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National characteristics in international scientific co-authorship relations

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The main objective of this study is the elaboration of national characteristics in international scientific co-authorship relations. An attempt is made to find statistical evidence of symmetry and asymmetry in co-publication links, of the relation between international co-authorship and both national research profiles and citation impact. Four basic types can be distinguished in the relative specialisation of domestic and internationally co-authored publications of 50 most active countries in 1995/96 concerning the significance of the difference between the two profiles.

Co-publication maps reveal structural changes in international co-authorship links in the last decade. Besides stable links and coherent clusters, new nodes and links have also been found. Not all links between individual countries are symmetric. Specific (unidirectional) co-authorship affinity could also be detected in several countries.

As expected, international co-authorship, on an average, results in publications with higher citation rates than purely domestic papers. However, the influence of international collaboration on the national citation impact varies considerably between the countries (and within one individual country between fields). In some cases there is, however, no citation advantage for one or even for both partners.

Introduction

As already stressed in an earlier paper by *Glänzel* and *Schubert* (2001), international collaboration may reflect individual interests and motivation of individual scientists. Some of the factors influencing co-publication patterns have already been discussed in the basic papers on scientific collaboration by *deB. Beaver* and *Rosen* (1979) and *Luukkonen* et al. (1992). In his new paper, *deB. Beaver* (0000) has summarised eighteen main criteria for which authors collaborate. When one considers international collaboration, the economic and/or political dependence of a country or geopolitical region (such as the different forms and degrees of neo-colonial ties) or large or special equipment (such as CERN in Switzerland and the observatories in Spain or Chile), which are often shared in large multinational projects, also condition co-operation, apart

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from any individual motivation. And scientific collaboration between member countries of the EU promotes European integration into one of the world's most advanced systems of science and technology. On the other hand, co-publications might simply result as mandatory exercises within the framework of bilateral agreements between institutions, science administrations or governments.

It is clear that a variety of different purposes and motivations, the manifold of factors influencing (international) collaboration must have at least in part a measurable impact on the published results of joint research work. In the above-mentioned paper by *Glänzel* and *Schubert*, the relation between international co-authorship and citation impact in the field of chemistry has been studied. Proceeding from these results, which often confirmed but sometimes contradicted wide-spread notions on the efficiency of international collaboration, we have elaborated a more complex scheme to uncover national characteristics in international scientific co-authorship patterns. In this context, we will try to answer the following four questions.

- First, in how far is international collaboration reflecting the political and economical changes in the world,
- Second, has international collaboration a measurable influence on national publication strategy,
- Third, does international collaboration uniquely influence chosen publication channels, and,
- Fourth, does international collaboration in general result in higher citation rates, or are there even 'losers' in international co-authorship?

Finally, it will be shown that certain national characteristics can be found in international co-authorship patterns which, of course, may be subject to change in the course of time. Since the study is based on a large body of data, only examples can be presented in most cases to give the answers to the above questions. Except for the data on country pairs and citation distributions, all used basic indicators are, therefore, presented in a separate Appendix.

Data sources and data processing

The fundamental principles underlying the construction of basic indicators as well as the methodology of data processing have been adopted from earlier studies (e.g., *Glänzel*, 1996; REIST-2, 1997; *Glänzel* and *Schubert*, 2001). All papers recorded in the annual volumes of the *Science Citation Index* (SCI) of the Institute for Scientific Information (ISI) as Article, Letter, Note or Review were taken into consideration. The papers were assigned to countries based on the corporate address given in the by-line of

the publication. All countries indicated in the address field have thus been taken into account.

Subject classification of publications was based on the field assignment of journals (in which the publications in question appeared) according to the eight major fields of science: Clinical Medicine (MED), Biomedical Research (BRE), Biology (BIO), Chemistry (CHE), Physics (PHY), Mathematics (MAT), Engineering (ENG) and Earth and Space Sciences (ESS).

The study is based on papers published in 1995 and 1996. Citation counts have been determined on the basis of an item-by-item procedure using special identification-keys. Citations were counted in 3-year periods: in the year of publication and the two subsequent years, that is, for instance, if papers published in 1995 or 1996 were considered, all citations received by them in the period 1995-1997 or 1996-1998, respectively, have been counted. The choice of the citation window is in keeping with recent methodological considerations and practical experience (see, for instance, *Glänzel* et al., 1999). Since in several cases the obtained co-publication sets proved too small for annual co-authorship analyses the publications years and citation windows have been shifted and the corresponding publication and citation counts have been summed up. This procedure has already been applied to several recently published studies (e.g. *Glänzel*, 1996). The 50 most active countries in all fields combined in 1995/1996 have been selected for the present analysis. These countries had at least 1000 publications each in these two years.

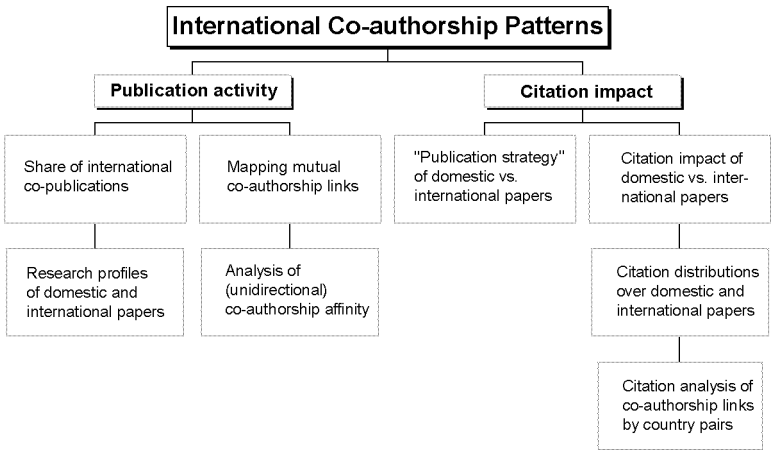
The basic indicators, that is, the publication counts in 1995 and 1996 and the observed number of citations received in a three-year window by papers published in 1995 and 1996 for the 50 selected countries can be found in Table A–D of the Appendix. In addition, the values of Mean Expected Citation Rate (MECR) for 1995 and 1996 are presented in Tables E and F.

Methods and results

In the following, the same terminology and methodology as in *Glänzel* and *Schubert* (2001) and *Glänzel* (2000) will be applied. Papers that have been published in co-operation of at least two different countries will be called internationally co-authored or briefly international papers, other papers will be called domestic papers of the country under study. The term (international) co-publication will be used as a concise synonym for (internationally) co-authored paper. In the co-authorship analyses, binary links between countries or regions were studied. A link between two countries is established,

whenever the two given countries co-occurred in the corporate address in the by-line of a publication.

In order to be able to reflect the complexity of international co-authorship patterns at the macro level the following methodological scheme has been used for the present study.



Subjects in the scheme can be studied separately or in combination with each other. Thus the "publication strategy" or the citation impact of domestic vs. international papers can, for instance, be analysed in the context of the research profiles of domestic and international papers, or, a citation analysis of co-authorship links by country pairs can be conducted in the light of the strength of bilateral co-authorship links. An example for such an approach has been given by *Glänzel* and *Schubert* (2001). In particular, strong links with a mean citation rate greater than the domestic mean observed citation rate of any of the two contributing countries were called *hot links*, and, by contrast, *cool links* are co-authorship links with a mean citation rate smaller than the corresponding domestic MOCR values. More examples for this approach will be given in the corresponding subsections below.

Publication activity

Share of international co-publications

The absolute number of international papers and their share in the total national publication output serve as basic indicators of international co-authorship relations and scientific collaboration. International collaboration depends on the country's 'size' (cf., for instance, *Schubert* and *Braun*, 1990). This result has recently been confirmed by *Katz* (2000). The analysis of the amount of international collaboration and the 'size' of the institution or country in these two papers showed underlying power law relationships. According to *Katz*'s results, some types of collaboration exhibit Metthew effect others exhibit the inverse effect. At the national level, the share of international collaboration in large countries is necessarily lower than that of medium-sized or even small countries. The share of all international papers in the world can, in principle, be determined as the complementary share of the ratio of all countries' domestic papers and the total world publication output. However, such 'world average' is not an appropriate reference standard for international collaboration activity (cf. *Schubert* and *Braun*, 1990), and will, therefore, not be used here.

Table 1 presents the national publication output and share of international papers in the national total in all fields combined for the years 1985/1986 and 1995/1996, respectively. The most active 50 countries are ranked in descending order by their share of international papers in 1995/1996.

The highest share of international publications ($\geq 45\%$) can be found in Thailand, in Economies in Transition (EIT), in Chile, in Switzerland and in the EU member countries Belgium and Portugal. The dramatic increase of the share of international co-publications in EIT countries (Hungary, Czech Republic and Poland, but also Bulgaria, Croatia, Romania, Slovenia, Slovakia) in the 90s has already been discussed by *Glänzel* (1995) and *Braun* and *Glänzel* (1996) in the context of an at least partial compensation for the negative financial effects which have hit their basic research systems before and after the economic and political changes. The situation in Portugal somewhat differs from that of the EIT group as already mentioned in earlier studies.

Table 1
Change of national publication output and share of international co-publications
(All Fields Combined, 1985/86 vs. 1995/96)

Rank	Country	1995/96		1985/86	
		Papers	Share	Papers	Share
1	Thailand	1131	64.2%	583	46.5%
2	Hungary	5213	50.3%	4670	26.5%
3	Portugal	2870	50.1%	813	37.8%
4	Czech Republic	5587	49.1%	n. a.	[18.9%][1]
5	Switzerland	20872	47.5%	13506	32.1%
6	Poland	12374	45.7%	9261	20.2%
7	Chile	2496	45.4%	1557	25.5%
8	Belgium	14695	45.0%	9009	28.1%
9	Venezuela	1137	44.9%	733	30.8%
10	Romania	2069	44.7%	1301	15.0%
11	Slovenia	1264	44.6%	n. a.	n. a.
12	Slovakia	2815	44.3%	n. a.	[18.9%][1]
13	Denmark	11809	43.3%	8387	24.2%
14	Croatia	1401	43.0%	n. a.	n. a.
15	Mexico	4960	42.6%	1997	29.9%
16	Austria	9479	42.6%	5439	23.8%
17	Brazil	9417	41.7%	3918	26.9%
18	Bulgaria	2503	40.4%	2611	20.9%
19	Ireland	3162	40.3%	1807	25.0%
20	Norway	7131	40.0%	5129	23.4%
21	Sweden	23698	39.0%	17143	21.9%
22	Greece	5556	37.5%	2629	25.4%
23	Hong Kong	4191	37.5%	1179	23.0%
24	Israel	14067	37.1%	11142	25.0%
25	Finland	10361	35.6%	6143	19.3%
26	Netherlands	29773	35.4%	18153	19.8%
27	France	73925	34.2%	47640	20.3%
28	Belarus	1653	33.6%	n. a.	n. a.
29	Germany	93683	33.3%	[58164][3]	[19.4%][3]
30	Italy	46757	33.1%	23913	21.1%
31	Argentina	5167	32.0%	3108	13.2%
32	Ukraine	6691	31.3%	n. a.	n. a.
33	New Zealand	5967	31.3%	4729	15.8%
34	Egypt	3266	31.0%	2409	21.9%
35	Yugoslavia	1326	30.8%	2387	30.1%
36	Canada	54369	30.6%	43001	18.6%
37	Spain	29538	30.0%	10409	15.1%
38	PR China	18861	28.8%	6442	23.2%
39	Singapore	2676	28.8%	760	23.7%
40	UK	110898	27.2%	86721	14.4%
41	South Africa	5448	27.0%	5893	11.8%
42	South Korea	10007	26.8%	1221	27.3%
43	Australia	30139	26.4%	21200	14.5%
44	Russia	44664	25.5%	n. a.	[3.3%][2]
45	Saudi Arabia	1797	23.7%	1173	26.5%
46	Turkey	4798	21.4%	926	25.9%
47	USA	403056	18.1%	340275	9.5%
48	Taiwan	11594	17.5%	1883	23.5%
49	India	21449	15.2%	21335	8.5%
50	Japan	108019	14.4%	67234	7.3%

[1] Czechoslovakia, [2] Soviet Union, [3] without GDR

Results presented in the *European Report on Science and Technology Indicators* (*REIST*-2, 1997) indicated the stronger presence of Portuguese scientists in the European programmes launched by the EU as one possible reason for the increase in foreign collaborations. The REIST-2 study also explained the large share in Switzerland partially as a consequence of the outstanding publication activity of CERN in particle physics (almost 10% of the publication performance of Switzerland stems from large multinational projects realised through this international research institution). However, joint research with foreign scientists in clinical medicine and biomedical research also contributed considerably to the high level of co-operation of Switzerland.

Among the Scandinavian countries, Denmark's great share of international papers of more than 40% is worth mentioning. A more detailed discussion of the co-operativity of the Nordic countries has been given by *Glänzel* (2000).

