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Building everyday democracy

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ISBN 1-904431-07-0

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This report discusses the future of UK research collaboration with other countries.

If the UK is not positioned to exploit potential links with the emerging leaders – of which China is the strongest – it will face significant opportunity costs. The UK's excellent research base makes it a good partner for China now. In the new geography of science, China will be an essential partner for the UK.

International collaboration provides access to research investments made by other leading nations. Collaborative research is often highly innovative and has exceptional impact. The UK has one of the best-performing research bases in the world, and its volume of internationally co-authored research in leading journals is increasing by about 2% per year.

The UK has had strong links with the USA, with which it has a common language. It has expanding links within Europe, where there is a shared culture. Collaboration has been readily created and sustained by informal, personal partnerships.

The management of collaboration must change as the geography of science develops new peaks around the globe. The compass of research and innovation is swinging more and more strongly to the east. Serendipity is not enough to address all the new opportunities and will be wholly inadequate for the UK's key interface with India and with China, the fastest growing science and technology-based economies in the world.

China is an increasingly important and competitive research economy. Its R&D investment is expanding at 20% annually, offering unprecedented new possibilities in a rapidly diversifying research portfolio.

The relative increase in UK co-authorship with Europe is dwarfed by five-fold growth in collaboration with China, from what was previously a very low base. But research management in China is more centralised than that in the UK and may limit further informal expansion.

To enable the UK research base to exploit its partnership opportunities we will need new, more adequate and better structured support mechanisms – clear policy commitment, dedicated funding, better exchange programmes, better support for young researchers who participate in the schemes. We also need more detailed analysis of the UK's present links to its new partners to understand how collaboration with China works and to establish models of good practice.

The authors

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Evidence Ltd is registered in England, Company no 4036650, VAT registration 758 4671 85, http://www.evidence.co.uk

The new geography of science

Among the 150 million items stored at the British Library in London are many of the treasures of modern European thought: Shakespeare's first folio, Mozart's scores and Einstein's calculations. By law, a copy of every book published in the UK must be deposited there, enabling the Library to serve as the custodian of our scientific and intellectual memory.

New powers and priorities in the geography of knowledge

But earlier this year, a few eyebrows were raised when this venerable institution announced a significant shift in its strategy. From 2007, the Library will place far greater priority on collecting material from China and India. "We don't have a crystal ball," admitted Caroline Pung, the Library's head of strategy, "but we have looked at Foreign Office predictions and done our best to inform ourselves so we can provide for the needs of future researchers. China and India are growing massively."[i]

The British Library is far from alone in having to adjust to shifts in the global distribution and generation of knowledge. We used to know where new ideas would come from: the top universities and research laboratories of large companies based in Europe and the US. While production was being dispersed among global networks of suppliers, it was assumed that more knowledge-intensive tasks would stay at home. All that is changing fast. As globalisation moves up a gear, ideas are emerging in unexpected places and flowing around the world just as easily as money and commodities, carried by a mobile diaspora of knowledge workers.

China and India – growing research power

We are used to the idea of China as a location for low-cost manufacturing, last year producing 50% of the world's cameras, 30% of its air conditioners and 25% of its washing machines. And we have just about got used to the idea of India as a provider of call centres, software and back office services. But now China and India are becoming world class centres for scientific research, particularly in emerging fields such as bio- and nano-technology.

Annual increases of 20% in R&D spend

Headline numbers give pause for thought. Since 1999, China's spending on research has increased by more than 20% each year. In 2005, it reached 1.3% of GDP, up from 0.7% in 1998. It is now third in the global league table in terms of actual expenditure, behind only Japan and the US. In January 2006, China's Science and Technology Congress approved a new Medium to Long-Term Science and Technology Development Plan, which confirms the aim of boosting investment further, to 2% of GDP by 2010 and 2.5% by 2020. President Hu Jintao, in his keynote speech to the Congress on 9 January 2006, called on China to become an "innovation-oriented society" and predicted that: "by the end of 2020, China will join the ranks of the world's most innovative countries."

Increases in the pool of talent

In India, the total amount being spent on R&D is still a more modest 0.8% of GDP, but science budgets increased by 24% in 2005 and 16% this year. India's pool of younger university graduates with less than seven years of work experience, is about 14 million – twice that of the USA. This reservoir of talent increases every year by 2.5 million new graduates in IT, engineering and life sciences, along with 650,000 postgraduates and around 6,000 PhDs.

The most striking feature of the new geography of science is the sheer scale of investment and mobilization of people behind innovation that is underway in countries such as China, India, Brazil and Korea, driven by a high-tech vision of how to succeed in the global economy.

