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Indicators

Problems with the 'measurement' of national scientific performance

Loet Leydesdorff

It has been argued that British science was in decline during the 1970s and the first half of the 1980s. However, a computer count of the percentage of contributions with a UK address among the sources of the* Science Citation Index *gives a different picture: British scientific output was relatively stable over the 1970s, then showed a remarkable increase from 1981 onwards. The discrepancies between these figures and those of earlier publications can be explained in terms of the databases which were used.

Loet Leydesdorff is at the Department of Science Dynamics, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands.

THE EVALUATION OF national research peformance in terms of publications and citations is more complex than the simple outcomes of rising or declining figures suggest.[1] Of course, the two major questions involved are (i) how good are the data? and (ii) how are the data handled statistically so that conclusions can be drawn?

The *Science Citation Index (SCI)* of the Institute for Scientific Information (ISI) in Philadelphia has been widely accepted as the major source of data for this type of scientometric study. Since the institutional affiliations of authors are also organized by country of origin in the printed edition of this index, a computer is hardly necessary to get an impression of national research performance. For example, one can simply count or estimate the number of records per country, and divide the result by the total number of records. This will lead to a fairly good first approximation of a given nation's percentage of the total publications for the year. Alternatively, one can access one of the publicly available installations of this database to do a more accurate publication or citation count.

ISI collected the data for the *SCI* from the 'top' 3,500 or so scientific journals. However, the choice of entries in this 'top' is made on statistical grounds.[2] To follow developments in science, the company has developed a set of criteria which is used by a panel to decide whether to accept new journals or to remove others from the database.[3] This leads to a turnover in journals of about 7% per year. Until now, ISI seems to have been able to resist commercial pressures, and also pressures from under-developed countries to give their journals preferential treatment.[4]

However, given such a changing database, it is not feasible without further processing to disaggregate the figures into individual disciplines.[5] For that reason, the US National Science Foundation, when it started its biennial *Science Indicators* reports in 1972, contracted with Computer Horizons Inc (CHI) for the development of an 'analytic version' of the *SCI*. In this project, which has continued ever since, a matrix of journals versus nations is being constructed to enable one to follow publication and

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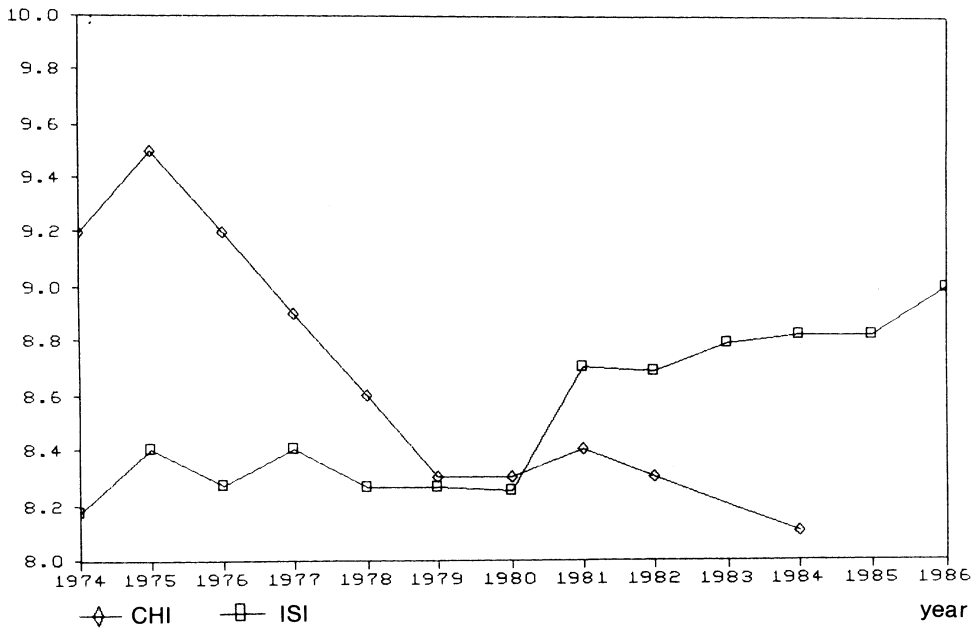

Figure 1. Percentage publications with a UK address 1974-1986

citation trends at the disciplinary and specialty level. To make such comparisons possible, however, CHI used a 'fixed journal set' in which each journal is attributed— with or without a coefficient— to one or more of the disciplines. As a result, a change in the fixed journal set could disrupt the analytic basis for comparison.

Major trends are evident using either of the two databases.[6] In the case of Britain, however, there are dramatic differences in the results provided by the two methods: the CHI figures indicate a decline,[7] while the ISI data show an increase in British scientific research output in terms of publications (see Figure 1). The futher we move away from 1972 the more serious these differences become, and for this reason, CHI recently has revised the fixed journal set, so that new figures for national performance have recently become available from this institute.[8]

What causes the differences?

One plausible reason why advanced industrial countries would show better performance when measured in terms of the dynamic journal set, seems to be that scientists in these countries publish more in new journals and less in disappearing journals than the world average.

Since these differences in results from the two databases were first noted in 1985, other contributing factors have been suggested, in addition to the differences between using a fixed journal set (CHI) versus a dynamic journal set (ISI). First, CHI has pointed to the difference in the number of misspellings of country names in the database in various years. CHI takes care of misspellings in the analytic version of the *SCI*, and it claims that this raises the British contribution for earlier years. In Table 1 some of the misspellings of 'England', as noted in a letter of CHI,[9] have been checked for their frequencies using the *SCI* on-line. As the reader can see, these effects are not of an order of magnitude capable of affecting the general trend.

Table 1. Misspellings of 'ENGLAND' in corporate addresses for 1974*

		% of world total
ENGLAND	27,222	6.45**
ENGGLAND	1	0.00024
ENGLAAND	4	0.001
ENGLANG	1	
ENGLLAND	4	

Notes: *The count was performed in November 1985.
**UK: 8.17%; this includes Scotland, Wales and Northern Ireland.

A more serious argument brought forward in defence of the CHI/NSF database concerns the attribution of internationally co-authored articles to national performance.[10] When one searches in the *SCI* directly, all publications with a British address are counted equally, independent of whether the publication is fully British or internationally co-authored ('integer counting'). When processing the data, CHI not only attributes journals to disciplines but also publications to countries, taking a weighted ratio for co-authored articles ('fractional counting').

Hence, fractional counting implies that internationally co-authored papers contribute for a fraction only to the national total. However, one might wonder whether fractional counting is more adequate than integer counting in measuring performance. Why should a single author be given more credit for a publication than someone who has co-authored a paper as a result of international co-operation? Using this method, a simple increase in international co-authorships could *ceteris paribus*

CHI takes a weighted ratio for co-authored articles so that a simple increase in international co-authorships could cause apparent decline in national performance

Table 2. English and French co-authorship

Year	French and English address	% of total
1974	156	0.04
1978	301	0.05
1982	458	0.07
1986	565	0.08

cause a decline in national performance.

In our opinion, the two issues — measurement of national performance and developments in international co-authorship — should be studied separately. When one deals with the latter in the framework of the former, introducing coefficients into the counting, the two trends cannot be reconstructed from the mixed results without access to the CHI database. A rough indication of the size of international co-authorship can be obtained from an on-line search by specifying, for example, the number of articles with an English and French address for various years as a percentage of world total (Table 2).