The direct comparison between the two shares (1995/96 and ten years earlier) is rather difficult, and does not lead to valid results. Instead of the shares the ratio of international and domestic papers can be used to visualise at least the extent of the changes. This measure (which takes values between zero and infinity) can be obtained from the shares of co-publication given in Table 1 by an elementary transformation. While the change of the 'world total' roughly amounts to 2.2, the ratio of international and domestic papers of Soviet Union/Russia changed by factor 10. This means a step from almost complete isolation into a co-operativity, which, by and large, corresponds to the size of this country. The values for Argentina, Poland, Czech Republic and Slovakia and Romania range between factor 3 and 4.5, followed by Hungary, South Africa and Bulgaria with values between 2.6 and 2.8. The increasing co-operativity of South Africa is certainly a consequence of the political changes in this country.

On the other hand, we have few changes in the Far East, except for Japan, Hong Kong and Thailand. In South Korea and Taiwan a clear decrease of co-operativity can be observed. There is a decrease by a factor 0.9 in Saudi Arabia, too. The stagnation in case of Yugoslavia (1.0) might be interpreted in the context of the political and economic situation in this region.

Research profiles of domestic and international papers

The next question to be answered is in how far international co-operation influences a country's publication profile and whether there are preferred research fields for scientific collaboration. The national publication profile can be expressed by the Relative Specialisation Index (RSI). This measure indicates whether a country has a relatively higher or lower share in world publications in a particular field of science than

its overall share in world total publications. RSI has been defined in REIST-2 (1997), and is closely related to the Activity Index (AI) originally introduced by *Frame* (1977). Both definition and interpretation of the Relative Specialisation Index can be found in *Glänzel* (2000), therefore, a detailed description of the two indicators and their relationship will be omitted here. RSI, which take values in the range [–1, +1], indicates a lower-than-average if RSI < 0, and reflects a higher-than-average activity in so far RSI > 0. Otherwise, if RSI = 0 the situation is completely balanced. RSI ≡ 0 for all fields corresponding to the 'world standard'. In the following, national 'publication profiles' are determined on the basis of the eight major fields of science introduced in the *Data sources and data processing* section. The graphical presentation of the 'standard case' RSI ≡ 0 for all fields is a regular octagon. Any deviation from this standard results in a more or less characteristic deformation of the regular octagon.

In earlier studies, four basic paradigmatic patterns in publication profiles could be distinguished, namely,

I. the 'western model' with clinical medicine and biomedical research as dominating fields,
II. the characteristic pattern of the former socialist countries with excessive activity in chemistry and physics,
III. the 'bio-environmental model' with biology and earth and space sciences in the main focus,
IV. the 'Japanese model' with engineering and chemistry being predominant.

In the analysis of the deviation of the relative specialisation of international publications from domestic ones, the following four cases occurred.

1. No significant deviation between the two profiles in the country;
2. Increase of national characteristics through international co-publications;
3. Weakened national characteristics in international papers;
4. Deviation, which cannot be classified in any other category.

Of course, the borderlines between the four types (I – IV), on one hand, and these four cases (1 – 4), on the other hand, are fuzzy. Nevertheless, the following twelve examples may visualise changes (or the absence of changes, respectively) which sometimes contradict widely held views.

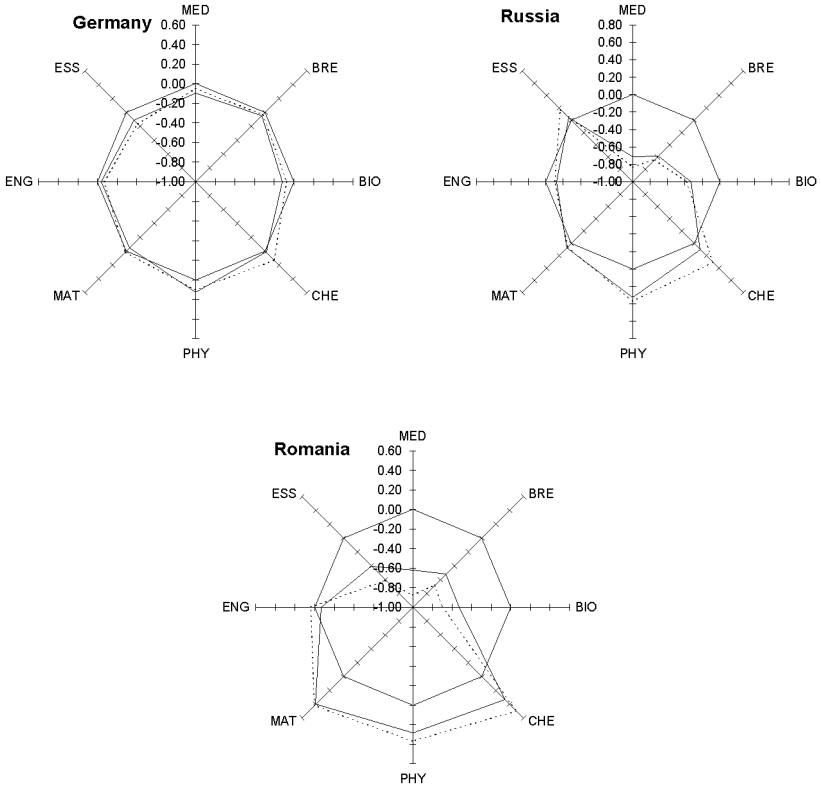


Figure 1. Relative specialisation based on eight major science fields (Case 1) (thin line: world average, dotted line: domestic papers, solid line: international papers)

Figures 1 through 4 show three examples each for the above-mentioned four cases. Figure 1 presents the relative specialisation of domestic and international publications in Germany, Russia and Romania. The profiles in Figure 1 correspond to case 1, that is, the profiles of international publications largely correspond to those of domestic ones. One would expect that first of all big advanced countries would fall into this category.

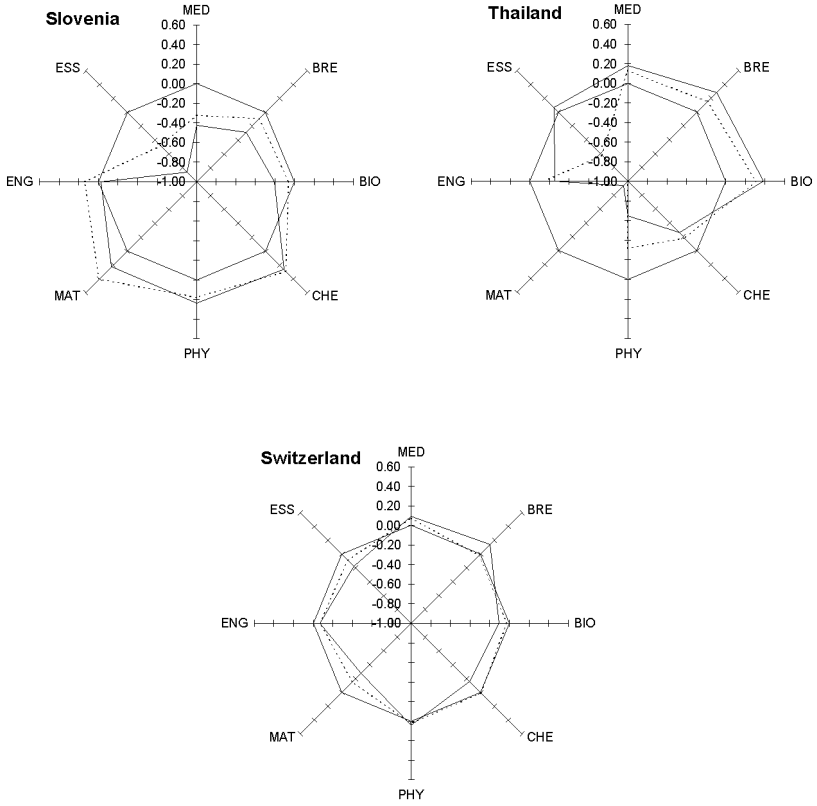


Figure 2. Relative specialisation based on eight major science fields (Case 2) (thin line: world average, dotted line: domestic papers, solid line: international papers)

Here, we have found some counterexamples. Germany slightly deviates from the western model (I) in favour of physics and chemistry. Russia and Romania still represent the pattern of the former socialist countries (II) and little has changed if it comes to international scientific collaboration. At least, the basic type has not really changed.

A certain change of national characteristics through international co-publications is characteristic for the second group (cf. Figure 2). The irregular octagons of the domestic profiles of Slovenia and Thailand become even more degenerate for international

papers. The changes in mathematics and earth and space sciences, however, cannot be considered really significant since the number of domestic publications in these fields is almost negligible. A quite interesting observation is that the medium-sized but highly-developed country, Switzerland, also falls into category 2. The domestic profile already shows the typical pattern of the western model, however, with an almost regular octagon. The pattern of the western model becomes even more evident for the international profile.

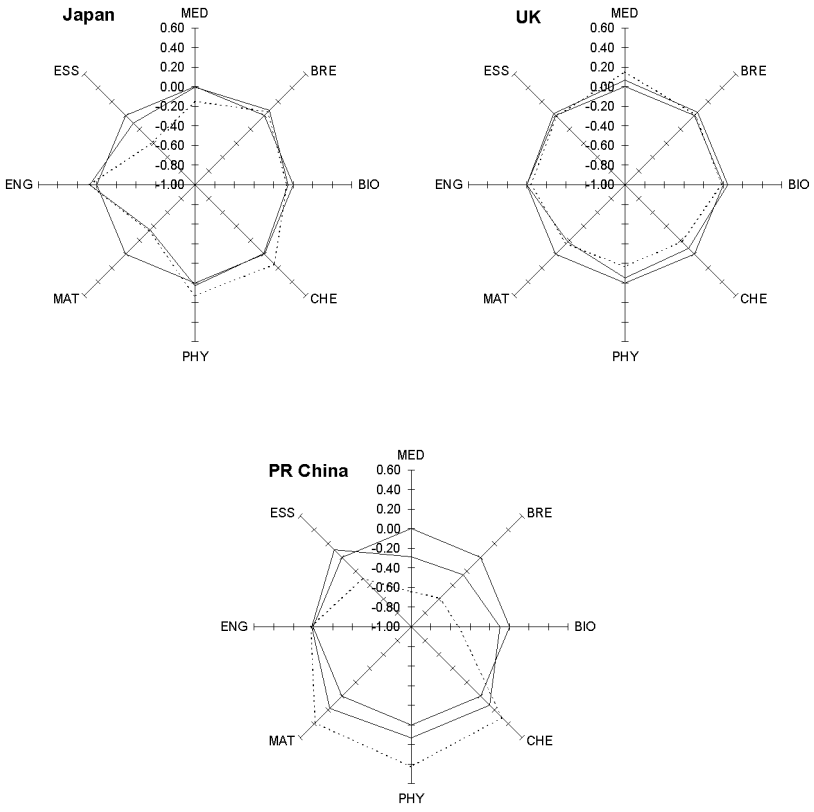


Figure 3. Relative specialisation based on eight major science fields (Case 3) (thin line: world average, dotted line: domestic papers, solid line: international papers)

Figure 3 shows the opposite case. The irregular octagons of the domestic profiles of Japan and China are less degenerate for international papers. The international profile of the otherwise Type IV country Japan corresponds almost to the standard type, with mathematics as the only noticeable exception. China's international profile is still of Type II, but the octagon is much less irregular than that of the domestic profile. Finally, the domestic profile of the UK is typical of the western model, but deviates from the standard type in favour of the life sciences. The international profile here is closer to the standard pattern.

Figure 4 shows examples for those patterns which do not fall in any other category. The octagons representing the domestic profiles are irregular for all three countries Chile, Morocco and Egypt. While the Egyptian domestic profile can be regarded as Type II, the profiles of the other two countries rather have to be considered as mixtures of different types. The octagons representing the international profiles are still irregular in all three countries, that is, internationally co-authored papers reflect a profile, which deviates completely from that of domestic research. This situation indeed does not occur very frequently, and is – as expected – rather characteristic for small countries. It has, however, to be mentioned that the publication counts of all three countries still allow reliable statistical analyses for all fields.

Mapping mutual co-authorship links

Salton's measure will be used as an indicator of international collaboration strength. It is defined as the number of joint publications divided by the square root of the product of the number (i.e., the geometric mean) of total publication outputs of the two countries. Following the practice of earlier studies, the 'natural topology' is used to illustrate the structure defined by scientific co-authorship on the basis of Salton's measure which is calculated for country pairs. It should be mentioned here that as a consequence of treating collaboration links of each country pair separately, co-publication counts and shares are not additive, and thus cannot be summed up to the total over any part of the world. One has, consequently, to distinguish between the number of co-publications and of co-authorship links.