Emerging indicators of research excellence

Does this investment yield results and change maps of research strength? It is starting to. Indicators of innovation can be hard to pin down, but scientific publications are one of the most useful places to start. According to Thomson Scientific®, the world's leading supplier of information about research publications and their citations, Asia-Pacific's share of the world's scientific papers rose from 16% in 1990 to 25% in 2004. In certain fields critical to technological development, such as material science, the most marked change is the inexorable and steep rise of China.

UK research: data background

Data sources

The data described in this report are drawn from the databases of Thomson Scientific which regularly indexes data on articles in about 8,500 journals published world-wide. Numerous studies have confirmed that Thomson Scientific's data management policy ensures that its databases cover serials regarded by researchers as the most significant in their field.

Indicators of collaboration

Research collaboration is marked by a range of programmes for investment in joint projects, in a multitude of formal and informal collaborative work and in the emergence of new ideas fed by intellectual development on all sides of these partnerships.

Lists of joint projects are not, by themselves, a sufficient marker of the strength of relationships. Some of these projects may be substantive and depend on real and ongoing activity, but others represent an intellectual commitment that has yet to be realised more tangibly.

Money is a potentially strong marker, but the absence of funds set up specifically for international liaison means that many joint projects are funded at two home locations by national agencies and are functionally indistinguishable from other national research.

Publications are a pervasive currency

Joint publications are a sound and valid marker. Publication data are readily available, cover a wide range of countries, and can be grouped by year and subject. Every research paper includes the names and addresses of the authors and therefore both the country of origin of the authors and the association between co-authoring nations can be checked and indexed.

UK publication: international collaboration

Two years were taken as benchmarks: 1997 and 2004. UK total output has increased in line with that of major competitors, such as the other research-intensive nations in the G8 and elsewhere in Europe, during this period.

UK output has increased but international collaboration has grown even more rapidly

	1997	2004
UK research publications in Thomson indexed journals	96,956	104,219
Papers with a non-UK co-author	17,935	33,411
International collaboration as % output	18.5	32.1

Collaboration has increased substantially, by about 2% per year, over the period analysed. The combination of underlying growth and increased collaboration means that the absolute amount of international co-authorship roughly doubled between 1997 and 2004.

UK collaboration – specific partners

Most links are long established

The UK's top ten research partners in 1997 were also those for 2004, and in almost the same order.

But China is new

China's is by far the most notable ranked change in the two tables. We have analysed this change in more detail (below).

The greatest change between the two years was China's appearance in the top table

1997		
Collaborating country	**Count of joint papers with UK**	**% of UK co-authorship**
USA	5824	32.5
GERMANY	2406	13.4
FRANCE	1932	10.8
ITALY	1513	8.4
NETHERLANDS	1255	7.0
CANADA	1113	6.2
AUSTRALIA	955	5.3
JAPAN	891	5.0
SPAIN	839	4.7
SWITZERLAND	809	4.5
SWEDEN	750	4.2
BELGIUM	592	3.3
RUSSIA	550	3.1
DENMARK	538	3.0
IRELAND	355	2.0

2004		
Collaborating country	**Count of joint papers with UK**	**% of UK co-authorship**
USA	10660	31.9
GERMANY	4831	14.5
FRANCE	3628	10.9
ITALY	2928	8.8
NETHERLANDS	2482	7.4
CANADA	2283	6.8
AUSTRALIA	2202	6.6
SPAIN	2037	6.1
SWITZERLAND	1582	4.7
JAPAN	1479	4.4
SWEDEN	1457	4.4
P R CHINA	1365	4.1
BELGIUM	1310	3.9
DENMARK	1002	3.0
RUSSIA	969	2.9

The USA was the most frequent location of co-authors for UK researchers in both 1997 and 2004

The most frequent partner for the UK is the USA. A recent study led by Sir Gareth Roberts examined this aspect of international partnerships in some detail and demonstrated that a clear benefit of joint international research work was a significant gain in research impact. Jointly authored UK-USA articles were cited more often by other researchers than either UK or USA articles published in the same field at the same time.[ii]

The USA is a huge and accessible resource

The USA's position at the top of the table is due to both its research excellence, which makes it an attractive partner, and its research scale, which makes it a more likely partner. Furthermore, the ready movement of research staff between the UK and the USA creates long-term research links[iii].

The UK is also closely linked to European neighbours

Major European research partners form the next tier. On the whole, the frequency of co-authorship is related to the scale of the research economies. The strong position of the Netherlands – 5th in both tables – is of interest and this reflects its notable research excellence for a relatively small research base. Many of the UK's European partners have increased their share of the UK's international links, whereas the USA has fallen back slightly (from 32.5 to 31.9%, but >40% increase in volume). Germany has become a relatively more frequent partner by 1% overall; Spain has shifted up from 4.7 to 6.1%.

Common cultures make liaison easy

The common language with the USA and a shared culture across Europe make research links easier to forge and to sustain, with many emerging informally and spontaneously from personal contact rather than from structured programmes.