However, it may be that there has indeed been a substantial rise in other international co-authorships over the past decade. Since that could raise interesting policy questions, it would be useful if CHI could specify which international co-authorships have increased significantly.

In addition to these considerations, when attributing addresses to papers, one should keep in mind that there is an unknown effect produced by publications without any institutional address. Moreover, we may expect publication behavior to vary in this respect among sciences[11] and among nations.[12]

More recently, it has been brought to my attention that some of the differences between using the *SCI* and the CHI database may be explained because the CHI database consists solely of papers, notes and reviews. It is possible to reproduce this selection on-line from the *SCI*. That brings us to Figure 2, which is essentially a window to Figure 1 for the period after 1978 with a third, additional line.[13]

Two conclusions and one question follow from this line. First, there is a considerable increase in scientific materials other than articles with a British address (editorials, orbituaries, and so on). Maybe British scientists are now putting institutional addresses on things which were formerly left without addresses? Secondly, the difference between this selection and the CHI-selection has grown smaller. This difference has to be explained in terms of the effects of the assumptions about the fixed journal set and international co-authorship.

However, examining the new graph, I began to wonder what makes it deviate from a smooth curve. Since, in a case like the UK, the numbers are rather large anyhow, one would expect flat and steady patterns. If we disaggregate the graph further into its constituents, of papers, notes and reviews, we achieve a better understanding of the underlying distributions (Figure 3).

The larger group of articles is almost stable (as a percentage of the world production of articles), notes are somewhat more fluctuating, and reviews (which include also bibliographies) are most unstable. Of course, it remains an open question whether these fluctuations are created by the British production of reviews, the world production of them, or by an underlying heterogeneity of this category.

However, from the graphs we may conclude, firstly that Britain is almost stable in its production of scientific articles, and, secondly, that comparatively it produces more reviews than would be expected statistically in relation to the remainder of the world.

Conclusion

I have shown in this article that it is possible to produce graphs indicating the rise, the decline, or the relative stability of British science by making different selections. However, as can easily be seen,

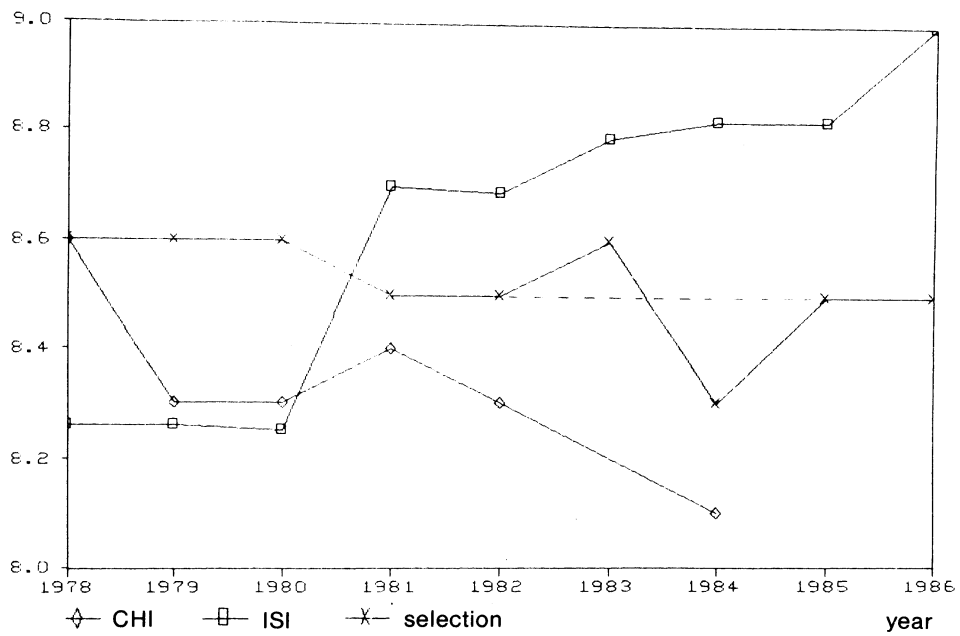

Figure 2. Percentage publications with a UK address 1978-1986

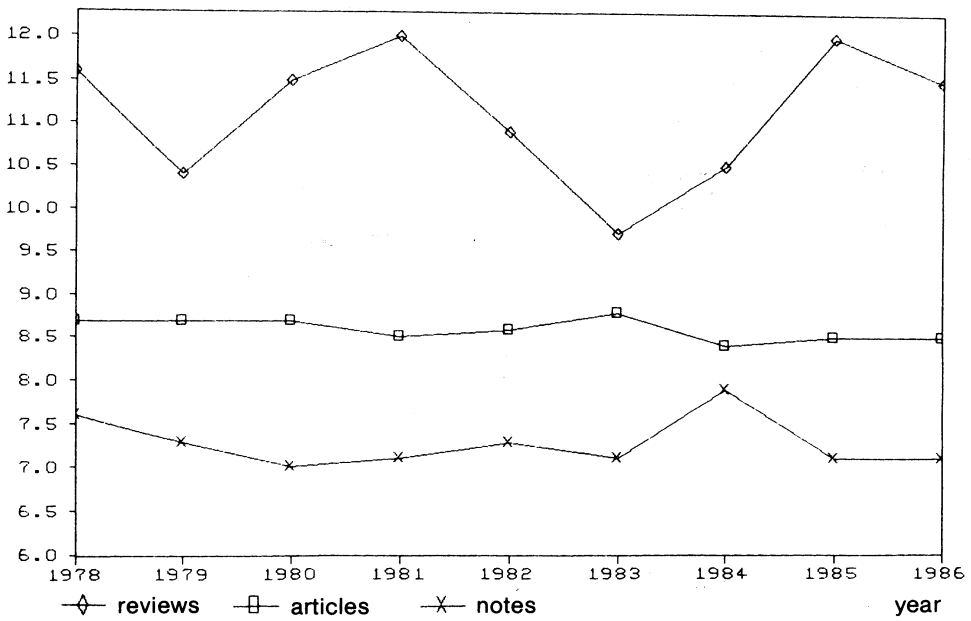

Figure 3. Percentage reviews, articles and notes

one cannot avoid making selections. I have argued that the selections used to demonstrate British decline are of a problematic nature: it is unlikely that science can be represented by a fixed journal set instead of a changing one, and it is also questionable that international co-authorship has to be counted as a minus in terms of national performance. If someone wants to maintain these arguments, more substantial support for them is needed.

I have also mentioned that an argument in favour of using a 'fixed journal set' can be advanced, when the purpose is to compare developments over time at the level of a discipline or a specialty, as long as one is technically unable to attribute journals to disciplines dynamically. However, for comparisons at the national (aggregated) level there seems to be no reason to prefer the results of the CHI index, which was initially a reorganization of the *SCI* for the specific purpose of disaggregation, over the raw data available from the *SCI*. The latter have the further advantage in science policy debate, that they can be easily accessed by everybody.