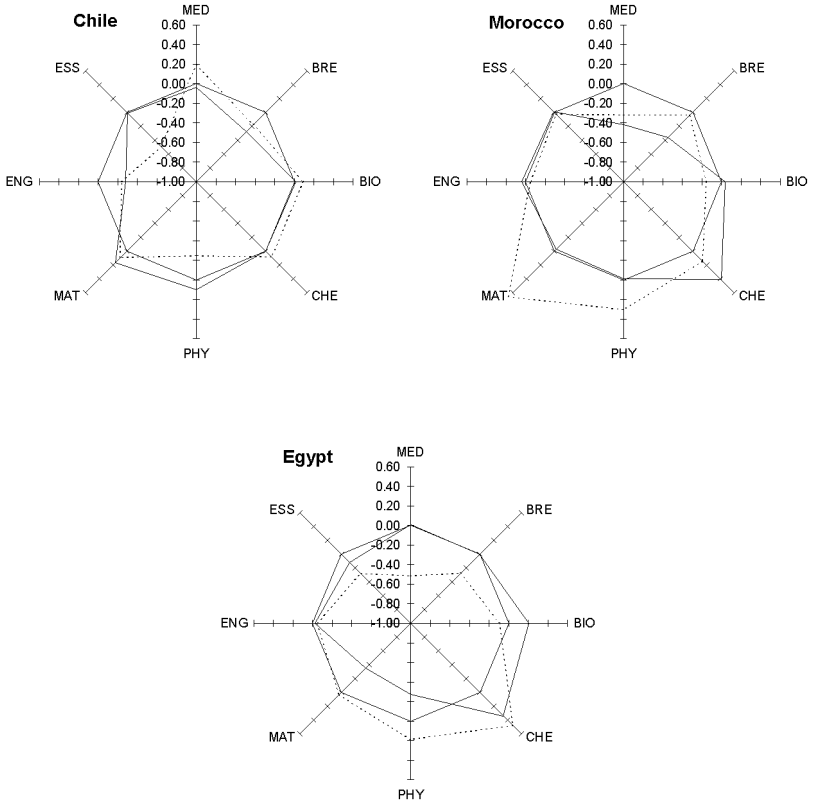


Figure 4. Relative specialisation based on eight major science fields (Case 4) (thin line: world average, dotted line: domestic papers, solid line: international papers)

Figure 5 shows the co-authorship map of 46 selected countries for the years 1985/86. Note, that the GDR and Czechoslovakia still existed that time, whereas Belarus, Ukraine, Croatia, Slovenia, Czech Republic and Slovakia did not yet exist as independent states. Since international scientific collaboration was in the first two-year period not as intense as ten years later, lower thresholds (r_{ij}) of Salton's measure had to be used for the 1985/86 data. As the lower threshold for medium (very) strong links, r_{ij} = 1.5% (2.5%) has been chosen. Values of Salton's measure exceeding 5% did not occur in 1985/86. The position of the countries on the map is intended to reflect the

'natural geographic order' as much as possible, and to express, at the same time, the structure defined by the co-authorship links. The map presented in Figure 5 very much resembles that in Figure 3 in *Schubert* and *Braun* (1990). *Schubert* and *Braun* have analysed international collaboration of 36 countries in the sciences in the period 1981-1985. On the basis of Figure 5 little can be added to their comments. *Schubert* and *Braun* found four clusters of unequal size, namely, a big one including Western Europe, USA and Canada and two smaller ones with the Scandinavian and the Eastern European countries, respectively. A tiny cluster, finally, included Australia and New Zealand. In addition to these four clusters, there is a fifth one consisting of Egypt and Saudi Arabia and a sixth one with Brazil and Argentina; both can be found in Figure 5. The latter ones are isolated, whereas the Nordic, the Oceanean and the Eastern European clusters are connected to the Western European/American cluster through the links Sweden–USA, Australia–UK and Poland–F.R. German, respectively.

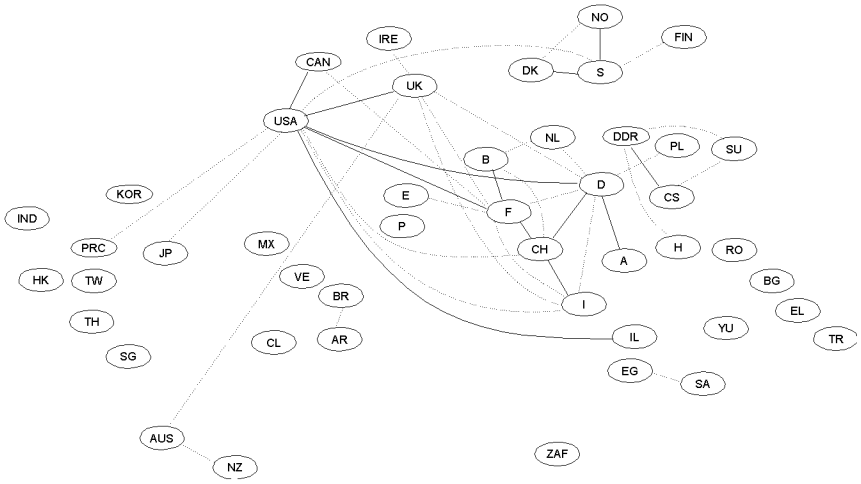


Figure 5. Co-authorship map for 50 most active countries in all fields combined in 1985/86 based on Salton's measure (dotted line ≥ 1.5%, solid line ≥ 2.5%)

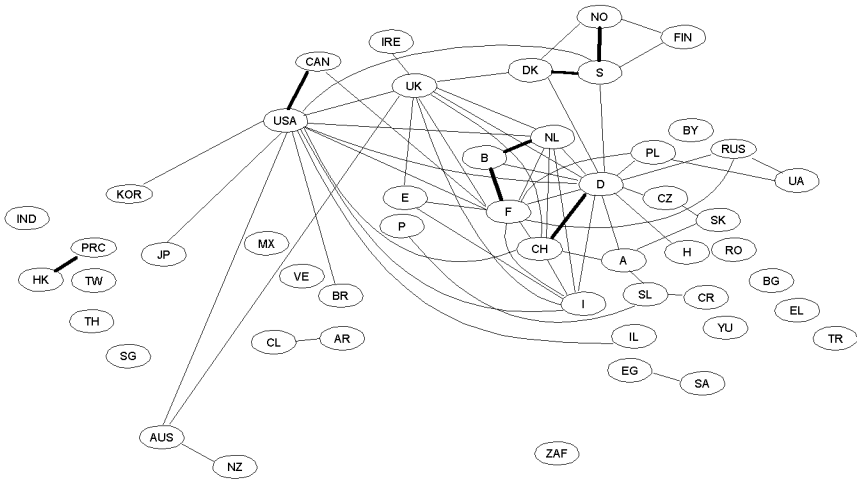


Figure 6. Co-authorship map for 50 most active countries in all fields combined in 1995/96 based on Salton's measure (solid line ≥ 2.5%, thick line ≥ 5%)

The co-publication map presented in Figure 6 shows a quite different situation ten years later. All co-authorship links of the 50 most active countries in 1995/96 are plotted. Since the intensity of links has increased considerably from the 80s to the 90s, the corresponding thresholds had to be modified. The dense network of links had otherwise made the map unintelligible. Links with a strength below 2.5% have, therefore, not been plotted. In addition, co-publication links stronger than 5% are represented by thick lines (see Figure 6). The changes are striking. First, the overall strength of links has increased; thus dotted lines in Figure 5 are regularly replaced by solid ones in Figure 6. Second, the network of co-publication links became denser although the lower threshold of 1.5% has been omitted in 1995/96. Third, a structural change can be observed. The Arabian cluster is still isolated, and has not changed. The South American cluster has undergone some structural changes. The strength of co-authorship links between Brazil and Argentina did not reach the necessary threshold of 2.5%, whereas new medium strong links between Chile and Argentina, on one hand, and Brazil and the USA, on the other hand, have been established. A tiny new cluster formed by the P.R. China and Hong Kong arose in Far East. The link between these two countries (5.9%) is one of the strongest in the period under study (a couple of years before the crown colony returned to China).

The biggest cluster includes Europe, the USA and Canada. Other features already found in the map published in *Glänzel* (2000) can be observed here, too: a strongly cross-linked EU cluster connected to the USA, a coherent Scandinavian cluster connected through Denmark and Sweden with the rest of the North American/European main cluster and a loosely connected Central/Eastern-European cluster joined to the main cluster through Germany and – as a new development – Poland which plays the role of a newly-fledged node in Eastern Europe. The Far East and Oceanea are linked to the main cluster through the USA.

The link between Slovenia and Portugal is somewhat unexpected, but it should be noted that this is caused by the two countries' joint contribution to multinational papers in physics. This is a by-effect which may occur if multilateral co-authorship links of small countries are split into pairs.

The strongest links can be found between Canada and the USA, Hong Kong and P.R. China, between Belgium and both France and the Netherlands, between Germany and Switzerland and within Scandinavia as those links connecting Sweden with Denmark and Norway, respectively.

Analysis of (unidirectional) co-authorship affinity

Salton's measure is designed as a symmetric indicator. Thus, the map presented in Figures 5 and 6 reflect mutual links but does not reveal anything about specific unidirectional 'affinities' of a country for co-authorship with other countries. Of course, one can often proceed from the assumption that at least the strong links like those connecting the Nordic countries or the Central European countries which each other are of mutual nature.

A possible way to characterise the relative 'importance' of other countries for selected countries according to a method introduced by *Glänzel* (2000) and *Glänzel* and *Schubert* (2001) is presented in Table 2. Sixteen selected countries, that is, about $^1/_3$ of the 50 most active countries in 1995/96 have been analysed for their co-authorship affinity. The table presents the bi-literal codes of the 10 most important partner countries out of the above 50 countries (column A), the number of joint papers in all fields combined (column B), the percentage share of joint papers in the internationally co-authored papers of the selected country (column C) together with the percentage share of the total number of publications of the same set of countries in the world total minus the number of publications of the selected country (column D).

Table 2
Co-authorship affinity for the sixteen selected countries ranked by share of joint papers
(A = Country, B = number of joint papers, C = Share of joint papers in all international papers,
D = Share of partner country in the world total minus country under study)

Ausztria				Denmark			
A	B	C	D	A	B	C	D
DE	1468	36.39%	8.13%	**US**	1511	29.57%	35.04%
US	991	24.57%	34.97%	**UK**	967	18.92%	9.64%
UK	445	11.03%	9.62%	**SE**	895	17.51%	2.06%
FR	383	9.49%	6.41%	**DE**	837	16.38%	8.14%
CH	378	9.37%	1.81%	**FR**	532	10.41%	6.43%
IT	328	8.13%	4.06%	**IT**	451	8.83%	4.06%
NL	225	5.58%	2.58%	**NL**	410	8.02%	2.59%
PL	210	5.21%	1.07%	**NO**	392	7.67%	0.62%
ES	204	5.06%	2.56%	**ES**	323	6.32%	2.57%
CZ	172	4.26%	0.48%	**CH**	300	5.87%	1.81%

Germany				France			
A	B	C	D	A	B	C	D
US	9381	30.03%	37.72%	**US**	6701	26.47%	37.04%
UK	3780	12.10%	10.38%	**DE**	3528	13.94%	8.61%
FR	3528	11.29%	8.77%	**UK**	3295	13.02%	10.19%
RU	2626	8.41%	4.18%	**IT**	2547	10.06%	4.30%
CH	2567	8.22%	1.95%	**CH**	1820	7.19%	1.92%
IT	2242	7.18%	4.38%	**ES**	1785	7.05%	2.71%
NL	1946	6.23%	2.79%	**BE**	1635	6.46%	1.35%
JP	1499	4.80%	10.11%	**CA**	1593	6.29%	5.00%
AT	1468	4.70%	0.89%	**RU**	1445	5.71%	4.10%
SE	1259	4.03%	2.22%	**NL**	1326	5.24%	2.74%

Hungary				Japan			
A	B	C	D	A	B	C	D
US	853	32.53%	34.84%	**US**	7268	46.67%	38.23%
DE	579	22.08%	8.10%	**DE**	1499	9.63%	8.89%
UK	335	12.78%	9.59%	**UK**	1479	9.50%	10.52%
FR	333	12.70%	6.39%	**CA**	999	6.41%	5.16%
IT	245	9.34%	4.04%	**FR**	885	5.68%	7.01%
CH	215	8.20%	1.80%	**CN**	841	5.40%	1.79%
JP	150	5.72%	9.34%	**KR**	619	3.97%	0.95%
NL	141	5.38%	2.57%	**IT**	606	3.89%	4.44%
FI	128	4.88%	0.90%	**RU**	581	3.73%	4.24%
CA	127	4.84%	4.70%	**AU**	518	3.33%	2.86%

Table 2
(Continued)

