

**Supplementary data to:  
The Fourth Age of Research (Comment in *Nature* 497, 557–560; 2013)  
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The main text describes the changing balance of domestic and international research papers over the period from 1981 to 2012, using data from articles in journals indexed on Thomson Reuters *Web of Science*. Domestic papers are those that only have author addresses from one country whereas international papers are those that have at least one co-author from a second country. Some of the international papers also have authors from third countries, and so on.

Total and domestic output of articles and reviews in 1981 and 2012 (part year) for a set of established (USA and Western Europe) and emerging (Eastern Europe, Asia and Brazil) research economies. Domestic publications are those that have no foreign co-author and these are shown as ‘domestic share’ (percentage of the total). As an index of change: growth is the ratio of 2012/1981 values; share is the difference of 2012-1981 values.

	1981			2012			Change		
	Total output	Domestic count	Domestic share %	Total output	Domestic count	Domestic share %	Collab'n growth	Domestic growth	Domestic %
USA	170,499	159,972	93.8	342,688	225,093	65.7	11.2	1.4	-28.1
UK	37,194	32,721	88.0	96,138	45,212	47.0	11.4	1.4	-40.9
Germany	33,741	29,954	88.8	91,417	43,396	47.5	12.7	1.4	-41.3
France	23,536	20,471	87.0	63,281	28,440	44.9	11.4	1.4	-42.0
Netherlands	6,820	5,732	84.0	33,752	14,069	41.7	18.1	2.5	-42.4
Switzerland	6,339	4,871	76.8	24,424	7,649	31.3	11.4	1.6	-45.5
Poland	4,800	4,118	85.8	20,076	13,112	65.3	10.2	3.2	-20.5
China	1,553	1,385	89.2	172,503	130,087	75.4	252.5	93.9	-13.8
S Korea	247	165	66.8	45,595	32,352	71.0	161.5	196.1	+4.2
India	10,967	10,375	94.6	44,277	34,180	77.2	17.1	3.3	-17.4

	1981			2012			Change		
	Total output	Domestic count	Domestic share %	Total output	Domestic count	Domestic share %	Collab'n growth	Domestic growth	Domestic %
Brazil	1,923	1,530	79.6	33,275	23,616	71.0	24.6	15.4	-8.6

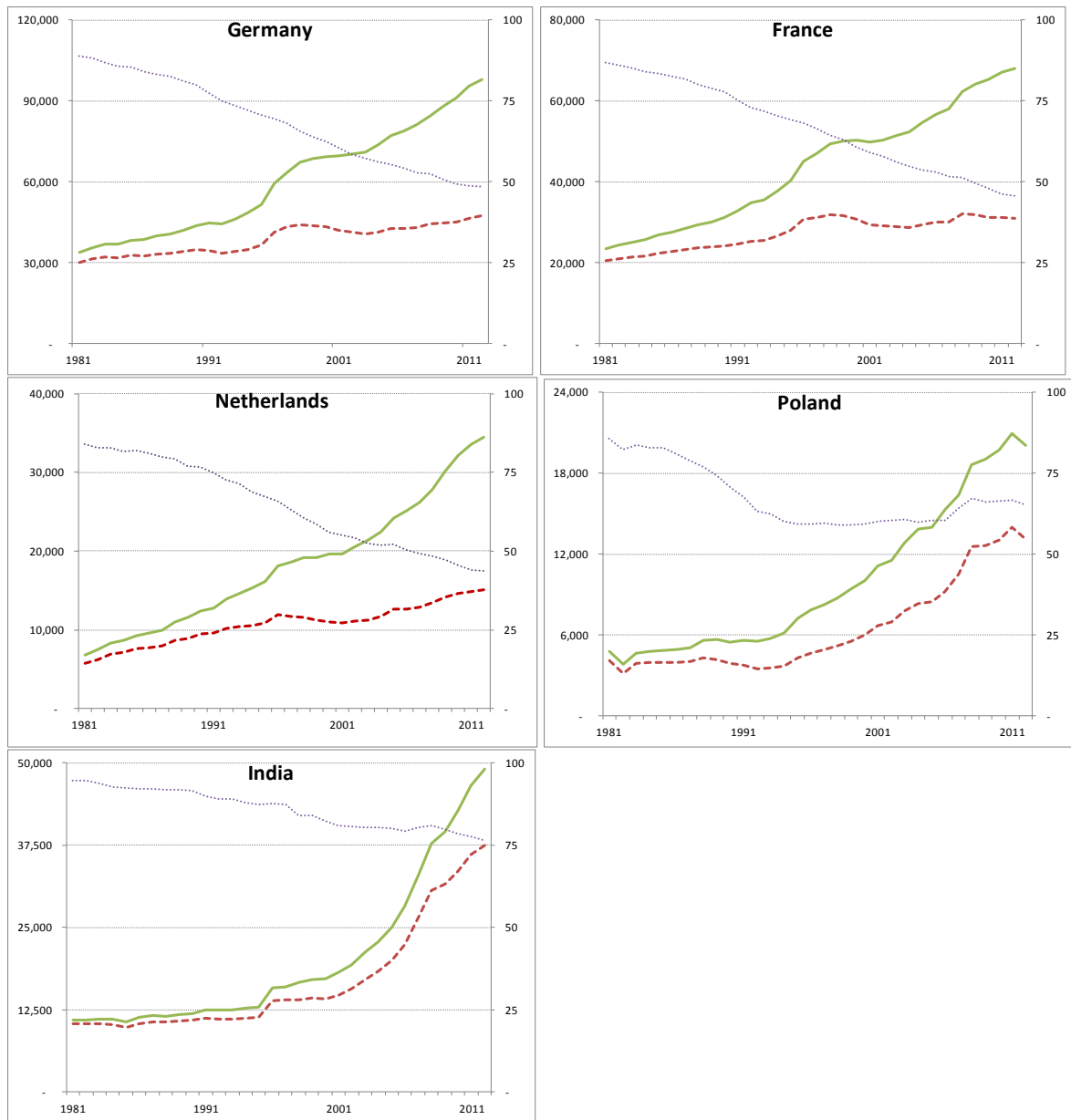
Data for Germany include pre-unification figures for the Democratic and Federal Republics, deduplicated for E/W collaboration.