Notes and references

1. B R Martin, J Irvine, F Narin, C Sterritt, "The continuing decline of British science", *Nature,* 330, 12 November 1987, pages 123-126.
2. E Garfield, *Citation Indexing* (New York, Wiley, 1979).
3. E Garfield, "How do we select journals for *Current Contents?*", *Current Contents,* November 5, 1979.
4. "The discussion at the meeting focused specifically on the feasibility of expanding the *SCI* to include all the work performed in the developing countries which is deemed of sufficiently high quality by commonly agreed standards and which is published in scientific journals." The Final Report of the Philadelphia Workship on *Strengthening the Coverage of Third World Science,* M J Moravcsik (editor), Oregon, University of Oregon, 1986.
5. See also L Leydesdorff, "Various Methods for the Mapping of Science", *Scientometrics,* 11(5-6, 1987, pages 291-324.
6. M Callon, L Leydesdorff, "La recherche française, est-elle en bonne santé?" *La Recherche,* 18.(186) March 1987, pages 412-419.
7. J Irvine, B Martin, T Peacock and R Turner, "Charting the decline of British science", *Nature,* 316, 15 August 1985, pages 587-590. See also ABRC Science Policy Studies No 1, *Evaluation of National Performance in Basic Research. A Review of Techniques for Evaluating National Performance in Basic Research, with Case Studies in Genetics and Solid State Physics* (London, 1986).
8. B Martin, *et al,* 1987, see reference 1.
9. Letter of October 31, 1985 to the Editor of *Nature,* with cc to the author.
10. A third argument which was brought forward in 1985, was based on the misunderstanding that I would use publication years instead of tape years. See also B Martin *et al,* 1987, reference 1.
11. See, for example, S Gillmor, "Ionospheric Physics", *Social Studies of Science 16* (1986) page 117.
12. For example, this effect is probably at the base of the spectacular increase in the percentage of Dutch contributions in the *Social Science Citation Index:* notably from 0.44% in 1974 to 0.89% in 1984, compared with an increase in England from 7.43% to 8.75% over the same period.
13. In 1987, because of a reload of the *SCI*-file for 1974-1977 on Dialog, changes were introduced into the organization of this database which make it currently impossible to use this installation for comparisons.

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Indicators

On-line approaches to measuring national scientific output: a cautionary tale

Joe Anderson, Peter M D Collins, John Irvine, Phoebe A Isard, Ben R Martin, Francis Narin and Kimberly Stevens

Previous research by the authors shows that the output and impact of British science has declined significantly over the last decade relative to other major industrial nations. This paper responds to the claim made by Leydesdorff elsewhere in this issue of the journal that British research output has instead exhibited "a remarkable increase" from 1981 onwards. A detailed analysis of the available statistical evidence shows that Leydesdorff's claims are spurious, and serves as a caution to those attempting to use on-line bibliometric data-bases for science-policy purposes without first processing the 'raw' figures.

Francis Narin and Kimberly Stevens are at CHI Research/Computer Horizons Inc, 10 White Horse Pike, Haddon Heights, New Jersey 08035, USA; Joe Anderson is at the Ciba Foundation, 41 Portland Place, London W1N 4BN, UK; Peter Collins is at the Science and Engineering Policy Studies Unit, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, UK; and John Irvine, Phoebe Isard and Ben Martin are at the Science Policy Research Unit, University of Sussex, Falmer, Brighton BN1 9RF, UK. No order of seniority implied.

Martin, Irvine and Isard would like to express their thanks to the Economic and Social Research Council for financial support of the SPRU Programme on 'Science Policy and Research Evaluation'. Correspondence concerning the paper should be addressed to Martin at SPRU.

IN 1984, TWO OF THE AUTHORS published an article in *New Scientist*, showing quantitatively that there had been a decline in the relative international output and impact of UK scientific research over the period 1973-80.[1] The bibliometric (publication and citation) indicators employed were based on an analysis of the *Science Literature Indicators Data-Base*, which is compiled biennially for the US National Science Foundation by CHI Research.[2] The CHI data-base is, in turn, derived from the *Science Citation Index (SCI)* produced by the Institute for Scientific Information (ISI).[3]

The bibliometric statistics were later updated to 1984 and subjected to further analysis in several articles.[4,5,6] The overall conclusion was that the relative decline of British science continued over the first four years of the 1980s, although at a slower rate than in the previous decade. While Britain's world-share of publications in all scientific and engineering fields fell from 9.2% in 1976 to 8.3% in 1980, it then declined only to 8.1% in 1984.[7]

It was in 1985 that Dr Loet Leydesdorff first suggested that a simple on-line search of the *Science Citation Index* yielded very different figures on the UK's percentage share of the world total for scientific publications, as can be seen from Table 1. His conclusion was that "British scientific output was relatively stable over the latter half of the 1970s (about 8.3% of the world total), then showed *a remarkable increase* . . . from 1981 onwards" [emphasis added].[8] These findings were described in a short article submitted for publication in the leading British scientific journal, *Nature*.

Shortly afterwards, a response was prepared by CHI Research explaining why the 'raw' statistics from an on-line search of the ISI data-base do not provide reliable indicators of national scientific output. This outlined the extensive range of complex tasks involved in processing the data before they can be used in this way in the statistical series prepared for the National Science Foundation.[9] As a result,

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Table 1. UK publications as a percentage of total world publications — comparison of CHI data with Leydesdorff's on-line statistics

	CHI[a]		Leydesdorff[b]
	1973 journal-set	1981 journal-set	
1974	9.25		8.17
1975	9.48		8.40
1976	9.17		8.27
1977	8.91		8.40
1978	8.57		8.26
1979	8.32		8.26
1980	8.30		8.25
1981	8.36	8.35	8.70
1982	8.27	8.30	8.69
1983	8.31	8.35	8.79
1984	8.06	8.15	8.82
1985		8.28[c]	8.82
1986		8.23[c]	9.00

Notes: [a] *Source:* CHI/NSF Science Literature Indicators Data-Base.
[b] *Source:* see note 13.
[c] Provisional figures from forthcoming update of CHI/NSF Science Literature Indicators Data-Base.

the journal decided against publishing Leydesdorff's paper.[10]

Early in 1987, however, Leydesdorff commented briefly on the discrepancies between the ISI on-line data and those of CHI in an article on the state of French science co-authored with Professor Michel Callon.[11] Later that year, in a paper analyzing the most recent CHI data, we proposed possible reasons for the differences. Besides citing the various problems caused by not processing the raw ISI data, we also suggested that the apparent upturn in Britain's publication world-share found by Leydesdorff might be partly related to the fact that papers from countries like the United States and the United Kingdom tend to enter the ISI data-base faster than those from Eastern Europe and the Third World.[12]

However, during discussions at a science-policy conference in Amsterdam in December 1987, it became clear that other factors were likely to be at play. In order to resolve the technical disagreement, it was proposed that a joint 'working party' be established, chaired by Dr C le Pair, Director of the Dutch Technology Foundation (STW). However, Leydesdorff preferred to publish his criticisms of the CHI data separately.

In his paper,[13] Leydesdorff suggests several possible reasons for the differences evident in the two sets of figures and puts the case for preferring his own approach for generating the data. For example, he argues that papers involving international collaboration between the UK and other countries should be counted once for each country rather than being divided on a fractional basis among all the authors (as is done in the CHI data-base). Most importantly he claims that the CHI data, based on a constant set of journals, are less relevant than the on-line statistics, which include all the journals added by ISI each year.