Netherlands				PR China			
A	B	C	D	A	B	C	D
US	3121	29.59%	35.59%	**US**	1805	33.24%	35.25%
UK	1999	18.96%	9.79%	**JP**	841	15.49%	9.45%
DE	1946	18.45%	8.27%	**DE**	668	12.30%	8.19%
FR	1326	12.57%	6.53%	**HK**	524	9.65%	0.37%
BE	1048	9.94%	1.30%	**UK**	505	9.30%	9.70%
IT	941	8.92%	4.13%	**FR**	358	6.59%	6.47%
CH	645	6.12%	1.84%	**CA**	340	6.26%	4.76%
ES	578	5.48%	2.61%	**IT**	289	5.32%	4.09%
RU	531	5.04%	3.94%	**AU**	204	3.76%	2.64%
SE	527	5.00%	2.09%	**SE**	183	3.37%	2.07%
Poland				South Korea			
A	B	C	D	A	B	C	D
US	1434	25.33%	35.05%	**US**	1687	62.85%	34.98%
DE	1250	22.08%	8.15%	**JP**	619	23.06%	9.38%
FR	928	16.39%	6.43%	**DE**	204	7.60%	8.13%
UK	600	10.60%	9.64%	**RU**	180	6.71%	3.88%
RU	567	10.02%	3.88%	**UK**	177	6.59%	9.63%
IT	562	9.93%	4.07%	**CN**	169	6.30%	1.64%
SE	380	6.71%	2.06%	**IT**	154	5.74%	4.06%
NL	314	5.55%	2.59%	**FR**	149	5.55%	6.42%
CH	309	5.46%	1.82%	**ES**	109	4.06%	2.56%
ES	266	4.70%	2.57%	**CA**	107	3.99%	4.72%
Taiwan				USA			
A	B	C	D	A	B	C	D
US	1445	71.25%	35.03%	**DE**	9381	12.84%	12.34%
JP	206	10.16%	9.39%	**UK**	9296	12.73%	14.61%
CN	107	5.28%	1.64%	**CA**	8703	11.91%	7.16%
CA	104	5.13%	4.73%	**JP**	7268	9.95%	14.23%
UK	84	4.14%	9.64%	**FR**	6701	9.17%	9.74%
IT	81	3.99%	4.06%	**IT**	5112	7.00%	6.16%
DE	78	3.85%	8.14%	**CH**	3145	4.31%	2.75%
FR	65	3.21%	6.42%	**NL**	3121	4.27%	3.92%
HK	61	3.01%	0.36%	**IL**	2976	4.07%	1.85%
KR	48	2.37%	0.87%	**AU**	2859	3.91%	3.97%

Table 2
(Continued)

Israel				UK			
A	B	C	D	A	B	C	D
US	2976	57.04%	35.11%	**US**	9296	30.82%	38.34%
DE	799	15.32%	8.16%	**DE**	3780	12.53%	8.91%
FR	493	9.45%	6.44%	**FR**	3295	10.92%	7.03%
UK	473	9.07%	9.66%	**IT**	2433	8.07%	4.45%
IT	347	6.65%	4.07%	**NL**	1999	6.63%	2.83%
CA	317	6.08%	4.74%	**CA**	1769	5.86%	5.17%
RU	261	5.00%	3.89%	**ES**	1592	5.28%	2.81%
CH	248	4.75%	1.82%	**AU**	1583	5.25%	2.87%
JP	225	4.31%	9.41%	**JP**	1479	4.90%	10.27%
NL	182	3.49%	2.59%	**CH**	1426	4.73%	1.99%
Russia				India			
A	B	C	D	A	B	C	D
US	2699	23.68%	36.07%	**US**	1253	38.41%	35.33%
DE	2626	23.04%	8.38%	**DE**	454	13.92%	8.21%
FR	1445	12.68%	6.62%	**UK**	434	13.30%	9.72%
UK	1029	9.03%	9.92%	**FR**	323	9.90%	6.48%
IT	927	8.13%	4.18%	**JP**	235	7.20%	9.47%
JP	581	5.10%	9.67%	**CA**	215	6.59%	4.77%
PL	567	4.97%	1.11%	**IT**	189	5.79%	4.10%
UA	562	4.93%	0.60%	**RU**	121	3.71%	3.92%
SE	553	4.85%	2.12%	**CH**	102	3.13%	1.83%
NL	531	4.66%	2.66%	**AU**	99	3.03%	2.64%

The latter two values are identical if a country is exactly as important for the country under study as it is for the rest of the world. The deviation from this ideally balanced situation is in reality often considerable.

For example, the share of the USA in the world minus Austria's publication output amounts to about 35%, the share of joint Austrian-US papers in all internationally co-authored Austrian publications is only about 25%, that is, the USA are less important as a partner for Austria than the United States are as contributor to the world's total publication output. Germany is, roughly speaking, more than four times as important for Austria (ca. 36%) as it is for the world (ca. 8%). On the other hand, Japan's productivity share amounts to about 10%, its share in German international papers is less than 5%.

Without any further detailed discussion of the indicator values presented in Table 2, the following conclusions can be drawn. Although the USA have the highest share in the international papers of almost all selected countries, the USA are a less important partner for Europe than they are for the world. The USA play an important role as co-

publication partner for Israel, India and the countries in Far East (except for China, where Japan, Germany and Hong Kong have a greater relative weight). Germany proved a very important partner for most selected countries, especially, for Austria and the three EIT countries Hungary, Poland and Russia, but only to a lesser extent for Taiwan and South Korea. Vice versa, Russia became an important partner for several Eastern and Western European countries as well as for Israel and South Korea. On the other hand, Japan, one of the most important collaboration partners in the Far East, is still less important for Europe, USA and Israel.

Citation Impact

"Publication strategy" of domestic vs. international papers

The relative expected citation index of international co-publications is a relative indicator designed to measure the deviation of a country's mean expected citation rate of international publications from domestic papers with respect to the world standard. The indicator is defined in similar manner as the Relative Specialisation Index, in particular,

$$\left(\frac{\mathrm{MECR}_{\mathrm{int}}}{\mathrm{MECR}_{\mathrm{dom}}} / \mathrm{WS} - 1 \right) / \left(\frac{\mathrm{MECR}_{\mathrm{int}}}{\mathrm{MECR}_{\mathrm{dom}}} / \mathrm{WS} + 1 \right),$$

where MECRint (MECRdom) is the mean expected citation rate of international (domestic) publications of a selected country in a given field and WS is the corresponding 'world standard' of this ratio. The index takes values in the interval [-1, 1] and its neutral value is 0. The index values for the eight fields are presented in Table 3.

The world standard indicates a higher expected citation rate of international publications in all science fields. The WS ratio ranges between about 1.1 (CHE, ESS) and about 1.3 (MED, BRE, PHY and ENG). Negative values in Table 3 indicate that the deviation between international and domestic MECR is less than in case of the corresponding reference standards, or, that the international MECR of a country is even below the domestic one. Such cases, when countries are publishing their internationally co-authored papers on average in journals with lower impact than their domestic papers, are indicated in italics (Table 3). This phenomenon can be observed, first of all, in mathematics but, in part, also in chemistry and earth and space sciences. Not only less advanced countries are concerned, but also highly developed countries like the USA (in chemistry) and Australia (in mathematics).

Table 3
Relative expected citation index of international co-publications (1995/1996)
(absolute decrease is indicated in *italics*)

	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS
ARGENTINA	0.14	0.10	0.12	0.04	0.03	*–0.08*	0.13	0.13
AUSTRALIA	0.05	0.03	0.09	0.01	0.05	*–0.12*	0.07	0.04
AUSTRIA	0.09	0.03	0.16	–0.04	0.03	0.03	0.02	0.02
BELARUS	0.21	0.41	0.36	0.30	0.23	0.06	0.49	0.77
BELGIUM	0.01	0.05	0.07	*–0.06*	–0.01	–0.03	0.10	0.09
BRAZIL	0.03	0.29	0.09	0.03	0.00	*–0.08*	0.07	0.12
BULGARIA	–0.07	0.17	0.33	0.07	0.19	0.05	0.13	–0.06
CANADA	–0.01	0.06	0.08	–0.05	0.06	–0.04	0.10	0.04
CHILE	0.44	0.16	0.10	0.20	0.00	*–0.18*	0.06	0.04
CROATIA	0.13	0.06	0.25	0.04	0.03	*–0.22*	0.10	–0.03
CZECH REPUB	0.09	0.14	0.21	0.20	0.12	0.00	0.11	0.02
DENMARK	0.05	0.11	0.07	0.02	–0.01	0.02	0.03	0.07
EGYPT	–0.06	0.28	0.21	0.21	0.09	*–0.13*	0.30	0.10
FINLAND	0.08	0.10	0.08	0.01	0.05	–0.01	0.17	0.09
FRANCE	0.12	0.10	0.04	0.00	0.03	0.11	0.05	0.00
GERMANY	0.14	0.11	0.08	–0.01	0.00	0.01	0.05	0.01
GREECE	0.11	0.27	0.21	0.08	0.09	0.10	0.21	0.00
HONG KONG	0.03	0.10	0.02	–0.04	0.05	–0.06	0.03	0.13
HUNGARY	0.10	0.13	0.16	0.13	0.07	0.06	0.09	0.07
INDIA	0.16	0.24	0.09	0.13	0.08	*–0.08*	0.00	0.03
IRELAND	0.03	0.01	0.14	–0.02	–0.08	–0.02	0.12	0.03
ISRAEL	0.12	0.12	0.08	0.02	–0.02	–0.05	0.01	–0.02
ITALY	0.07	0.14	0.07	0.04	0.06	0.04	0.13	0.05
JAPAN	0.06	0.15	0.11	–0.02	0.07	–0.01	0.14	0.04
MEXICO	0.11	0.14	0.02	0.06	0.13	*–0.08*	0.10	–0.02
NETHERLANDS	–0.02	0.06	0.03	–0.04	0.01	–0.06	0.08	0.04
NEW ZEALAND	0.15	–0.02	0.11	0.05	0.14	–0.03	0.03	0.05
NORWAY	0.01	0.06	0.08	–0.04	0.10	0.11	0.18	0.06
PEOPLES R C	0.37	0.25	0.00	0.07	0.06	–0.06	0.02	0.14
POLAND	0.07	0.11	0.15	0.12	0.14	0.06	0.10	0.03
PORTUGAL	0.02	0.16	0.05	0.08	0.03	0.17	0.14	0.04
ROMANIA	0.23	0.20	–0.05	0.32	0.14	0.14	0.07	0.11
RUSSIA	0.48	0.68	0.46	0.44	0.39	0.29	0.45	0.58
SAUDI ARABI	0.00	0.13	0.07	0.05	0.03	*–0.29*	0.24	*–0.13*
SINGAPORE	0.27	0.14	0.16	0.07	–0.11	*–0.12*	0.15	0.10
SLOVAKIA	0.28	0.27	0.29	0.24	0.21	0.17	0.15	0.01
SLOVENIA	0.10	–0.06	0.02	0.05	0.11	–0.01	0.16	*–0.23*
SOUTH AFRIC	0.22	0.05	0.09	0.02	0.09	*–0.08*	0.33	0.13
SOUTH KOREA	0.10	0.13	–0.03	0.03	0.14	*–0.23*	–0.02	–0.01
SPAIN	0.16	0.12	0.05	0.00	0.00	0.00	0.00	0.05
SWEDEN	0.03	0.06	0.04	–0.03	–0.01	0.05	0.04	0.03
SWITZERLAND	0.10	0.01	0.03	–0.03	0.02	0.01	0.00	0.01
TAIWAN	0.03	0.01	0.02	0.04	0.18	0.02	0.05	0.15
THAILAND	0.11	0.15	0.02	–0.02	–0.08	n. a.	0.13	*–0.14*
TURKEY	0.06	0.14	0.12	0.17	0.13	*–0.21*	0.23	0.06
UK	0.07	0.03	0.01	–0.03	0.03	0.00	0.08	0.00
UKRAINE	0.27	0.42	0.31	0.27	0.32	0.24	0.24	0.44
USA	–0.07	–0.07	–0.04	*–0.08*	–0.09	–0.03	–0.08	–0.04
VENEZUELA	0.09	0.10	0.02	0.09	0.01	*–0.13*	0.05	0.12
YUGOSLAVIA	0.09	–0.08	0.07	–0.02	0.08	*–0.15*	0.06	*–0.12*

Citation impact of domestic vs. international papers

The citation analysis of domestic/international papers is based on the interpretation of 'attractivity charts' similar to those introduced in *REIST-2* (1997). Citations have been counted for a 3-year period each to papers published in 1995 and 1996, respectively, as described in the section "Data sources and data processing". The Mean Observed Citation Rate (MOCR) reflects the factual citation impact of a country, whereas the Mean Expected Citation Rate (MECR) is based on the 3-year mean citation rate of the journals in which the countries under study have been publishing. This journal citation measure is used as the reference standard for papers published in the corresponding journal.

The relative citation attractivity is measured by the Relative Citation Rate (RCR) as defined and applied in earlier studies by *Braun*, *Schubert* and *Glänzel* (for instance, 1985). In particular, RCR is defined as the ratio of the Citation Rate per Publication to the Expected Citation Rate per Publication, that is, RCR = MOCR/MECR. RCR measures whether the publications of a country attract more or less citations than expected on the basis of the average citation rates of the journals in which they appeared. The indicator ranges between 0 and infinity, the neutral value is 1. RCR < 1 (RCR > 1) means attractivity is below (above) expectation.