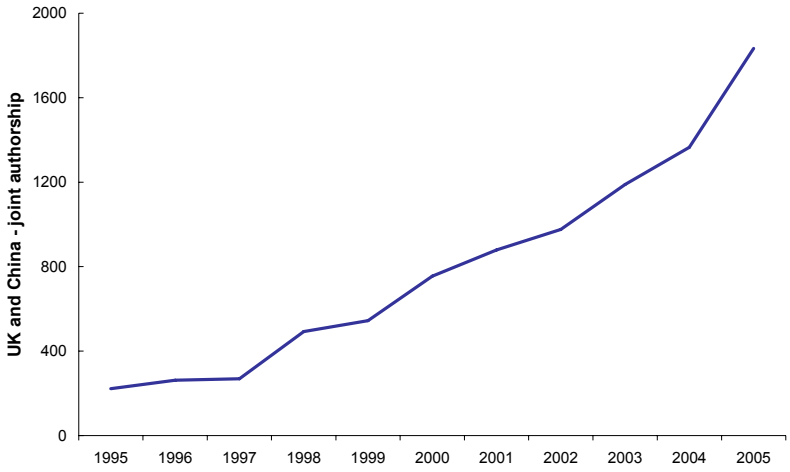
Cultural hurdles may need to be addressed by new mechanisms

These informal arrangements may not be sufficient when links are with less familiar cultures and across challenging language hurdles. For example, Japan is the only nation to have seen a notable relative decline in UK collaboration, but even this represents an increase in absolute numbers of joint papers. China represents a challenge in language, culture and management style, but one that must be tackled.

China – UK publications and co-authorship

In 1997 China would have been the UK's 23rd most frequent co-author, with 269 joint-UK papers. The level of collaboration between the two countries then started to accelerate. By 2004 the level of jointly authored papers had increased five-fold and pushed China up to 12th. The trend was extended in 2005 and appears likely to continue, with steady increases not only in the number of collaborations but in the rate of expansion.

The numbers of journal articles with authors based in both the UK and China has increased rapidly over the last ten years



The quality and breadth of Chinese research is improving rapidly

The quality of Chinese research is increasing all the time. *Evidence*'s most recent report on comparative international research performance, for the UK Office of Science & Technology (now the Office of Science & Innovation), showed that it more than trebled its research publication output between 1995 and 2004, with a steady increase in the numbers of citations for each paper published.[iv]

Chinese research is also diversifying. The growth of China's research economy and its expansion from engineering and applied sciences into other areas will make this the most important area to watch for the future.

International collaboration: a source of comparative advantage

Science is not a zero-sum game

Against this backdrop, it is not surprising that there is a growing interest in the quantity and quality of research links with Asia. Some view the rise of Chinese and Indian science as a threat, worrying that it will damage high-technology sectors in the UK. But most policymakers recognize that science is not a zero-sum game: more in Asia doesn't necessarily mean less in Europe or the USA. Alongside new sources of competition, the rise of China and, in the near future, India creates new opportunities for collaboration.

Collaborative research produces high impact outcomes

Policy makers also recognise that collaboration is the best way of accessing the knowledge development and innovation that comes out of research that other nations invest in. It is part of knowledge networking. As Sir Gareth Roberts' work has shown, it is also a source of real gain, because joint projects benefit from joint intellectual investment and rich synergies. Collaborative research produces more highly cited publications.[v]

React to opportunities, not threats

Find out what works and why

The data on levels of UK co-authorship that we have shown here are aimed at increasing awareness of the opportunities – and of the need to react to them at institutional and national levels. Although the USA, Germany and France remain the most popular partner countries for UK researchers, China's rise in frequency as a co-author for UK publications is a sign that things are changing. More research could help to place these data in context. For example, it would be useful to understand more about the spread of Chinese and Indian co-authorship across different countries, how the UK ranks as a partner of choice, who are China's partners in the UK and why them.

A stronger commitment to collaboration

Despite these early signs of increased collaboration, there is no room for complacency. Given the ambition and investment that China, India and other emerging players are pouring into science and innovation, collaboration should become a higher strategic priority for the UK. Over time, the depth and quality of our networks in Asia are likely to become more crucial to sustaining our long-term scientific and economic success.

How can the UK express and reify a commitment to new partnerships?

Develop new support mechanisms tuned to different cultures

Unlike the UK's 'bottom-up' approach to funding research, the Chinese and Indian governments are closely involved in deciding which universities and institutes get funding and for what areas of work. This means that government and other key institutions in China and India are well disposed to large-scale, bilateral programmes for collaboration (e.g. joint research centres), which do not fit naturally with the UK's researcher-led approach.