Leydesdorff has now accepted that his earlier unpublished article failed to take into account different types of 'publications' (papers, letters to the editor, etc). However, he still claims, paradoxically, that British research output increased markedly after 1981, while at the same time noting that, if one includes only articles, notes and reviews (and excludes such non-research articles as meetings abstracts, editorials and obituaries), then the apparent upward trend in the UK percentage share of the world total completely disappears.[14]

In what follows, we analyze Leydesdorff's claims about the CHI data-base. We show that the use of a constant journal-set has little or no effect on the figures obtained for Britain's world-share of publications. We then examine in detail a range of other factors, including those suggested by Leydesdorff, that might explain the differences between the two data-sets. In order to do this, we had first to replicate Leydesdorff's figures. This we have been able to do exactly for 1978 onwards (but not, as will be seen, for earlier years).

We are hence able to show that his approach is beset not only with instrinsic technical difficulties but also with simple errors. While it is not possible in all cases to estimate the exact effect of these shortcomings on the UK percentage share of world publication output, overall it is clear that Leydesdorff's claim that the British share has shown "a remarkable increase from 1981 onwards" is spurious.

Before presenting our analysis, however, one point should be stressed — the problems we identify below should *not* be seen as criticisms of ISI and the *Science Citation Index*, but rather of the method used by Leydesdorff to access the data and construct national performance indicators. The *SCI* has been and will remain an indispensable tool for quantitatively assessing scientific output and impact, whether of nations, laboratories or groups. The authors, all of whom have made extensive use of it in their past work, would therefore like to acknowledge here their considerable debt to ISI for providing this unique science-policy resource.

Changing journal coverage

One difficulty in using the *Science Citation Index* to assess trends in national scientific performance is that ISI has over time markedly increased the number of journals scanned. Since the procedures by which new journals are added are not always clear, CHI and the National Science Foundation concluded that basing bibliometric indicators on a constant set of journals, and then updating that set periodically, would result in more easily interpretable data. Then, if a particular country's percentage share of the world publication total increases, at least one knows that the growth has taken place within the constant journal-set, rather than perhaps being the consequence of wider ISI coverage of journals (in particular, those originating in that country).

This problem of discontinuities in time-trends stemming from changed journal coverage is especially pronounced for smaller countries and for data disaggregated to the subfield level. CHI has therefore opted to use a 'constant journal-set' in compiling its main bibliometric indicator series. Because the data-base runs from 1973, the original indicators are based on the '1973 journal-set' — that

Table 2. Effect on UK publication world-share of failure to exclude psychology, 1974-84

	1973 journal-set				1981 journal-set	
	1974	1978	1981	1984	1981	1984
All science and engineering excluding psychology	9.25	8.57	8.36	8.06	8.35	8.15
Psychology	6.70	10.51	10.75	8.72	10.05	8.64
All science and engineering including psychology	9.18	8.59	8.38	8.07	8.36	8.16
Effect of failure to exclude psychology	-0.07	+0.02	+0.02	+0.01	+0.01	+0.01
% change as a result of failure to exclude psychology	-0.8%	+0.2%	+0.2%	+0.1%	+0.1%	+0.1%

Source: CHI/NSF Science Literature Indicators Data-Base.

is, the 2000 or so journals scanned by ISI in that year. From the outset, however, it was intended to update the journal-set periodically, and, since 1981, CHI has compiled an alternative data-series based on the approximately 3000 journals scanned by ISI in that year.

According to Leydesdorff, perhaps the major reason why the CHI data fail to reveal an upturn in Britain's percentage share of publications during the 1980s is that they ignore new journals where Britain may have a stronger presence. To examine this hypothesis, let us consider the figures for 1981. The CHI 1973 journal-set yields a UK world-share of 8.36% (see Table 1). Does the fact that ISI has added 1000 new journals to the *SCI* since 1973 account for the rather different value for the UK publication world-share of 8.7% in 1981 obtained by Leydesdorff? This is easily answered using the parallel CHI data based on the 1981 journal-set.

As can be seen from Table 1, the effect of including the additional 1000 journals is negligible,[15] the decline of 0.01 to 8.35% being insignificant. It should also be noted that the figures for 1982-84 based on the two journal-sets are again very similar, the largest difference being less than 0.1%. Since fewer than 300 new journals were added by ISI between 1981 and 1986, one would expect the widening of coverage to have much less effect (less than 0.1%) than that which took place between 1973 and 1981. Hence, it is highly unlikely that the differences between the Leydesdorff and CHI figures can be attributed to this factor.

A related problem associated with the on-line search method adopted by Leydesdorff concerns the treatment of psychology. During the late 1970s, large numbers of psychology journals were moved by ISI from the *Science Citation Index* to the *Social Science Citation Index*. Consequently, if a country's world-share of psychology papers differs from its share for all other fields combined, then this narrowing of coverage will give rise to an apparent change in overall world-share.

There is little consensus as to whether or not collaborative papers should be fractionated in evaluative studies but care must be taken with the 'world total' if using 'whole-counting'

This is well illustrated by the US data: if psychology is included, the US world-share of publications for all fields combined apparently fell from 38.8% in 1974 to 36.8% in 1984.[16] However, half of this decline is due to the changing coverage of psychology. If journals in that field are wholly excluded, the US share only drops from 37.7% in 1974 to 36.6% ten years later.

The effect on the equivalent UK figures is rather smaller, as can be seen from Table 2. Nevertheless, given this problem, from the point of view of analytical rigour, psychology should clearly be excluded from bibliometric analyses of national scientific performance. Such an exclusion is not possible with the on-line method.

Fractional vs whole-counting

There is little consensus among the scientometric research community as to whether or not collaborative papers should be fractionated in evaluative studies. Indeed, while preferring fractionation, we have ourselves employed both approaches in previous studies. Leydesdorff has put the case for 'whole-counting' (although the on-line approach gives him no choice). There are, however, equally convincing arguments for fractionation.[17] If one does not fractionate, then care must be taken when calculating each country's percentage world-share to employ the correct divisor (that is, the 'world total' corrected to allow for the double-counting of each international collaborative paper) and hence ensure that national percentage shares still sum to 100%.[18]

To illustrate this point, consider the figures in Table 3. The left-hand columns show data on national percentage shares of the world publication total (based on the 1981 journal-set) for leading scientific countries after fractionating all papers involving international collaboration. The middle columns, in contrast, contain the corresponding figures after 'whole-counting' but using the same world total (without allowing for the double-counting thus introduced) to calculate national 'percentage' shares.

Consequently, one finds that the UK 'percentage' share for 1984 is raised from 8.15 to 8.90 (compared with Leydesdorff's figure of 8.82 for that year). However, every other country's 'percentage' share is

Table 3. Effect on national publication shares of using uncorrected divisor when 'whole-counting', 1981-84.

	Fractional counting[a]			Whole-counting with uncorrected divisor[b]			Apparent change as result of uncorrected divisor	% change as result of using uncorrected divisor[c]
	1981	1984	Change 1981-84 (A)	1981	1984	Change 1981-84 (B)	(B-A)	
US	35.85	35.44	-0.41	37.21	37.12	-0.09	+0.32	+0.9%
UK	8.35	8.15	-0.20	8.99	8.90	-0.09	+0.11	+1.3%
USSR	8.02	7.94	-0.08	8.14	8.07	-0.07	+0.01	+0.1%
Japan	6.80	7.30	+0.50	6.98	7.56	+0.58	+0.08	+1.2%
FRG	6.29	5.95	-0.34	6.81	6.58	-0.23	+0.11	+1.7%
France	5.03	4.84	-0.19	5.46	5.38	-0.08	+0.11	+2.2%
Canada	3.92	4.22	+0.30	4.30	4.68	+0.38	+0.08	+2.0%
Rest of world	25.74	26.16	+0.42	28.05	29.02	+0.97	+0.55	+2.1%
World total	100.00	100.00	0.00	105.94	107.31	+1.37	+1.37	+1.4%

Notes: [a] *Source:* CHI/NSF Science Literature Indicators Data-base, 1981 journal-set.
[b] *Source:* CHI.
[c] *(B-A)* expressed as a percentage of the 1981 world-share (fractional counting).

also raised appreciably, the US for example increasing from 35.44 to 37.12%, Germany from 5.95 to 6.58%, and so on. As a result, when the 'percentage' shares for all countries are then added up, one finds that they come to 107.31% rather than the slightly more conventional figure of 100%.