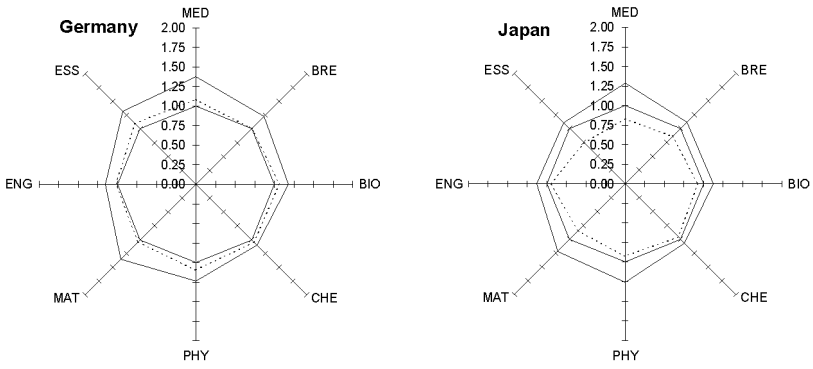


Figure 7a. Citation impact of domestic vs. international papers ('big advanced' countries)
(thin line: world standard, dotted line: domestic papers, solid line: international papers)

In order to analyse citation impact of domestic vs. international papers, the 50 most active countries have been grouped into four categories according to their size and their stage of development. Following the practice of the *REIST-2* report, four categories

have been created, namely, 'big advanced', 'small advanced', 'big non-advanced' and 'small non-advanced' countries. Each category is represented by two selected countries, the attractivity patterns of which will be shown in Figures 7a-d.

Germany and Japan are the two selected representatives of the first category, the group of 'big advanced' countries (see Figure 7a). As a rule, international papers have a higher attractivity than the domestic ones (cf. *REIST-2*, 1997, *Glänzel*, 2000). Even in Germany, where the domestic attractivity is already above the world standard, international co-authorship increases citation attractivity. Japan is even more affected by the effect of international collaboration on attractivity. Here the attractivity of domestic publications in all fields is below the world standard, but the Relative Citation Rate has grown strikingly if publications were the result of international collaboration. In both countries international collaboration has a strong effect in clinical medicine and mathematics. In Japan international collaboration also considerably increases the attractivity of physics.

Denmark and New Zealand have been selected from the group of 'small advanced' countries (Figure 7b). International co-authorship increases citation attractivity in comparison to the already high domestic standard also in these countries. The impact of domestic publications in Denmark is already above the world standard, except for physics and engineering, which are slightly below the expectation. In Denmark the field 'clinical medicine' shows a remarkable increase in attractivity if foreign authors are involved. More details on the attractivity patterns of Nordic countries expressed by the Relative Citation Rate of domestic/international papers can be found in *Glänzel* (2000).

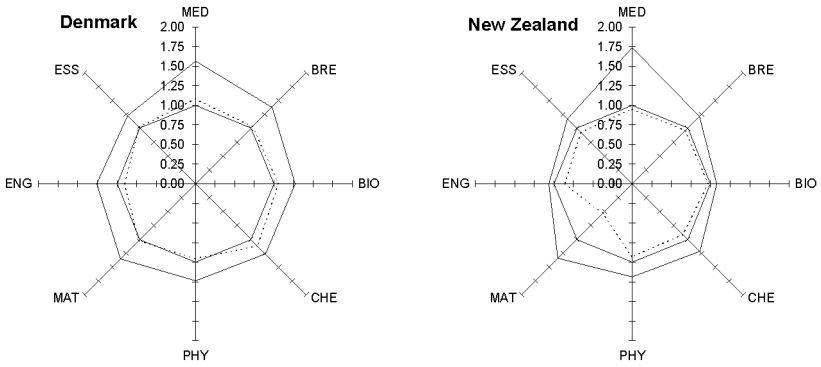


Figure 7b. Citation impact of domestic vs. international papers ('small advanced' countries)
(thin line: world standard, dotted line: domestic papers, solid line: international papers)

The attractivity of New Zealand's domestic publications is slightly below the expectation, except for mathematics and engineering. In the latter fields it is clearly below the standard. The increase in attractivity through international collaboration in mathematics and clinical medicine is immense.

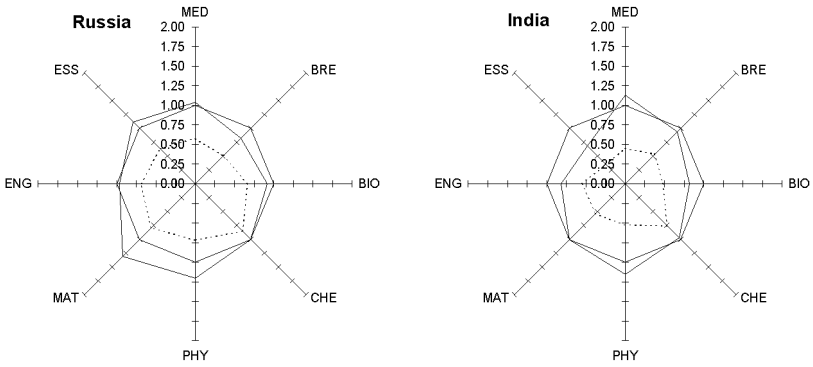


Figure 7c. Citation impact of domestic vs. international papers ('big non-advanced' countries)
(thin line: world standard, dotted line: domestic papers, solid line: international papers)

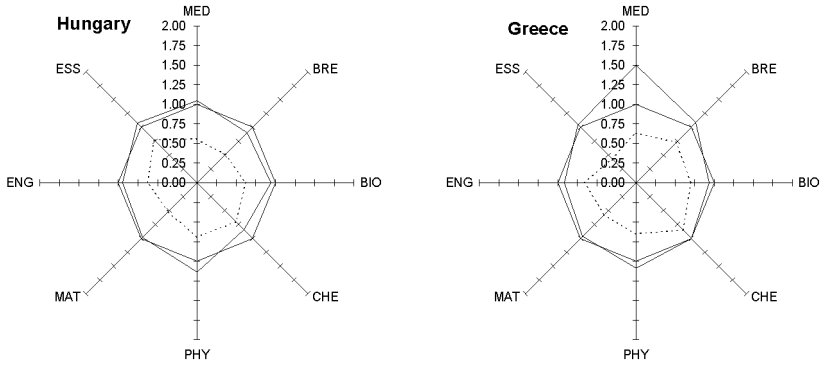


Figure 7d. Citation impact of domestic vs. international papers ('small non-advanced' countries)
(thin line: world standard, dotted line: domestic papers, solid line: international papers)

Citation-based indicators of internationally co-authored papers are in the distinctly higher attractivity zone for less advanced countries than domestic indicators. This applies to both large and small countries (cf. Figures 7c and 7d). In most countries

the improvement of citation impact by international co-authorship does not mean that attractivity becomes high, often it is only not as low as in the case of the national standard (cf. *REIST-2*, 1997). In Russia, Hungary and Greece domestic attractivity below expectation is, however, contrasted by the attractivity of international co-publications corresponding to or lying even above the expectation. The relative citation rate of Russia in physics (1.20) and mathematics (1.31) and of Greece in clinical medicine (1.49) is indeed high. In India only international co-publications in clinical medicine and physics have a citation attractivity which lies above the expectation.

Frequency distributions of domestic and international papers

In the following, the frequency distributions of domestic and international papers will be compared for one representative each of the above four categories according to size and scientific/economic development. Figures 8a-d present the comparison of the frequency distribution of citations received by domestic and international papers for the four selected countries in all fields combined in 1995/96. The domestic distributions of Germany ('big advanced'), Denmark ('small advanced'), Russia ('big non-advanced') and Hungary ('small non-advanced') differ considerably. Those of the two non-advanced countries are more skewed, less polarised, and have shorter tails. Russia's distribution of citations over domestic papers reflect the least impact among the selected countries.

According to expectations, Denmark and Germany have the most propitious 'domestic' citation distribution among the four countries under study. As already shown in the context of a similar analysis made for Scandinavian countries (see *Glänzel*, 2000), one can conclude that, concerning the influence of international collaboration, the same kind of deviation of the citation frequency of international papers from that of domestic publication can be observed for all four countries. In particular, the 'head' of the distribution, that is, the share of uncited and less frequently cited papers decreases if international papers are considered, whereas frequencies in the 'trunk' of the distribution increase and the 'tail' becomes longer.

The distance between domestic and international distributions of one and the same country, on one hand, and citation distributions of different countries, on the other hand, will be measured on the basis of the normalised sum over the weighted absolute deviation between corresponding relative frequencies.

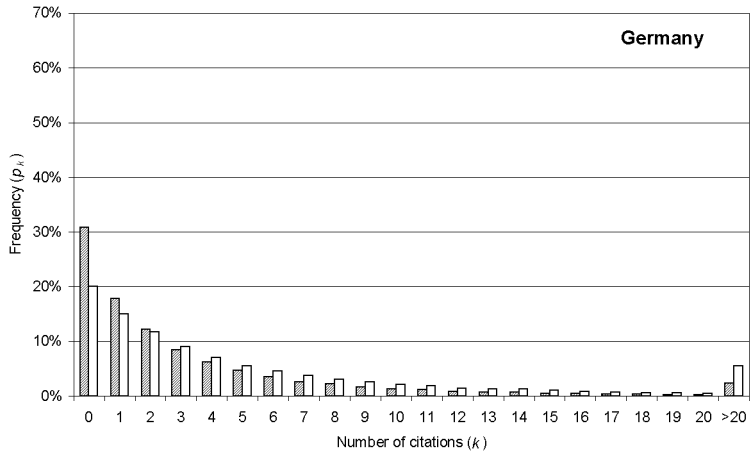


Figure 8a. Frequency distributions of citations over domestic and international papers ('big advanced' country) (shaded bars: domestic papers, white bars: international papers)

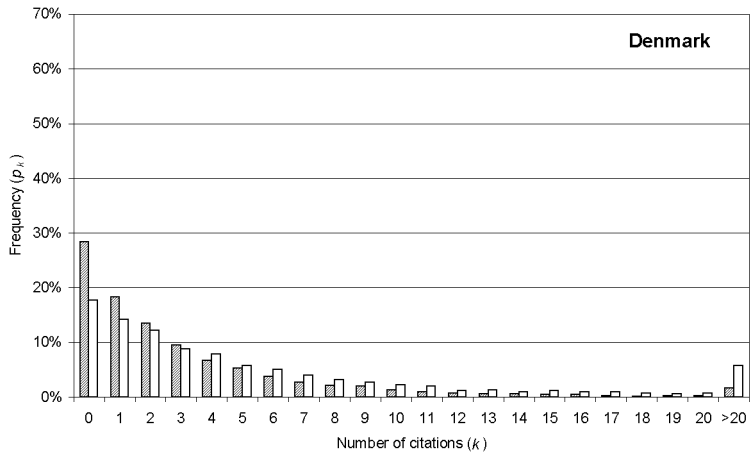


Figure 8b. Frequency distributions of citations over domestic and international papers ('small advanced' country) (shaded bars: domestic papers, white bars: international papers)

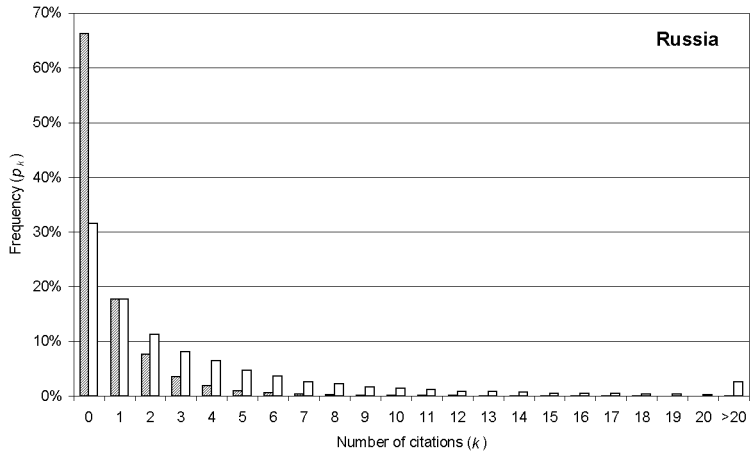


Figure 8c. Frequency distributions of citations over domestic and international papers ('big non-advanced' country) (shaded bars: domestic papers, white bars: international papers)

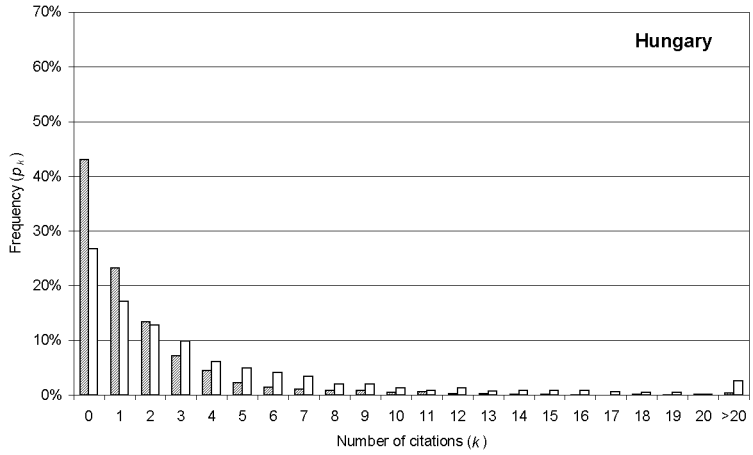


Figure 8d. Frequency distributions of citations over domestic and international papers ('small non-advanced' country) (shaded bars: domestic papers, white bars: international papers)

This measure, which ranges between 0 (identical distributions) and 1 (maximum deviation) has already been applied in the paper on Scandinavian science (*Glänzel*, 2000). The least deviation of the international distribution from the domestic one (d = 0.21) can be observed for Germany (see Figure 8a). The deviation is slightly greater for Denmark (d = 0.28, Figure 8b). As expected, greater deviations can be found for the less advanced countries, where the d-values amount to 0.47 for Hungary (Figure 8d) and to 0.72 for Russia (Figure 8c). The latter value of about ¾ in connection with the low impact of Russian domestic research (see also previous section) reflects an almost critical situation.

