliverables set out in their scorecards.

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.

Platform is a term used to indicate the bulk of research activity in the higher education and national research base. It is envisaged as a broad base upon which a peak of research excellence may sit.

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

PPARC The former Particle Physics and Astronomy Research Council merged with CCLRC in April 2007 to become the Science and Technology Facilities Council (STFC). PPARC funded research and training in particle physics, astronomy, solar system science and particle astrophysics and supported international scientific facilities in Edinburgh, La Palma and Hawaii.

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.

PSRE Public Sector Research Establishment. This term includes the research institutes and laboratories of the UK Research Councils, as well as

other laboratories attached to or associated as agencies with Government departments.

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

Purchasing Power Parity, see PPP.

QR is the quality-related core funding granted by the HEFCs to HEIs to enable them to support the research infrastructure, including the salaries of academic staff. It was created as a funding element in 1992. In 2006-07, HEFCE will distribute £1,342 million for research of which £1,318 will be QR with the residuum being 'research capability' funding. The quality ratings used in the QR formula allocations are generated through the RAE.

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 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.

RCUK Research Councils UK.

REF Research Excellence Framework.

RDA Regional Development Agencies form a tier of UK regional government covering 10 geographical sectors in England. Scotland and Wales have their own regional Parliaments.

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 Base Funders' Forum was set up by the DTI in 2005 to allow governmental and non-governmental funders of 'public good' research to consider the collective impact of their strategies on the sustainability, health and outputs of the Research Base. The Forum includes representatives from charities, industry, Research Councils, Funding Councils, Regional Development Agencies, the HE sector and Government departments. While it includes representatives from Government, it is not a Government body and its views should not be taken as a statement of Government policy.

Research Councils There are currently (2007) seven UK Research Councils: Arts and Humanities Research Council (AHRC); Biotechnology and Biological Sciences Research Council (BBSRC); Engineering and Physical Sciences Research Council (EPSRC); Economic and Social Research Council (ESRC); Medical Research Council (MRC); Natural Environment Research Council (NERC); Science and Technology Facilities Council (STFC). The Councils employ around 12,000 staff, and support around 30,000 researchers, including 15,500 doctoral students in UK universities and in their own research institutes.

Research Councils UK (RCUK) is a strategic partnership between the seven UK Research Councils. RCUK was established in 2002 to enable the Councils to work together more effectively to "enhance the overall impact and effectiveness of their research, training and innovation activities, contributing to the delivery of the Government's objectives for science and innovation". Each year the Research Councils invest around £2.8 billion in research covering the full spectrum of academic disciplines from the medical and biological sciences to astronomy, physics, chemistry and engineering, social sciences, economics, and the arts and humanities.

Research Excellence Framework (REF) is the proposed successor to the UK's RAE (q.v.) after the RAE 2008 cycle. It is expected to make more

extensive use of quantitative indicators than did the RAE, but it will still make use of peer review.

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

Research Services Group (RSG) of Thomson Reuters Healthcare & Science is a team of research analysts, computer programmers, and database designers. RSG supplies diverse clients (science policy agencies, government laboratories, universities, libraries, independent research institutes) worldwide with the most detailed data and sophisticated tools available today for analysing research performance, for identifying significant trends in the sciences and social sciences, and for assessing the outcome of investments in basic and applied research. The data provided by RSG is based on the bibliographic and citation information that Thomson Reuters collects from its multidisciplinary database of thousands of influential, peer-reviewed journals. RSG manages over 300 projects annually for customers worldwide.

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.

Resource Centre is used with Department and Unit to refer to HEI organisational entities.

RSG See Research Services Group.

Robbins The Robbins Report (1963) was the stimulus for a major 1960s expansion of higher education in the UK and led to the conversion of some existing HE college institutions into universities in their own right as well as to the creation of wholly new campuses. Lionel Robbins (1929 Chair in Political Economy LSE; 1959 life peer) was the Chair (1961-64) of the Committee on Higher Education.

Roberts Review See SET for Success.

Roberts Sir Gareth Roberts FRS FREng (1940–2007) was a Welsh physicist of great influence in UK science policy through his chairmanship of several academic bodies and his reports on the RAE (q.v.) on the future supply of scientists (SET for Success, q.v.). He was elected FRS in 1984, knighted in 1997 and elected FREng in 2003. He was Chief Scientist at Thorn EMI, presented the Royal Institution Christmas Lectures in 1988, was a member ACOST (q.v.) (1989-1992), Vice-Chancellor of the University of Sheffield (1991-2000, Chairman of CVCP (q.v.) (1995-1997)), President of the Institute of Physics, founding president of the Science Council (2000-2007) and President of Wolfson College, Oxford (2001-2007).

Rothschild Nathaniel Mayer Victor Rothschild (3rd Baron Rothschild, GBE GM FRS; 1910–1990) was a biologist, chair of the ARC (q.v.) (1948-1958), head of research at Royal Dutch/Shell (1963-1970) and a security adviser and head of the Central Policy Review Staff (1971-1974). In 1982 he published An Enquiry into the Social Science Research Council at the behest of Sir Keith Joseph, Minister for Education & Science.

Rothschild Report (The) Lord Rothschild established the customer-contractor principle for research commissioned by Whitehall departments: “However distinguished, intelligent and practical scientists may be, they cannot be so well qualified to decide what the needs of the nation are, and their priorities, as those responsible for ensuring that those needs are met. This is why applied R&D must have a customer”. See: The Organisation and Management of Government R&D, published as an appendix to the Green Paper A Framework for Government Research and Development (Cm 4814 November 1971)

Royal Academy of Engineering (The) was founded in 1976 as the Fellowship of Engineering. It was granted a Royal Charter in May 1983 and its current title in July 1992. It receives a grant-in-aid through the UK Science Budget.