We need to identify new approaches to bilateral collaboration that build on the best of both systems, by supporting the best UK, Chinese and Indian scientists to work together in a bottom-up way, while also ensuring the political visibility and access to people and resources that comes with more 'top-down' programmes.

Support talent flows

Currently, the UK attracts large numbers of Chinese and Indian students to its universities. The majority of these are at undergraduate level (unlike the USA, where they tend to study for a higher degree). Other work by *Evidence* has shown that it is PhD and postdoctoral researchers who are the key to successful ongoing collaborations.[vi] When they return home, they are likely to retain good links with their supervisor and colleagues, which can become the basis for joint research. Although there are various scholarships available for overseas students to undertake PhD and postdoctoral study in the UK, these tend to be small-scale and highly competitive.

Improve alumni management

There is a strong case for scaling up levels of investment in this area, and establishing new Chinese and Indian equivalents of the Sino British Friendship Scholarship Scheme (SBFSS), which has now ended but brought a significant number of high-quality Chinese researchers to the UK in the 1980s. We also need to improve the management of our overseas alumni networks, which are often poorly coordinated and not usually identified as our greatest asset in developing new forms of collaboration.

Conclusions

Collaboration is growing

The UK has steadily increased the proportion of its research which is internationally collaborative, as indicated by co-authorship of research articles with other countries. The level of collaboration with traditional partners in Europe and the USA remains high, with European links increasing at a higher rate, but the most rapid change has been its newer partnership with China.

There is a lack of detailed analysis

At the moment we know every little about the UK's links with China. Who is involved? In which fields? Why have these links succeeded? And are there models of good practice to build on for the future? Collaboration will remain dependent on serendipity without more detailed research and analysis.

China is an essential partner

China's profile, its sheer size, its improving excellence and its interface with the rest of the international research base make it an essential partner in any future international research portfolio. Its culture of research management is different, however, so a key task for UK research base managers will be to ensure they have the mechanisms in place for their researchers to take advantage of opportunities to collaborate with China when they arise.

Informal links depend unduly on local investment

Sir Gareth Roberts[vii] has drawn attention to the costs of 'double jeopardy' when both partners in a potential link must depend on local decisions. A commitment to creating appropriate joint funding would overcome that jeopardy at no cost to quality. The balance of top-down management and bottom-up commitment to real and worthwhile goals will need careful consideration.

Exchanges must increase

People are the core of long-term partnerships. Arrangements for enabling more postgraduate exchange to and from China and India is vital, and must be linked to a commitment to make such exchange stimulating and sustaining for long-term relationships for those involved.

Knowledge is the new commodity

The cost of not making a commitment to partnership with China will be significant in terms of both intellectual and economic development. Britain is an island that has benefited financially from trading goods in the past. The new 'must have' is knowledge and the UK must be fully involved in its future trade, or it will be marginalised intellectually as well as geographically.

The UK has an excellent research base[viii] and is a good partner for China now. In the new geography, China will be an essential partner for the UK.

Endnotes and references

[i] 'British Library sets sights on the East', The Observer, 23 April 2006

[ii] Roberts, G (2006) International partnerships of research excellence, available at http://www.admin.ox.ac.uk/po/news/2005-06/may/4.shtml

> The report explores collaboration between the UK and its major international partners: USA and Germany. It draws attention to the exceptional quality of research that involves international partnerships, providing gains to both parties. It also notes that there are relatively few sources of support dedicated to fostering international links, which is barrier to further expansion at a time when such partnerships provide the scale to tackle major research challenges.

[iii] Gurney K A and Adams J (2006). Tracking UK and international researchers by an analysis of publication data. Higher Education Policy Institute, Oxford. http://www.hepi.ac.uk/pubdetail.asp?ID=181&DOC=Reports

> Contrary to fears of a brain drain, these analyses reveal a high level of brain circulation. Many of the UK's top researchers have benefited from career development in the USA, maintaining their links after returning to a UK University. Switzerland also has a high level of researcher emigration and immigration and the benefits of this are reflected both in performance data and national policy.

[iv] *Evidence* Ltd (2005). The UK's comparative international research performance: Public Service Agreement research performance indicators – a report to the UK Office of Science and Technology. DTI accession URN 06/1104 at http://www.ecdti.co.uk/CGIBIN/priamlnk.cgi?MP=CATSER%5EGINT65&CNO=1&CAT='58'

> The annual PSA target report compares a basket of 30 countries, using a wide range of data across nine themes and more than 40 indicators related to income, activity, outcome and impact. The most recent edition confirmed the profile of UK research efficiency and effectiveness and showed that its performance was challenging the USA in key research areas. It also demonstrated the exceptional rise in activity and performance for China.

[v] Roberts (2006) op. cit.

[vi] Gurney and Adams (2006) op. cit.

[vii] Roberts (2006) op. cit.

[viii] *Evidence* Ltd (2005) op. cit.