The data show that during a period of growth in research output across all countries, much of the growth in the established economies has been attributable to international co-authorship with much less change in the share of output that is generated solely by the domestic research base. In consequence, less than half of the papers produced by countries in Western Europe are actually derived solely from domestic research. By contrast, in the emerging economies the domestic research base has been the primary source of growth and a much higher percentage of papers have no international co-author.

International research collaboration is a critical source of understanding not only what research is being produced but how the problems are determined and specified, how problems are overcome and how analysis and interpretation of the results are developed. The alternative is to read the final papers which produce only an outline and summary of the positive results.

Figure 1. Total and domestic research output of article and reviews in journals indexed on Thomson Reuters Web of Science (1981-2012) for established (Germany, France, Netherlands) and emerging (Poland, India) research economies and domestic output as an annual percentage of the total. (Data for USA, UK, Switzerland, China, South Korea and Brazil are shown in main article.) Data for 2012 are part-year pro-rated.

In each graph: the left hand-axis is annual output where (1) the continuous green line refers to total and (2) the dashed red line refers to domestic output; (3) the right-hand axis refers to the percentage of total output that is domestic in each year and is shown by the dotted purple line.



The increasing relative volume of papers produced through international collaboration has been discussed elsewhere. It has been suggested that multinational collaborative programs on ‘grand challenge’ projects such as particle physics, astronomy and climate change are an important driver. The data for the UK and the USA present a rather different picture.

The bulk of collaboration with frequent-partner countries is bilateral, not multilateral. Less than 2% of UK publications had authors from both France and Germany and less than 1% had authors from these two and the USA. The percentages of multilateral papers are even smaller for the USA.

Figure 2. UK research co-authorship with three major partner countries over the ten-year period 2003-2012. Data refer to articles and reviews in journals indexed on Thomson Reuters *Web of Science*<sup>TM</sup>. Circles are scaled to output; the boxes are not scaled.

*To interpret the data: over the ten-year period the UK published 878,006 papers of which 46,667 (5.3%) had a French co-author. Of these, 13,567 (1.5% of UK) had a third author from Germany and, of these, 7,009 (0.8% of UK) had a fourth author from the USA.*