Royal Society (The) is the UK’s national academy of science. It was founded in 1660, is independent of UK Government (although receiving a grant-in-aid through the Science Budget) and has some 1300 Fellows and Foreign Members. It is the world’s oldest scientific academy in continuous existence.

Russell Group (The) is an association of 20 research-intensive UK universities formed in 1994 at a meeting convened in an hotel in Russell Square, London. In 2004/5, Russell Group institutions accounted for about

two-thirds of UK HEI research grant and contract income and quality-related research funding (QR) allocated by the Funding Councils.

Science Budget is the money allocated to the Research Councils, which then fund their own institutes and HEIs, usually in the form of peer-reviewed grants for specific research projects as part of the dual support system and through research studentships. There are also directed programmes, initiatives and centres. The Government's three-year (2005-08) total spend on science will top £10 billion, reaching £3.4 billion in 2007-08.

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

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.

Science Research Council (SRC) was established by the Science and Technology Act (1965) to take over from DSIR and from NIRNS.

Science and Technology Act (1965) established a Science Research Council (SRC) and a Natural Environment Research Council (NERC) to join the existing ARC and MRC. The Research Councils were at this stage placed under the Minister of Technology.

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).

SERC The Science and Engineering Research Council grew out of the former SRC. In 1994 it was split into EPSRC and PPARC with its biotechnology responsibilities being transferred to the new BBSRC.

SET refers to Science, Engineering and Technology.

SET for Success was the title of a review by Sir Gareth Roberts. Sir Gareth was appointed by the Chancellor of the Exchequer and the Secretaries of State at the DTI and at DfES in March 2001 to undertake a review into the supply of science and engineering skills in the UK. The report was published in April 2002.

Share 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.

Social Science Research Council (SSRC) was the predecessor body to the ESRC.

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

SRC See also SERC, EPSRC. The SRC became a Research Council in 1965 and absorbed the former DSIR and NIRNS.

SRIF The Science Research Investment Fund was a joint initiative by the Office of Science and Innovation (OSI) and the Department for Education and Skills (DfES) absorbed in 2007 under DIUS. Its purpose is to contribute to HEIs' long-term sustainable research strategies and address past under-investment in research infrastructure. SRIF2 is ongoing: £1 billion was invested in 2004-06. Half the allocation is based on institutions' 2002-03 quality-related research income and the other half on total research income received by the institution in 2000-01. SRIF3 was announced for 2006-08, as part of the Science and Innovation Investment Framework.

SSRC See also ESRC. The Social Sciences Research Council was founded in 1965 under the influence of Lord Heyworth, who had been influential as a director of Unilever.

STFC The Science and Technology Facilities Council was formed in April 2007 through a merger of CCLRC and PPARC and the transfer of responsibility for nuclear physics from EPSRC. It is an independent, non-departmental public body of DIUS. It is one of seven national Research Councils in the UK.

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

Super-UoAs See SUoAs.

TEOs Tertiary Education Organisations, spanning the further and higher education boundary.

Text-words are terms created from an initial analysis of a set of publications that are then used to search databases for additional and related material. Text-words may be used for searches of article titles, attached keywords or abstracts.

Thomson Healthcare & Science, a part 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. Healthcare & Science encompasses a number of information businesses, including Current Drugs, Delphion Research, Derwent, ResearchSoft, Techstreet, and Wila-Derwent.

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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.

UFC The Universities Funding Council was short lived and was created by the Education Reform Act, 1988. From 1 April 1989 it administered DES funds 'for the provision of education and the undertaking of research by universities'. It was merged in 1993 with the PCFC to create the regional HEFCs.

UGC The University Grants Committee was responsible between 1919 and 1989 for allocating research and teaching money to UK universities. The UGC was succeeded by the UFC.

UK Statistics Authority is an independent non-ministerial department, directly accountable to Parliament. It was established on 1 April 2008 by the 'Statistics and Registration Service Act 2007'. The Authority's overall objective is to promote and safeguard the quality of official statistics that serve the public good. It is also required to safeguard the comprehensiveness of official statistics, and ensure good practice in relation to official statistics. One of its main functions is the oversight of the Office for National Statistics (ONS, q.v.) - its executive office

Universities UK (sometimes abbreviated wrongly to UUK) is the representative body for universities and other degree-awarding institutions in the UK. It had an earlier existence as the Committee of Vice-Chancellors and Principals (CVCP) until 2000.

Validation is the process of confirming that the details given for a publication correspond to the details supplied by the publisher to the ISI® electronic databases. This includes confirmation of authorship, title,

journal, year and pagination. Some details vary because of changes between draft and final versions; in other cases items given as 'in press' do not have complete details but these can be added during validation.

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.

YBCat Yearbook Category is the grouping of subject areas (disciplines, UoAs) used for this publication by Evidence.

Zuckerman Lord (Solly) Zuckerman, Baron Zuckerman OM KCB FRS (1904-1993) was a UK zoologist and scientific advisor. He began his career at the London Zoological Society, became chief scientific adviser to the Ministry of Defence in 1960, and subsequently Government Chief Scientific Adviser (1964-1971). He was awarded a life peerage as Baron Zuckerman, of Burnham Thorpe in the County of Norfolk in 1971.

evidence

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