It is also important to note that, since international collaboration has been growing over time (more than doubling between 1973 and 1984), the gap between the fractionated and the whole-counted 'percentage' shares has likewise been increasing. In other words, an apparent increase in world publication share is superimposed on any real trends in the shares of different countries, as can be seen from the final column of Table 3. (For example, the effect of using the uncorrected divisor is to reduce the decline in the US share between 1981 and 1984 from 0.41 to 0.09, and to increase the growth in the share for the 'rest of the world' from 0.42 to 0.97.)

This is one of the main reasons why Leydesdorff's statistics suggest that the UK's publication world-share has been increasing during the 1980s. The problem with the on-line approach is that it is extremely difficult to fractionate collaborative papers. Yet if one uses 'whole counts' of such papers, it is then almost impossible to derive on-line the appropriate world total to use as the divisor in calculating national percentage shares. (One would need to search for all possible country combinations — pairs, triplets, quadruplets, and so on — for all 180 or so countries, and for all 50 states of the US, and for all the variants in country names mentioned below.)

What effect does the use of an uncorrected divisor have on Leydesdorff's statistics for the UK? The figures in the final column of Table 4 (derived from a special analysis of multi-national papers undertaken by CHI) show that, if one 'whole-counts' collaborative papers and then employs the correct divisor, this reduces the UK percentage share in 1984 from 8.90 to 8.29 — in other words, Leydesdorff's figure is 7.4% too high.

The corresponding figures for other years are shown in the bottom row of the table. The table also shows that, whether one 'fractionates' or 'whole-counts' collaborative papers, one obtains broadly the same trends over time, provided the correct divisor is employed. For example, the decrease between 1981 and 1984 is identical for the two approaches.

Another technical problem stemming from not fractionating is specific to the UK. In the 'Corporate Index' section of the *Science Citation Index*, British papers are listed separately under England, Scotland, Wales and North *(sic)* Ireland, rather than together under the United Kingdom. With Leydesdorff's procedure, one therefore has to search on-line under all four home countries and add up the totals.

The result is that Leydesdorff has inadvertently double-counted all papers involving a collaboration between two of the home countries (and triple-counted papers where authors in three of the

Table 4. Effect on UK world-share of using Leydesdorff's divisor, 1974-84

	1973 journal-set				1981 journal-set	
	1974	1978	1981	1984	1981	1984
Fractional counting[a]	9.25	8.57	8.36	8.06	8.35	8.15
Whole counting:[b]						
Correct divisor[c]	9.35	8.69	8.50	8.21	8.49	8.29
Uncorrected divisor	9.69	9.12	9.03	8.83	8.99	8.90
Difference as result of using uncorrected divisor	0.34	0.43	0.52	0.62	0.50	0.61
% change as result of using uncorrected divisor[d]	+3.6%	+4.9%	+6.1%	+7.6%	+5.9%	+7.4%

Notes: [a] *Source:* CHI/NSF Science Literature Indicators Data-Base (excluding psychology).
[b] *Source:* CHI.
[c] 'Correct' in the sense that the national shares for all countries add up to 100%.
[d] Expressed as a percentage of whole counting figure with correct divisor.

Table 5. Effect on UK world-share of double-counting intra-UK co-authored papers, 1974-84

	1974	1978	1981	1984
Leydesdorff's figure for UK publication total[a]	37,186[b]	46,820	51,709	56,685
UK world-share (using uncorrected divisor)[c]	8.82	8.26	8.70	8.82
No of UK papers:				
double-counted *(A)*	578	823	932	1,134
triple-counted *(B)*	4	8	17	25
quadruple-counted *(C)*	0	0	1	0
Total double-counting in Leydesdorff *(A+2B+3C)*	586	839	969	1,184
UK world-share after subtracting double-counting	8.68	8.12	8.54	8.63
% change in UK world-share as result of double-counting[d]	+1.6%	+1.7%	+1.9%	+2.2%

Notes:
[a] *Source:* see note 8.
[b] Figure obtained in 1988 from Dialog using Leydesdorff's procedures. However, he obtained a figure of 34,450 in 1985 (see Table 8).
[c] See Table 7, colume 2 for uncorrected world total.
[d] Expressed as a percentage of the UK world-share after subtracting double-counting (penultimate row).

countries are involved). The effect is to inflate the UK world-share by between one and a half and two per cent, as can be seen from the final row of the figures in Table 5.

The logic for double-counting papers involving collaboration between, say, England and Wales, but not those involving collaboration between, for example, two Länder in the Federal Republic of Germany, is not obvious. However, it could conceivably have a certain appeal: by the simple expedient of decreeing that next year all authors in England should have, say, a Welsh collaborator, and all Scottish ones a Northern Irish co-author (and so on), the UK 'world-share' — as measured by Leydesdorff — could be almost doubled to 15% or 16%. This could be achieved without the government having to increase its funding of basic research, and indeed without there being any change in the actual number of papers produced!

How much to include

The *Science Citation Index* provides bibliographic information on several different types of publications — articles, notes (including research letters), review articles, meetings abstracts, editorials, letters to the editor and miscellaneous minor categories such as awards and obituaries. In constructing indicators of national scientific output, which of these should be included? In the CHI data-base, only articles, notes and reviews (ANR) are incorporated, while Leydesdorff's claim of "a remarkable increase" in the UK publication share is based on an analysis of all types of papers. Let us examine the arguments for including or excluding each category.

There is little doubt about the status of 'articles' since these are the basic means of communicating new scientific knowledge. CHI also includes 'notes' because shorter publications in many important journals (such as *Physical Review Letters*) are classified by ISI as 'notes', and these are again a key part of the scientific literature.

The question of whether or not to include 'review articles' was considered by CHI and NSF at some length. The argument against inclusion is that a review does not generally constitute an original piece of research but rather a synthesis of work by others. It is not, therefore, so much an indication of research output as of scholarship. The counter-argument is that scholarship is a form of research.

Moreover, review authors tend to be regarded as authorities in their field, so this does provide information on the relative scientific standing of different countries. In the end, it was decided to include review articles in the CHI data-base. However, since they represent only one to two percent of the total papers covered in the *SCI* each year, this decision has little effect on national publication shares.

'Meetings abstracts', in contrast, account for 18-20% of the *SCI*-covered material. However, they are not included in the CHI data-base for two reasons. The first is to avoid double-counting — many scientific results initially presented at meetings are subsequently published as journal articles. Second, since the review procedure for such contributions is either much less rigorous than that for journal articles or non-existent, their quality is likely to be less uniform.