In the context of frequency distribution of citation over domestic and international papers, an interesting coincidence can be observed. The deviation between the citation distributions of Russia's international and of Germany's domestic papers of d = 0.03 is almost negligible, that is, from the viewpoint of number of received citations, Russian international papers statistically behave like German domestic ones (cf. shaded bars in Figure 8a and white bars in Figure 8c). It should, however, be stressed that this phenomenon has to be considered a mere coincidence.

Citation analysis of co-authorship links by country pairs

The results of the previous sections have confirmed the expectations, according to which international collaboration, on average, results in publications with higher citation rates than purely domestic papers, and that international collaboration thus seems to pay for all partners involved. However, results presented earlier have already shown that in some fields internationally co-authored papers may, on average, be published in journals with lower impact factors than domestic papers. In this section both the expected and observed citation rate of international co-publications will be analysed by country pairs. In order to give an insight into co-authorship links and citation impact, three subject fields have been selected. Biomedical research is representing the life sciences, chemistry the natural sciences and the third field is mathematics. The field of physics has not been selected because frequent multi-national co-authorships may distort or even falsify measures of links defined on country pairs. In order to obtain statistically reliable results, links with less than 25 (in mathematics less than 20) joint papers have been omitted. The indicators for seven countries in each of the three fields are presented in Tables 4-6.

Table 4 shows mean observed and expected citation rates of co-authorship links of Germany, France, Denmark, Australia, Poland, Israel and China in biomedical research for papers published in 1995/96. Data are arranged in descending order by the observed

citation rates. Note that all citation data are again based on 3-year citation windows. The field impact of the world total is 5.00. In this field co-publications mostly attract high citation rates. Germany and France have numerous co-publication links and most of them have MOCR and MECR values distinctly above both the own (domestic) values and the world standard. The same applies to Australia, Denmark and Israel, however, these countries are smaller and also have less co-publication links above the world reference standard. Strong links with a mean citation rate greater than the domestic MOCR of any of the two contributing countries were called *hot links* (*Glänzel* and *Schubert*, 2001). The links Germany–Austria (r_{ij} = 6.1%*, MOCR = 10.9) and Australia–Netherlands (r_{ij} = 2.5%, MOCR = 13.9) may just serve as examples for such hot links.

Table 4
Co-authorship links and citation impact for seven selected countries in biomedical research ranked by mean observed citation rate (domestic values are set in *italics*; field impact in 1995/96 = 5.00)

Germany			France			Denmark			Australia			Poland			Israel			P.R. China		
	Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.
CA	13.59	8.03	**JP**	15.35	7.93	**IT**	13.83	7.24	**NL**	13.86	8.06	**UK**	9.05	4.05	**UK**	12.55	6.67	**US**	4.89	4.29
ES	12.46	6.58	**AT**	13.46	5.94	**ES**	12.50	6.36	**FR**	11.38	6.53	**US**	6.88	4.93	**IT**	9.96	6.49	**SE**	4.28	3.62
JP	12.40	7.61	**FI**	13.11	7.38	**DE**	12.38	6.77	**CH**	11.10	6.96	**SE**	5.69	4.03	**US**	9.34	8.11	**DE**	3.91	4.51
DK	12.38	6.77	**CH**	12.08	8.82	**FR**	11.87	5.20	**SE**	10.96	6.05	**DE**	5.48	3.43	**FR**	8.87	6.42	**JP**	1.91	2.34
US	11.25	8.50	**DK**	11.87	5.20	**CH**	11.13	5.12	**DE**	10.91	7.64	**FR**	3.74	4.24	**DE**	8.15	6.71	**HK**	1.89	2.93
FR	11.10	6.96	**AU**	11.38	6.53	**NL**	10.75	4.63	**US**	9.07	7.70	**IT**	2.69	2.64	**CA**	7.03	5.89	***CN***	*1.02*	*1.56*
AU	10.91	7.64	**US**	11.14	8.23	**BE**	10.70	4.16	**CA**	8.72	5.81	**AT**	1.94	1.88	***IL***	*3.44*	*4.09*			
FI	10.46	6.40	**DE**	11.10	6.96	**UK**	10.65	5.11	**DK**	8.23	4.46	***PL***	*1.27*	*2.09*						
NL	10.13	6.83	**NL**	10.95	6.86	**US**	10.14	7.09	**IT**	7.49	6.54									
UK	9.90	7.20	**UK**	10.21	6.47	**NO**	8.41	5.80	**UK**	7.39	5.89									
BR	9.72	4.49	**ES**	9.16	5.75	**AU**	8.23	4.46	**JP**	7.06	5.81									
IT	9.48	6.87	**CA**	8.89	5.62	**FI**	7.94	4.75	**NZ**	4.80	4.96									
CH	9.29	7.30	**IL**	8.87	6.42	**SE**	6.96	4.93	***AU***	*4.03*	*4.35*									
NO	8.98	7.37	**IT**	8.42	6.28	**CA**	6.28	5.99												
SE	8.93	6.85	**SE**	8.40	5.53	***DK***	*3.51*	*3.40*												
AT	8.70	5.71	**BE**	7.85	5.23															
BE	8.55	4.99	**RU**	7.24	6.80															
GR	8.35	7.98	**NO**	6.88	4.72															
IL	8.15	6.71	**PT**	6.82	5.38															
HU	7.67	7.61	**GR**	6.31	5.66															
CZ	5.69	4.30	**BR**	4.53	5.62															
PL	5.48	3.43	**PL**	3.74	4.24															
ZA	4.53	3.86	***FR***	*3.72*	*4.09*															
DE	*4.16*	*4.13*																		
RU	4.10	3.55																		
CN	3.91	4.51																		

* r_{ij} values are not presented in Tables 4–6. Note that not all of the listed links can be considered strong according to Salton's measure

The results in the case of Poland and China, however, differ from those of the other selected countries. All MECR values here are below the world average and in China the MOCR values of joint publications with any other country do not reach the world average either. By contrast, the MOCR values of Poland's co-publications with UK, USA, Sweden and Germany are above this reference standard. Nevertheless, collaboration in this field seems to pay for most of the listed countries although not always for both partners involved.

Table 5 shows mean observed and expected citation rates of co-authorship links of Germany, Japan, Sweden, Canada, the Netherlands, Hungary and Denmark in chemistry in the same period as above. The field impact of the world total is here 3.07. Contrary to biomedical research, the situation is less favourable in chemistry. More MOCR and MECR values of joint papers are below the world average and one of the corresponding domestic standards and several values are even below both domestic reference values.

Germany, again, has many co-publication links and more than half of them have MOCR and MECR values distinctly above the two standards. It is worth mentioning that even Germany's domestic values lie clearly above the reference standard of the world total. Nevertheless, the by far 'hottest' link could be found for Sweden and New Zealand (r_{ij} = 3.0%, MOCR = 9.2).

The co-authorship links Netherlands–Switzerland ($MOCR_{NL(dom)}$ = 3.92, $MOCR_{CH(dom)}$ = 4.87) and Sweden–United Kingdom ($MOCR_{SE(dom)}$ = 3.86, $MOCR_{UK(dom)}$ = 3.56) attracted less citations than expected on the basis of the corresponding domestic reference standards. *Glänzel* and *Schubert* (2001) called this type of links *cool links*. It is, however, worth mentioning that Swedish-British co-authorship attracted on average more citations than the world standard.

This sample illustrates that international co-authorship does certainly not always increase the attractivity of national scientific publications. In several cases it is even below the domestic standards of one or both partner(s).

Table 6 shows mean observed and expected citation rates of co-authorship links of Germany, France, Israel, Australia, Poland, India and South Korea in mathematics (1995/96). The field impact of the world total is lower than in the preceding cases, and amounts to 1.44. Here the situation is similar to that in chemistry. Several MOCR and MECR values are again below one or both domestic reference value(s).

Germany and France have many co-publication links and most of them have MOCR and MECR values above the two standards. In mathematics, especially the co-publication link between Russia and Israel proved really hot (r_{ij} = 2.8%, MOCR = 5.6).

Table 5
Co-authorship links and citation impact for seven selected countries in chemistry ranked by mean observed citation rate (domestic values are set in *italics*; field impact in 1995/96 = 3.07)

Germany			Japan			Canada			Sweden			Netherlands			Hungary			Denmark		
	Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.
US	5.68	4.75	**CH**	7.44	4.79	IT	6.26	4.81	**NZ**	9.24	3.39	**IT**	6.70	3.63	**US**	3.58	3.87	**SE**	6.91	4.32
AU	5.43	3.78	**IT**	5.07	3.69	**CH**	6.00	4.48	**DK**	6.91	4.32	**US**	5.76	4.16	**FR**	3.22	3.19	**US**	5.97	4.41
CA	5.17	3.99	**NL**	4.88	3.04	**SE**	5.43	4.83	US	5.77	4.42	**UK**	5.44	3.33	**BE**	3.00	3.37	**UK**	4.74	3.76
FI	4.83	3.28	**US**	4.55	4.05	**BE**	5.31	3.11	**CA**	5.43	4.83	**JP**	4.88	3.04	**DE**	2.81	2.90	**DE**	4.57	3.57
NL	4.77	3.83	**FR**	4.44	3.67	**DE**	5.17	3.99	**NO**	5.38	3.82	**FR**	4.82	3.52	**IT**	2.74	3.25	***DK***	*3.57*	*3.18*
UK	4.75	3.80	**CA**	3.84	3.38	**AU**	4.82	3.99	**ES**	5.00	4.18	**DE**	4.77	3.83	**UK**	2.49	2.95	**FR**	3.28	4.09
GR	4.74	3.64	**DE**	3.51	3.53	**US**	4.59	4.26	**FR**	4.86	4.00	**CZ**	4.24	3.88	***HU***	*1.59*	*2.25*	**RU**	2.40	3.20
PT	4.60	3.64	**AU**	3.48	2.92	**UK**	4.03	3.52	**NL**	4.14	3.67	**SE**	4.14	3.67						
FR	4.60	3.93	**SE**	3.33	3.20	**ES**	4.00	4.26	**DE**	3.90	3.66	**RU**	4.09	3.18						
DK	4.57	3.57	**UK**	3.23	3.05	***CA***	*3.89*	*3.72*	***SE***	*3.86*	*3.51*	**BE**	4.06	3.52						
CH	4.39	3.80	***JP***	*2.97*	*3.09*	**JP**	3.84	3.38	**UK**	3.82	3.70	***NL***	*3.92*	*3.45*						
IL	4.34	5.22	**RU**	2.70	2.82	**FR**	3.68	3.73	**JP**	3.33	3.20	**ES**	3.83	3.11						
ES	4.23	3.98	**PL**	2.48	3.04	**RU**	2.62	3.55	**PL**	2.17	2.50	**CH**	3.78	3.20						
SE	3.90	3.66	**CN**	2.43	2.74	**PL**	2.21	3.28	**RU**	2.10	2.93	**PL**	2.36	2.73						
CZ	3.80	3.17	**KR**	2.23	2.18	**CN**	1.36	2.96												
IT	3.75	3.96	**IN**	1.97	2.18															
RU	3.71	2.81	**TW**	1.97	2.43															
BE	3.62	3.38	**EG**	1.77	2.44															
JP	3.51	3.53																		
DE	*3.44*	*3.28*																		
AT	3.04	2.91																		
NO	3.03	2.81																		
UA	2.93	2.57																		
HU	2.81	2.90																		
CR	2.78	3.45																		
PL	2.51	2.59																		
SK	2.42	2.17																		
CN	2.29	2.82																		
BR	2.26	2.48																		
TR	2.24	2.54																		
AR	2.14	3.38																		
IN	2.02	3.01																		
BG	2.00	2.89																		
EG	1.57	2.58																		
RO	1.30	2.22																		

Further hot links are, among others, Israel–Germany, Israel–USA, USA–Poland, USA–India, Germany–Italy, Germany–France, Germany–Hungary, Germany–Russia and France–Italy. On the other hand, the co-publication links Israel–Canada, India–Canada and South Korea–USA proved to be cool. The citation impact patterns of internationally co-authored papers in mathematics are even more polarised than they are in chemistry.