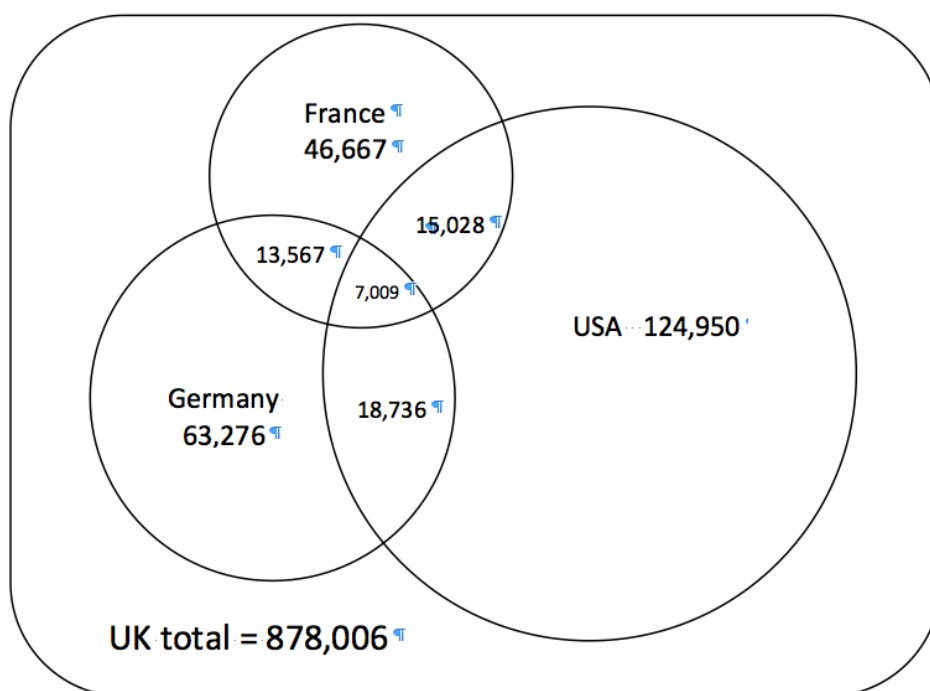


Figure 3. US research co-authorship with three major partner countries over the ten-year period 2003-2012. Data refer to articles and reviews in journals indexed on Thomson Reuters *Web of Science*<sup>TM</sup>. Circles are scaled to output; the boxes are not scaled.

*To interpret the data: over the ten-year period the USA published 3,246,694 papers of which 106,834 (3.3%) had a China co-author. Of these, 4,878 (0.15% of USA) had a third author from UK and, of these, 2,026 (0.06% of USA) had a fourth author from Germany.*

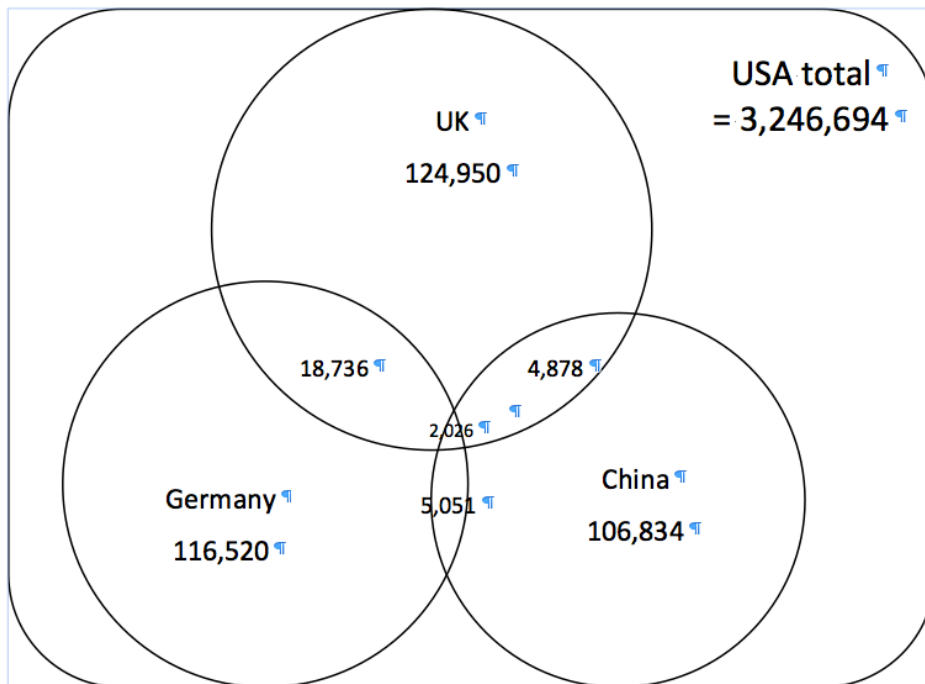


Figure 4. The percentage of UK university and college research papers that were internationally co-authored over the ten-year period 2002-2011 compared to the average citation impact of those papers (publication and citation data for journals indexed on Thomson Reuters *Web of Science*<sup>TM</sup>). The cross lines locate the median values for each axis. For institutions publishing more than 100 papers in the period, the correlation (Spearman  $\rho=0.75$ ,  $n=130$ ) is statistically significant.