'Editorials', 'letters to the editor' and the remaining categories of articles in the *SCI* are likewise excluded from the CHI data-base on the grounds that they do not normally report substantive

Table 6. UK world-shares for different categories of publications[a] and effect of failure to exclude non-research articles (NRA), 1981-84

	1981	1984
Articles (A)	8.4	8.2
Notes (N)	7.2	7.1
Reviews (R)	12.1	10.2
ANR subtotal	8.4	8.2
Meetings abstracts	8.0	8.7
Editorials	15.7	19.1
Letters to editor	21.5	21.8
Other	12.2	21.4
NRA subtotal	10.8	11.9
Total (ANR and NRA)	9.0	9.1
Effect of failure to exclude NRA	+0.6	+0.9
% change in UK world-share as result of failure to exclude NRA[b]	+6.8%	+11.1%

Notes:
[a] *Source:* CHI 1981 journal-set. Papers including international collaboration have been fractionated. (Percentage shares have been rounded to the nearest 0.1%.)
[b] Calculated using unrounded figures and expressed as a percentage of the ANR subtotal.

The decision as to which categories of papers should be included may have an appreciable effect on the resulting indicators of national scientific output

research contributions. (Henceforth, the term 'non-research articles' is used as a shorthand for all publication categories excluded by CHI.)

Table 6 shows that the decision as to which categories of papers should be included may have an appreciable effect on the resulting indicators of national scientific output. Since British authors tend to write proportionately more editorials, letters to the editor, obituaries and so on, inclusion of such non-research articles (NRA) raises the UK percentage world-share in 1981 from 8.4 (see the ANR subtotal for articles, notes and reviews) to 9.0.

For this reason, we would argue that Leydesdorff's overall 1981 figure for the UK is 7% too high, while the 1984 figure is inflated by 11%. Consequently, while the ANR figures indicate a decline in the UK share over this three-year period, a small increase is actually evident for all categories of publications combined. Leydesdorff is now aware of this problem, yet he continues in the abstract to his paper to refer only to the "remarkable increase" apparent in the global publication counts (that is, including non-research articles).

A related difficulty associated with Leydesdorff's procedure stems from the fact that the on-line version of the *SCI* data-base contains rather more publications than the final printed version. Table 7 shows the two sets of respective world totals and the percentage differences. According to ISI, the main reason for the difference is that several hundred other journals scanned in *Current Contents* (aside from those in the *Science Citation Index*) are included in the on-line version.

However, this raises the question of why the difference between the two totals fluctuates so much from year to year, falling from 26.7% in 1976 to 4.8% in 1979 and rising again to 12.9% in 1984. Part of the problem apparently results from unknown statistical artefacts associated with the Dialog file-loading procedure (discussed below). Given the uncertainty as to exactly what additional papers are included in the on-line version and why their numbers fluctuate so arbitrarily, it would seem unwise to use such an approach in attempting to construct indicators of national scientific output.

Table 7. Comparison of total source items in the *Science Citation Index (SCI)* and on-line version of the data-base

	SCI[a]	On-line version[b]	Percentage difference
1974	400,971	421,816	5.2
1975	418,903	458,792	9.5
1976	450,956	571,550	26.7
1977	494,861	553,140	11.8
1978	500,702	566,583	13.2
1979	517,557	542,299	4.8
1980	519,073	619,026	19.3
1981	538,261	594,154	10.4
1982	548,375	611,260	11.5
1983	566,671	610,350	7.7
1984	569,277	642,781	12.9

Notes: [a] *Source: Science Citation Index* (1986, pages 28-29).
[b] *Source: Scisearch* accessed through Dialog. Difference in accession numbers between the beginning and end of year.

Other problems

Country name error

In a certain proportion of papers in the *SCI* the country name may be omitted, misspelt or abbreviated. Leydesdorff identifies some (but by no means all) of the variants for 'England'. However, he ignores those British papers which list the county (Yorkshire, for instance) in place of the country. While it is impossible to pick up all such variants in an on-line search, these defects are rectified during the regular consolidating and processing of the ISI data undertaken by CHI.

We have not quantified the effect brought about by ignoring all papers with omitted, misspelt or abbreviated country names, but preliminary analysis suggests it was greater in former years. Consequently, Leydesdorff fails to pick up larger numbers of UK papers during the mid-1970s than in the 1980s. Again, this may have the effect of superimposing a small apparent upward trend on any real change in the UK world-share.

File-loading with Dialog

Leydesdorff obtained his publication statistics by accessing the *SCI* through Dialog. While we have been able to replicate exactly his statistics for 1978 onwards, we obtain completely different (and consistently higher) figures for the earlier years, as can be seen from Table 8. In this respect, Leydesdorff's note 13[19] is misleading in that it seems to imply that one can no longer obtain figures on the UK publication share between 1974 and 1977. One can. The problem is rather that the figures currently produced differ appreciably from those

Table 8. Effect on UK world-share for 1974 of file-loading problems

	Leydesdorff[a,c] run in 1985	SPRU[b,c] run in 1988
England	27,222	29,457
Scotland	3,774	4,063
Wales	2,959	3,116
Northern Ireland	495	550
UK total	34,450	37,186
UK world-share	8.17%	8.81%
% difference between 1985 and 1988 figures[d]	-7.4%	-

Notes: [a] *Source:* see note 8.
[b] *Source: Scisearch* accessed through Dialog.
[c] Both sets of figures include the effect of double-counting within the UK (see Table 5).
[d] Expressed as a percentage of the SPRU 1988 figure.

Leydesdorff reported in 1985,[20] the changes apparently having occurred in 1987 when Dialog reloaded the *SCI* file for 1974-77.

This raises the question, "Which set of statistics should we believe — the 1985 version or those currently obtained?" If we assume the current figures are incorrect, this then raises the even more awkward question of why we should believe the current on-line figures for other years (from 1978 onwards).[21]

If, on the other hand, the figures obtained in 1985 were invalid, this has the effect of raising the 1974 UK share from Leydesdorff's figures of 8.17% to no less than 8.81%. The result is that one then obtains a downward trend in the UK during the 1970s, in line with the CHI results.

On-line searching for countries

We have concentrated above on the technical problems involved in trying to use on-line searching to derive figures for the UK. However, further difficulties arise when one examines the publication output of other countries. For example, in 1974 most West German papers were listed under 'West Germany', but some also appeared under the 'Federal Republic of Germany'; by the 1980s, however, the situation had been reversed. One must therefore search under both these headings (taking care to avoid any double-counting!), as well as checking under 'Germany' (where there is no reference to either East or West) and 'Berlin'. Similarly, the majority of Dutch papers were originally listed under 'Holland', while most now appear under 'the Netherlands'.

The case of the United States is rather more complex because of the way its publications are listed in the *SCI Corporate Index* (they appear under individual states rather than the United States as a whole). In order to obtain an on-line figure for the US world-share, it would be necessary to search for all 50 states (and all variants in the abbreviations of state names), and avoid double-counting of papers written by authors from two or more states.

Similarly, in the case of the Soviet Union, it would be necessary to search under the individual republics as well as the USSR. Nor should it be assumed that the above list of potential difficulties is exhaustive — different problems are likely to arise in relation to other countries. In short, one must use great caution when searching the on-line data-base for all the papers from a given country.