Table 6
Co-authorship links and citation impact for seven selected countries in mathematics ranked by mean observed citation rate (domestic values are set in *italics*; field impact in 1995/96 = 1.44)

Germany			France			Israel			Australia			Poland			India			South Korea		
	Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.		Obs.	Exp.
ES	5.27	1.96	**DE**	3.21	2.05	RU	5.62	2.52	RU	2.95	2.06	**US**	3.51	1.86	US	1.71	1.86	*KR*	*1.00*	*1.57*
IT	4.20	1.95	**BR**	3.20	2.18	**DE**	2.50	1.98	**US**	2.00	1.29	**DE**	2.18	2.39	**DE**	1.32	1.78	**US**	0.93	1.11
DK	3.27	2.57	**IT**	3.02	2.11	**UK**	1.83	1.66	**DE**	1.97	2.18	**FR**	1.61	1.63	***IN***	*0.92*	*1.72*			
HU	3.23	2.82	**ES**	2.90	1.62	**US**	1.62	1.59	**UK**	1.92	1.33	**CA**	1.33	1.05	**CA**	0.75	1.32			
FR	3.21	2.05	**NL**	2.82	1.76	**FR**	1.41	1.29	***AU***	*1.45*	*1.50*	***PL***	*0.86*	*1.36*						
RU	3.19	2.26	**US**	2.47	1.89	***IL***	*1.24*	*1.56*	**CA**	1.03	1.33									
JP	2.93	2.01	**JP**	2.03	1.37	**CA**	0.81	0.97												
UK	2.88	1.71	**CH**	1.86	1.91															
CH	2.60	2.08	**RU**	1.84	1.66															
US	2.53	1.87	**BE**	1.83	2.02															
IL	2.50	1.98	**UK**	1.79	2.05															
AT	2.23	1.29	**PL**	1.61	1.63															
CA	2.20	1.70	**IL**	1.41	1.29															
PL	2.18	2.39	**CA**	1.23	1.50															
UA	2.00	2.18	***FR***	*1.16*	*1.20*															
NL	2.00	1.84																		
AU	1.97	2.18																		
DE	*1.67*	*1.60*																		
CN	1.41	1.97																		
IN	1.32	1.78																		
CZ	1.16	1.23																		

Finally, an example for the citation distribution of internationally co-authored papers of country pairs will be given. This example shall illustrate that normally, even in extreme cases and for small samples, the mean observed citation rate is not only determined by the citation rates received by very few papers. Figure 9 shows the citation distribution of Swedish–Russian chemistry publications in 1995/96 in comparison with that of papers published by authors from Sweden and New Zealand in the same field. Neither distribution is degenerate.

The shape of the citation distribution of joint papers from Sweden and New Zealand reflects a very favourable situation. The distribution is not especially skewed and, moreover, there are no uncited papers. It has a mode at 5 citations and the maximum citation rate amounts to 29 citations. Acceptable fits can, for instance, be obtained from a negative binomial distribution model.

The shape of the second citation distribution (joint Swedish–Russian papers in chemistry) reflects a much less favourable situation. The distribution is really skewed. The frequency of uncited papers is high, but the distribution has two modes, particularly, at 0 and 4 citations. The shape resembles to that of a Neyman's Type A

distribution with two modes. These two examples may illustrate that even such extreme cases of citation distributions still obey the rules of bibliometric laws.

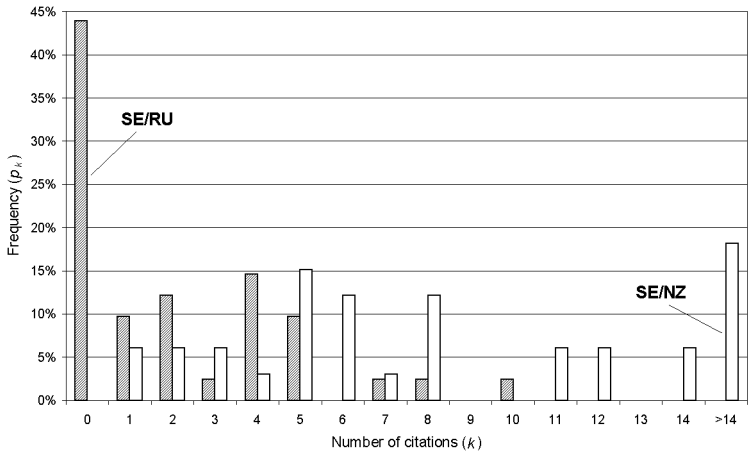


Figure 9. Frequency distributions of citations over international co-publications by authors from Sweden and Russia (N = 41) and Sweden and New Zealand (N = 33), respectively

Conclusions

On the basis of overall patterns and selected examples, the following answers have been found to the research questions formulated in the introduction. First, the analysis has confirmed once again that international collaboration has strongly intensified in the last decade. The most interesting observation concerned the re-integration of EIT countries into the scientific collaboration structures of Europe and the Western world. In addition to the co-authorship affinity to the USA, the traditional geopolitical links of these countries have also been re-established. Beyond that, a certain restructuring in South America has been experienced. And the strong co-authorship link between Hong Kong and China indicates the beginning coalescence of the two scientific systems.

Interesting national characteristics have been found in the context of publication profiles. In several countries international collaboration is in keeping with the profile of domestic research. Other countries compensate relatively weak domestic activities through international collaboration or, in contrast, they even intensify their own strong

activities in the preferred science fields by international collaboration. Although no obvious connection between these patterns and the countries' 'size' and degree of economic/scientific development could be found, the patterns proved to be typical of the national publication strategies. Finally, a group of countries, in which the international publication profiles completely differ from the corresponding domestic ones could be found. These indefinite patterns are rather typical of small and less developed countries.

The third question concerned the influence of international collaboration on chosen publication channels as reflected by journal impact factors. The somewhat unexpected answer was that in mathematics and in the natural sciences several countries publish their internationally co-authored papers on an average in journals with distinctly lower impact than their domestic papers. This observation may be at variance with the wide-spread notions concerning greater visibility of international co-publications. Similar contradictory observations could be made concerning the factually received citation rates of internationally co-authored papers. While the national totals of the citation impact of co-publications in all analysed fields often lay distinctly above the domestic 'standards', the situation changed if the citation impact is analysed by country pairs. Unlike in biomedical research, where the observed citation impact of most analysed country pairs was higher than the domestic impact of at least one of the involved partners, and often higher than the world standard, too, the patterns in chemistry and mathematics reflect a somewhat different situation. Besides the outstandingly high citation impact of co-publications of several country pairs, the attractivity of joint papers of some pairs was unambiguously low in these fields. Here developing countries and Eastern Europe are the most concerned countries. International co-authorship seems, therefore, not always to pay for all partners. The investigation of the reasons for this effect is beyond the scope and possibilities of bibliometric methods.

International scientific collaboration thus proved again to be a complex and heterogeneous phenomenon which cannot be sufficiently characterised by bibliometric indicators alone. International co-authorship relations represent a large range of frameworks and motivations, extending from bilateral or even multinational programmes to co-operation between individual scientists. The complexity and heterogeneity was adequately reflected by the results obtained, which sometimes contradict the customary notions of the impact of international collaboration on national science performance. Bibliometric methods, however, afford a deep insight into national characteristics in international co-authorship relations.

Appendix

Table A1. Scientific publication in 1995. International papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	121	75	173	97	215	37	98	31	740
AU	692	510	837	334	770	175	674	313	3799
AT	325	411	212	232	541	55	348	73	1883
BE	587	647	525	368	717	126	614	77	3162
BR	208	268	332	195	642	101	318	96	1885
BG	20	28	57	151	202	35	105	9	513
CA	1609	1233	1337	732	1725	430	1671	582	8161
CL	80	45	83	59	178	34	55	25	523
DK	504	385	471	219	657	80	447	112	2484
EG	77	66	106	132	76	10	83	21	485
DE	1902	1956	1822	1924	5439	606	2697	595	14785
FI	407	295	298	164	459	44	337	44	1759
FR	1530	1629	1630	1619	4125	492	2426	609	12202
GR	126	128	84	166	366	44	176	36	991
HK	113	100	67	95	188	39	179	5	669
HU	196	141	163	292	409	79	214	34	1289
IN	96	125	242	245	635	84	297	87	1562
IE	118	82	100	69	154	24	128	21	608
IL	413	301	355	209	774	250	532	65	2532
IT	1192	1230	797	878	2679	311	1216	214	7420
JP	1177	1265	1114	873	2344	156	1790	279	7596
MX	91	93	242	141	371	29	145	49	1022
NL	953	941	933	470	1268	136	1005	190	5129
NZ	159	102	234	112	113	25	140	95	866
NO	287	255	259	144	256	29	233	145	1361
CN	244	227	345	386	966	151	504	144	2567
PL	170	216	234	572	1464	113	528	43	2808
PT	51	60	132	128	200	21	149	16	649
RO	12	17	25	108	217	41	67	9	419
SA	50	34	45	31	36	7	51	7	215
SG	43	46	39	47	81	26	139	6	361
ZA	99	90	172	55	158	31	89	47	674
KR	93	124	167	209	493	36	366	22	1261
ES	448	444	680	764	1378	187	737	135	4120
SE	1028	826	720	355	1117	83	840	143	4418
CH	964	950	603	429	1526	117	805	149	4870
TW	144	119	131	124	287	62	268	41	996
TH	74	95	135	23	22	1	43	18	356
TR	63	45	81	94	143	9	112	34	487
VE	36	24	57	61	72	17	25	10	266
YU	36	24	24	35	66	6	30	5	203
US	6609	5839	5412	3183	9135	1562	7271	1846	35588
UK	2465	2342	2511	1536	3724	380	2873	725	14364
CZ	97	110	174	273	454	58	255	45	1261
SK	51	48	83	145	236	14	118	12	597
RU	146	225	428	863	3145	267	857	277	5542
UA	31	26	41	220	598	54	168	24	1020
CR	36	55	33	76	107	15	51	6	325
SI	19	22	28	59	127	11	47	0	271
BY	11	18	21	73	127	12	46	1	273
World	12291	11397	12480	9788	22575	3247	15369	3628	78561

Table A2. Scientific publication in 1995. Domestic papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	344	218	400	315	334	69	263	50	1666
AU	3264	1541	2761	1027	1296	221	1538	707	11021
AT	871	601	385	371	397	70	389	64	2702
BE	1056	827	700	516	612	112	766	69	3967
BR	374	579	456	353	660	133	394	64	2594
BG	48	80	104	242	226	35	130	18	745
CA	4627	2870	4430	2252	2393	485	3681	1201	19068
CL	257	77	132	123	74	22	84	5	689
DK	1159	669	820	278	335	70	494	120	3362
EG	89	100	160	473	292	31	198	20	1145
DE	6832	4821	4435	6301	6784	831	4992	717	31118
FI	1197	703	676	312	333	36	500	81	3295
FR	5761	4400	3398	3762	4498	963	4824	701	24405
GR	389	270	301	290	313	51	302	68	1659
HK	338	225	129	140	205	32	207	11	1157
HU	173	168	200	465	237	57	193	25	1293
IN	877	894	1441	2655	2430	217	1576	276	9076
IE	265	142	228	80	115	28	169	21	940
IL	1398	670	785	369	881	215	796	94	4513
IT	3934	3717	1902	2258	2662	448	2489	308	15074
JP	8047	8140	6649	9067	10571	531	9572	682	45003
MX	211	188	383	166	370	43	164	46	1348
NL	2821	2185	1993	1096	1173	200	1526	271	9717
NZ	625	249	704	153	127	30	200	155	2049
NO	633	431	511	226	185	59	320	154	2185
CN	356	251	307	1792	2971	354	1179	92	6629
PL	253	275	322	1223	1162	146	581	54	3352
PT	112	104	152	159	118	31	142	32	710
RO	10	18	13	217	188	27	103	3	480
SA	222	149	85	114	109	18	117	21	698
SG	164	115	91	133	225	40	335	12	978
ZA	584	215	595	216	210	27	218	81	2055
KR	219	308	268	918	1149	105	955	22	3253
ES	2408	1818	2141	2174	1365	307	1452	196	10069
SE	2390	1510	1316	705	870	107	1167	177	7168
CH	1539	863	837	850	997	101	878	145	5416
TW	675	519	557	948	1054	112	1351	44	4393
TH	59	41	62	15	14	0	22	2	187
TR	579	403	169	325	244	28	241	37	1656
VE	46	43	74	75	59	19	32	9	304
YU	66	79	36	78	130	18	99	7	430
US	46775	30422	28123	17292	24924	4346	32802	6795	167576
UK	13669	6820	6314	4160	5057	738	6856	1270	40417
CZ	103	95	278	469	287	34	213	39	1348
SK	70	122	170	288	134	33	120	14	773
RU	478	615	1195	5151	6534	482	2624	847	17446
UA	38	68	101	654	1384	47	330	33	2449
CR	71	62	62	123	85	9	49	13	401
SI	47	47	48	97	87	20	85	3	349
BY	9	11	20	181	281	23	128	13	614
World	123906	81105	80385	74418	89451	12628	91892	16481	500508