Country names in corporate addresses

When the user asks Dialog to identify all the papers from a given country, it searches for the appearance of a given keyword, for example, 'England', anywhere in the corporate address (not just under the 'country' line of the address). Leydesdorff has failed to recognize that this gives rise to a particular problem in the case of England and Wales. Searching under 'England' in 1984 yields around 1000 papers where 'New England' appears in the corporate address (for example, 'New England Medical Center') and which have no connection whatsoever with the United Kingdom.[22]

Similarly, a search using the keyword 'Wales' succeeds in locating 800 articles for 1984 from New South Wales, thereby increasing the apparent Welsh total by 40%. Indeed, Leydesdorff's 1974 and 1978 Welsh totals are more than doubled by the inclusion of these Australian papers.

The figures in Table 9 show that the combined effect of these two mistakes is to add between 3 and 8% to Leydesdorff's total for the 'UK' world-share. Whether there might be similar problems for Scotland or indeed other countries has not been investigated here, but clearly this possibility cannot be ruled out when searching Dialog on-line.

Table 9. Effect on UK publication world-share of including New England and New South Wales papers, 1974-84

Keyword(s) used in searching corporate address	1974	1978	1981	1984
'England'	29,457	36,673	42,235	46,035
'Scotland'	4,063	4,886	6,010	6,734
'Wales'	3,116	4,535	2,692[c]	2,846
'North Ireland'	550	726	772	1,070
Leydesdorff's[a] 'UK total'	37,186[b]	46,820	51,709	56,685
Leydesorffs's[a] 'UK world-share'	8.82	8.26	8.70	8.82
'England' but not 'New England'	28,973	35,951	41,479	45,015
'Wales' but not 'New S. Wales'	1,264	1,724	1,775	2,017
Corrected UK total	34,850	43,287	50,036	54,836
Corrected UK world-share[d]	8.26	7.64	8.42	8.53
% change from including New England and New South Wales[e]	+6.8%	+8.1%	+3.3%	+3.4%

Notes:
[a] Figures from on-line search which match those of Leydesdorff (see note 8).
[b] Figures obtained using Dialog to access Scisearch in 1988 (see Table 8).
[c] By 1981, the abbreviation 'NSW' was normally used in the corporate addresses of papers from that Australian state, whereas before then 'New S Wales' was more common. Searching with the keyword 'Wales' therefore picks up far more Australian papers before 1981. This accounts for the large apparent drop in Leydesdorff's figures for 'Wales' between 1978 and 1981.
[d] Accession numbers (see Table 7) as world total.
[e] Expressed as a percentage of the corrected UK world-share.

On-line searching is cheap, but economy is achieved at the expense of completely ignoring all the difficulties

Conclusions

In his paper, Leydesdorff advocates the use of an on-line search procedure in constructing indicators of national scientific output. What, then, are the advantages of this approach over the use of the CHI/NSF *Science Literature Indicators Data-Base*? Two are claimed to be especially important:

- On-line searching yields statistics based on all journals included in the *SCI* rather than a fixed journal-set. However, as we have demonstrated, this makes an almost negligible difference in the case of the overall UK world-share of science and engineering publications.
- Leydesdorff's method is undoubtedly cheap — he mentions a figure of "under $100" in an earlier version of his paper.[23] However, such economy is achieved only at the expense of completely ignoring all the difficulties with the on-line statistics analyzed above.

What about the disadvantages of Leydesdorff's approach and the specific problems associated with his statistics for the UK? Here, the list is longer:

- By including all journals in the on-line data-base — and hence failing to exclude psychology — Leydesdorff's statistics on national publication shares may be subject to spurious time-trends.
- It is extremely difficult to fractionate papers involving international collaboration. Yet if one 'whole-counts', one cannot then obtain the correct divisor to use in calculating national percentage shares of world publications.
- Leydesdorff double-counts publications co-authored by researchers in the four home countries of the United Kingdom.
- The effect of including non-research articles is to raise substantially the UK world-share.
- There is considerable uncertainty over the nature of the non-*SCI* publications included in the on-line data-base and the reason their numbers have been subject to such large fluctuations over time.
- Leydesdorff's method fails to take into account articles where country names are misspelt, abbreviated or omitted.
- On separate occasions, a search of the on-line data-base has yielded entirely different figures for the UK's publication share in 1974-77.
- Leydesdorff's method cannot realistically be used to analyze the world's leading scientific country because US papers are listed separately under individual states.
- Leydesdorff accidentally includes New England and New South Wales as part of the United Kingdom.
- Finally, one should remember that, unlike the approach used by CHI, the on-line search method permits no breakdown by field nor any analysis of citation impact. Yet both are an invaluable element in any systematic assessment of national scientific performance.

For the first nine of these reasons, we would conclude that on-line bibliometric statistics of national scientific output must be treated with extreme caution. Furthermore, we would argue that the differences between Leydesdorff's statistics and the indicators derived from the CHI data-base can be explained almost entirely in terms of the various problems with the on-line approach.

As Table 10 shows, most of these problems raise Leydesdorff's figures in relation to those of CHI. In addition, although not all the problems have been analyzed quantitatively, one can see that the magnitude of their combined effects has probably been increasing over time, giving rise to the apparent growth in UK output detected by Leydesdorff.

On the positive side, Leydesdorff's paper can be seen as providing an excellent example — and a timely caution — of the dangers involved in the over-simplistic use of science indicators and on-line searches. Certainly, we are grateful to him for spurring us on to look more closely for possible difficulties with the indicators that we have employed. As a result, we are now, if anything, more confident that our earlier findings from the CHI data-base about the relative international standing of British science still hold.

Table 10. Summary of problems with Leydesdorff's statistics and their effect on UK publication world-share, 1974-84[a]

	1974[b]	1978[b]	1981[c]	1984[c]
Failing to exclude psychology	-0.8%	+0.2%	+0.1%	+0.1%
Using uncorrected divisor when 'whole-counting'	+3.6%	+4.9%	+5.9%	+7.4%
Double-counting within UK	+1.6%	+1.7%	+1.9%	+2.2%
Including non-research articles	?	?	6.8%	11.1%
Inclusion of additional on-line source items	?	?	?	?
Excluding papers where country name misspelt or abbreviated	?	?	?	?
File-loading problems	-7.4%	-	-	-
Including New England and New South Wales papers	+6.8%	+8.1%	+3.3%	+3.4%

Notes:
[a] The figures are taken from the bottom rows of earlier tables. Plus signs indicate that Leydesdorff's statistics are too high and minus signs that they are too low.
[b] In comparison with CHI data based on 1973 journal-set.
[c] In comparison with CHI data based on 1981 journal-set.

Notes and references

1. B R Martin, J Irvine and R Turner, "The writing on the wall for British science", *New Scientist,* vol 104, pages 25-29.
2. See, for example, National Science Board, *Science Indicators: The 1985 Report* (Washington DC, US Government Printing Office, 1985, Chapter 1).
3. Institute for Scientific Information, *Science Citation Index* (Philadelphia, ISI, published annually).
4. J Irvine, B R Martin, T Peacock and R Turner, "Charting the decline in British science", *Nature,* vol 316, 1985, pages 587-90.
5. D C Smith, P M D Collins, D M Hicks and S Wyatt, "National performance in basic research", *Nature,* vol 323, 1986, pages 681-84.
6. B R Martin, J Irvine, F Narin and C Sterritt, "The continuing decline of British science", *Nature,* vol 330, 1987, pages 123-26.
7. J Irvine and B R Martin, "International comparisons of scientific performance revisited", paper presented at the Workshop on The Relations between Qualitative Theory and Scientometric Methods in Science and Technology Studies, Amsterdam, 10-11 December 1987, Table 1.
8. L Leydesdorff, "Increases in British and Dutch scientific performance", draft paper submitted to *Nature,* September 1985, page 1.
9. F Narin, letter to the editor of *Nature* responding to Leydesdorff's draft paper, October 1985.
10. Taken together with the fact that a revised version of the paper was subsequently turned down by another British journal, this led to a mistaken view in parts of the science studies community that there was a 'conspiracy' to prevent publication of Leydesdorff's statistics. This, it was argued, was because British science has much to gain in the present economic climate from evidence documenting a decline in international performance. Given the widespread circulation of this rumour, we welcome the opportunity of responding publicly to Leydesdorff's paper, and pointing to some of the technical problems that led to its earlier rejection.
11. M Callon and L Leydesdorff, "La recherche française - est-elle en bonne santé", *La Recherche,* number 86, March 1987, pages 412-19.
12. Irvine and Martin, see note 7. We have been unable to establish the effect of the difference between 'tape year' data (CHI) and 'accession year' data (on-line database), but according to Leydesdorff it is insignificant (personal communication, 2 December 1987).
13. L Leydesdorff, "Problems with the 'measurement' of national scientific performance", *Science and Public Policy,* 15(3), 1988, pages 149-152.
14. Leydesdorff, see note 13, Figure 3, page 152.
15. This is not necessarily the case in respect of smaller countries, nor when one is concerned with highly disaggregated subfield data. However, for major scientific nations and for all fields combined, changes in the journal-set employed make relatively little difference to world publication shares — see Irvine and Martin, note 7.
16. Figures are based on an analysis of the CHI/NSF Science Literature Indicators Data-Base.
17. See D Lindsey, "Production and citation measures in the sociology of science: the problem of multiple authorship", *Social Studies of Science,* vol 10, 1980, pages 145-162.
18. When fractionation is employed, the world total is the number of actual papers, and appropriate fractions are allocated to the totals for each participating country. If whole-counting is used, one whole paper is added to the total for each country participating in a collaborative paper. However, the world total then needs to be adjusted correspondingly upwards so that national percentage shares still sum to 100%. In the on-line searching undertaken by Leydesdorff, countries participating in collaborative papers are counted in full, but the world total is not corrected (ie the same total as in fractional counting is used). Consequently, it would be theoretically possible for the Leydesdorff approach to find a simultaneous increase in the 'percentage' world-shares of all the major industrial countries as a result of the growth in international co-authorship. Such a statistical artefact shows the problem of using an uncorrected divisor when measuring trends in national publication shares.
19. Leydesdorff, see note 13, page 152.
20. Leydesdorff, see note 8, Table 1.
21. Whether 'dummy' accession numbers in the Dialog *SCI* files are the cause of this problem is not clear — although there are large numbers of such dummy numbers from 1986 onwards, there appear to be relatively few in 1984 or earlier years. Further research on this problem is necessary before the Dialog installed version of the *SCI* can be used for science-policy purposes.
22. There are only a dozen or so papers involving collaboration between authors in England and New England.
23. Leydesdorff, see note 8.

Science and Public Policy, volume 15, number 4, August 1988, page 270, Beech Tree Publishing, 10 Watford Close, Guildford, Surrey GU1 2EP, England.

Indicators

Performance figures for British science

Loet Leydesdorff replies to his critics

IN THE APRIL ISSUE of this journal, Anderson *et al* discussed the use of the *CHI/NSF Science Literature Indicators Data-Base* to measure national performance in science, and, in particular, "the decline of British science".[1] They reacted extensively to my use of this database, and to my conclusion (that these indicators show no general decline).[2]

I accept most of their points on the measurement techniques of using 'on-line' databases for this purpose. My critics have drawn up an impressive list of potential sources of error in the use of on-line methods. They have indicated how various corrections affect my figures for the UK.

There are, however, two points on which I still question Anderson *et al.* One concerns the handling of international co-authorship, and the other, their use of a fixed rather than a dynamic journal set. Let me start with co-authorship.

My critics argue that my method of attributing internationally co-authored papers to different countries is defective, because it can lead to a world total of over 100%. They advocate a "corrected divisor". Take this hypothetical example.

Pretend there are 100,000 papers worldwide. Pretend that authors from country A have authored 6,000 on their own (ie no international co-authorship); and authors from country B are similarly solely responsible for a further 6,000. Let us now assume there to be 1,000 other papers, all jointly co-authored by people from A with authors from B.

My method is to attribute a total of 7,000 papers to A, and 7,000 to B, and thus to give each country a world-share of 7%. Anderson *et al* say that, if I am to include this 1,000 twice, then I should increase my divisor by 1,000. Thus each country's world-share (they would say) should be 7,000 out of 101,000, which is 6.93%.

They rightly point out that my method gives a higher percentage figure than would theirs. If authors from A write 25,000 published papers, but every one has an author from another country, I would give A a world-share of 25,000 out of 100,000 (ie 25%); Anderson *et al* using the corrected divisor would give it 25,000 out of 125,000 (ie 20%) or, using fractional counting, 12,500 out of 100,000 (12.5%).Perhaps a drawback to my method is that, were we to find another country whose authors also wrote 25,000 papers but did so with no help from abroad, I would give them the same 25% world-share, whereas it is arguable that their achievement is the greater.

A drawback of Anderson *et al*'s divisor is that it hits this latest, hard-working country too. Simply because *other* countries are co-authoring, Anderson *et al* would give it only 20% of the world share; thus 25,000 papers out of a world total of 100,000 comes out as 20%. I do not find this to be satisfactory. [Publisher's note: Anderson *et al* accept this point - adding that this is why they generally prefer to avoid this approach altogether, and to opt for 'fractionating'.]

The aggregation problem

Here the problem of the fixed journal set of *CHI* as against the dynamic journal set of ISI's *Science Citation Index* is addressed. My main concern relates to what types of paper to include, selected from which journals. Anderson *et al* exclude such items as editorials, obituaries, etc. I feel the theoretical grounds for excluding them are not well-founded (while Anderson *et al* seem to have similar qualms about including them). I also have reservations over the relatively fixed set of journals they include; if British authors are tending to favour newer journals, Anderson *et al* will miss this. This is a significant problem.

Changing the types of papers to be included, and the list of journals to be covered in the database, changes the conclusions to be derived. They have one set of criteria, and one set of conclusions; I have another set. Using the fixed journal set, Anderson *et al* find the well known decline of British science, but using the dynamic journal set, I find an increase in the UK world share.

Publisher's note: This is a highly edited version of Loet Leydesdorff's reply to Anderson et al. *Anyone wishing to see the full text is invited to write to Dr Leydesdorff at the address at the foot of this page.*

Loet Leydesdorff is in the Department of Science Dynamics, University of Amsterdam, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands.

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1. J Anderson, P M D Collins, J Irvine, P A Isard, B R Martin, F Narin, and K Stevens, "On-line approaches to measuring national scientific output — a cautionary tale", *Science and Public Policy*, 15(3), June 1988, pages 153-161.
2. L Leydesdorff, "Problems with the "measurement" of national scientific performance", *Science and Public Policy*, 15(3), June 1988, pages 149-152.

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