Table B1. Scientific publication in 1996. International papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	105	95	201	158	292	26	114	50	912
AU	771	476	839	419	863	212	728	395	4170
AT	402	454	264	223	653	58	360	80	2151
BE	662	624	563	392	869	113	668	130	3447
BR	238	246	396	205	710	108	323	113	2046
BG	21	30	58	123	211	31	107	10	499
CA	1710	1326	1422	762	1778	453	1661	642	8487
CL	87	46	101	83	221	32	67	29	610
DK	545	422	475	240	713	83	401	124	2626
EG	85	77	135	127	91	10	101	18	528
DE	2174	2119	2048	2099	6166	592	2869	628	16453
FI	453	316	320	152	507	39	319	82	1927
FR	1577	1737	1728	1771	4340	557	2544	800	13114
GR	135	153	106	165	402	39	194	62	1093
HK	151	115	96	145	278	71	210	18	901
HU	178	157	166	303	448	64	230	25	1333
IN	118	127	259	276	692	100	305	73	1700
IE	132	94	123	84	153	33	116	28	665
IL	433	278	364	247	883	277	561	63	2685
IT	1284	1340	849	947	2883	334	1364	249	8055
JP	1259	1311	1116	1044	2400	152	1693	330	7977
MX	113	88	239	151	402	50	164	47	1093
NL	967	971	924	519	1472	123	967	222	5417
NZ	183	102	291	108	105	43	168	137	999
NO	338	259	297	134	248	35	247	174	1493
CN	232	243	362	496	1083	168	564	183	2863
PL	184	214	242	611	1430	108	450	66	2853
PT	79	52	152	152	261	28	153	25	788
RO	22	25	20	125	259	49	89	10	505
SA	50	33	31	36	32	10	49	12	211
SG	51	29	39	59	96	31	167	5	409
ZA	94	98	195	79	205	33	94	66	795
KR	122	128	167	211	565	74	399	42	1423
ES	563	536	772	857	1556	189	772	175	4735
SE	1163	891	777	440	1091	75	872	207	4816
CH	933	912	663	479	1568	115	841	187	5047
TW	170	121	121	116	301	60	268	61	1032
TH	92	92	123	31	22	0	40	22	370
TR	85	50	87	105	140	19	119	36	540
VE	27	33	63	45	57	12	40	17	245
YU	35	30	16	37	69	13	29	3	205
US	7054	6034	5530	3404	9606	1730	7485	2049	37464
UK	2985	2382	2703	1704	4090	489	2958	817	15800
CZ	118	137	246	366	487	59	257	54	1482
SK	41	53	103	150	255	17	126	22	651
RU	160	208	468	888	3333	287	863	329	5856
UA	30	38	40	241	628	60	155	22	1074
CR	31	38	25	70	108	11	35	4	277
SI	17	23	31	63	137	26	55	2	293
BY	8	33	22	46	138	16	66	3	283
World	13446	11831	13129	10710	24269	3507	15860	4267	84245

Table B2. Scientific publication in 1996. Domestic papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	356	292	446	313	401	63	303	59	1849
AU	3372	1445	2827	1098	1314	246	1525	644	11149
AT	911	654	392	344	415	62	427	51	2743
BE	1084	844	683	581	699	106	746	98	4119
BR	458	627	546	409	706	132	471	64	2892
BG	47	74	105	218	233	35	158	10	746
CA	4810	2754	4426	2217	2056	495	3565	1201	18653
CL	244	77	132	119	75	20	68	10	674
DK	1184	656	790	253	383	54	465	109	3337
EG	90	105	142	483	300	30	177	21	1108
DE	7291	4686	4241	5860	7054	790	4989	736	31327
FI	1224	718	670	318	344	49	481	91	3380
FR	5740	4331	3270	3764	4372	1031	4642	775	24204
GR	396	308	289	352	304	74	353	98	1813
HK	433	311	151	204	266	49	299	10	1464
HU	208	170	198	438	267	64	170	24	1298
IN	874	830	1347	2721	2458	219	1696	261	9111
IE	272	139	230	103	98	23	162	20	949
IL	1439	662	649	398	834	219	748	92	4337
IT	4536	4034	1826	2336	2804	464	2599	330	16208
JP	8976	8500	6525	9519	11138	633	9897	641	47443
MX	246	221	379	195	437	45	180	45	1497
NL	2813	2146	1814	1210	1249	179	1414	246	9510
NZ	557	262	742	165	149	28	190	161	2053
NO	582	418	527	236	183	53	299	132	2092
CN	377	310	385	2020	3016	410	1363	143	6802
PL	311	343	371	1116	1128	135	493	56	3361
PT	107	94	158	164	137	35	164	22	723
RO	9	17	20	296	259	44	123	6	665
SA	251	144	93	102	96	17	94	10	673
SG	127	125	87	151	190	57	354	19	928
ZA	621	192	556	219	162	27	200	80	1924
KR	337	444	349	1113	1370	127	1125	35	4070
ES	2423	1852	2274	2278	1543	345	1526	247	10614
SE	2499	1479	1345	794	835	107	1132	207	7296
CH	1656	843	837	817	1064	103	857	154	5539
TW	967	612	643	1064	1225	154	1575	65	5173
TH	72	48	62	27	24	0	33	1	218
TR	796	462	185	393	311	33	285	46	2115
VE	45	48	76	82	54	13	40	10	322
YU	76	71	38	97	136	26	124	3	488
US	45887	29304	27853	17554	23700	4237	31649	6393	162428
UK	13799	6677	6351	4218	5337	778	6710	1285	40317
CZ	121	97	312	581	268	41	220	54	1496
SK	69	112	177	310	137	23	97	21	794
RU	280	564	1214	4238	6488	459	2304	691	15820
UA	19	61	70	554	1246	52	287	43	2148
CR	63	76	50	119	85	9	47	15	398
SI	42	47	52	94	94	22	84	5	351
BY	1	14	22	124	254	11	87	11	483
World	1125661	80680	79854	74931	89979	12769	90754	16130	498868

Table C1. Citation received in 1995-1997 by papers published in 1995. International papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	539	446	558	237	839	94	374	79	2737
AU	4644	3217	3791	1207	4154	254	4200	1184	21104
AT	1785	2983	1197	727	2658	102	2371	235	10606
BE	4182	4838	2751	1353	3533	346	4391	229	19940
BR	899	1240	942	473	3000	232	1133	333	7665
BG	28	86	156	362	638	63	233	24	1336
CA	10573	10856	5888	2697	10767	582	11861	2460	51989
CL	492	150	233	100	1078	82	340	52	2454
DK	3436	3567	2454	1050	4022	176	3689	464	16876
EG	148	135	222	177	180	12	226	28	991
DE	12942	16390	9705	7644	29706	1578	19615	2653	91578
FI	3273	2543	1418	540	2171	82	2969	196	11522
FR	10395	13974	8684	5875	21189	1115	16763	2564	73902
GR	657	720	279	623	1817	67	573	78	4277
HK	366	513	322	374	743	54	515	15	2387
HU	857	590	710	808	1942	124	813	117	5287
IN	407	452	522	616	2720	133	646	147	5057
IE	578	379	466	234	678	43	690	50	2764
IL	2572	2707	1780	891	5951	538	4573	157	17176
IT	8299	9947	3701	3928	14745	871	7426	616	45701
JP	6672	9616	5777	3189	12443	366	11015	972	45076
MX	372	463	671	338	1776	71	447	137	3875
NL	7419	8182	5455	2183	7571	304	8299	830	36299
NZ	1036	709	770	550	617	47	846	335	4159
NO	1587	1752	1175	446	1349	110	1725	566	7644
CN	869	814	782	867	3135	164	1058	366	7283
PL	874	931	754	1600	6373	232	1570	94	11197
PT	279	343	358	425	909	60	577	25	2671
RO	74	46	54	198	675	60	97	19	1089
SA	79	39	195	18	31	10	59	7	476
SG	213	184	260	172	144	18	666	10	1464
ZA	391	484	712	154	632	24	455	185	2961
KR	415	539	562	482	2735	54	683	38	4950
ES	2939	3033	2610	2892	6751	382	3291	344	19710
SE	5880	5418	4196	1640	6456	142	5643	548	26865
CH	6306	9583	3705	2038	11518	356	7154	606	38451
TW	443	421	401	232	1617	48	620	108	3580
TH	310	619	481	33	11	0	95	27	1434
TR	138	118	212	196	400	9	314	72	1691
VE	133	79	100	237	248	25	90	29	858
YU	225	80	36	57	212	4	23	4	650
US	44648	52968	31142	14248	58989	3414	56110	7945	248204
UK	17562	20148	12441	5568	20366	761	23002	3232	96781
CZ	390	625	676	930	1758	76	1049	144	4842
SK	230	229	213	334	1125	7	273	28	2187
RU	753	1012	1488	2120	14269	664	2719	876	22109
UA	156	129	84	351	1401	92	282	73	2455
CR	254	223	132	188	389	10	143	4	1220
SI	77	84	116	210	598	29	215	0	1215
BY	55	84	47	87	298	11	131	0	640
World	72979	84650	56490	34470	108954	6588	93627	13270	428363

Table C2 Citation received in 1995-1997 by papers published in 1995. Domestic papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	619	350	523	537	697	98	440	82	2853
AU	8774	6169	7689	3241	4098	284	5658	1842	33364
AT	1838	2426	1132	1059	1231	77	1670	127	8342
BE	3011	3245	2505	1606	1912	171	2742	152	12998
BR	572	639	626	572	1310	241	672	72	4024
BG	37	81	69	343	275	23	85	18	787
CA	15607	11855	12296	8495	6997	501	12838	3025	63604
CL	171	60	279	170	212	17	238	6	972
DK	3616	2131	2518	951	1283	88	1838	318	10995
EG	108	73	80	378	153	11	105	13	769
DE	20093	20294	16084	20726	25800	1342	23721	2332	115395
FI	3983	2840	1799	866	943	51	1675	114	10653
FR	15482	16712	11294	10791	13577	1003	17408	2062	76428
GR	537	516	414	617	624	40	445	68	2771
HK	742	463	371	460	427	19	333	16	2489
HU	256	265	281	722	446	36	291	48	2052
IN	717	805	1347	4203	3228	201	1729	195	10991
IE	613	471	468	230	287	36	390	28	2105
IL	2827	1994	2079	1396	2891	283	3170	135	12797
IT	10908	11660	4602	6887	6848	525	6662	555	42207
JP	21684	26500	18816	27724	28235	799	31280	1378	134428
MX	397	318	547	272	525	59	263	79	2106
NL	9591	10362	7623	4357	4562	347	7097	820	38401
NZ	1472	966	1413	393	380	15	599	291	4890
NO	1809	1367	1347	558	400	63	808	302	5796
CN	208	242	389	2573	3733	200	1125	66	7657
PL	373	360	427	1726	1580	120	690	49	4504
PT	158	217	312	347	207	30	228	37	1275
RO	19	28	18	125	183	13	70	2	374
SA	263	193	73	97	85	6	96	16	700
SG	219	215	155	322	257	25	354	12	1497
ZA	692	458	910	436	343	27	298	129	3069
KR	373	575	544	1725	1920	116	1132	24	5445
ES	4632	3921	4768	6866	3539	382	3935	267	24360
SE	8591	6667	4391	2672	3023	124	5224	385	26828
CH	4781	5162	3930	4112	4522	177	5861	426	25852
TW	1387	1136	1065	1929	1728	71	1803	57	7746
TH	76	57	77	16	18	0	16	0	224
TR	377	394	145	360	269	11	213	38	1490
VE	50	50	86	128	76	11	32	4	383
YU	55	84	23	65	141	15	81	7	420
US	213847	210489	132097	77269	133037	6694	207130	23570	896143
UK	41194	33767	22706	14860	18022	1005	32547	3774	147910
CZ	119	196	309	836	412	30	312	32	1971
SK	87	172	146	349	159	27	141	15	892
RU	249	188	951	3831	6267	381	1919	363	13126
UA	23	32	44	353	817	16	165	6	1334
CR	65	70	59	222	120	10	77	7	518
SI	31	47	77	240	200	34	176	4	644
BY	5	9	6	94	160	29	26	1	311
World	406409	388673	271760	220359	289638	16045	387137	43753	1786650

Table D1. Citation received in 1996-1998 by papers published in 1996. International papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	451	311	651	417	1161	34	435	112	3223
AU	4568	3739	3822	1638	4397	374	4741	1562	23306
AT	2434	3182	1385	695	3191	168	1783	235	11526
BE	3830	5552	2836	1467	3973	226	4864	608	20483
BR	908	1099	1118	518	2525	171	1234	365	7235
BG	30	67	162	310	721	42	245	10	1332
CA	12042	11888	7414	3084	11122	624	13899	2171	57602
CL	235	120	302	210	1173	30	178	62	2184
DK	3188	2682	2182	1114	4405	247	2544	468	15488
EG	193	171	253	214	185	9	216	21	1049
DE	14161	17463	11483	8401	32665	1463	20936	2855	100682
FI	2563	2310	1836	517	3980	98	2133	266	12565
FR	11863	13691	9053	6544	21387	1122	16743	3193	77819
GR	699	889	340	488	1789	65	754	202	5251
HK	473	389	257	595	805	76	471	40	2706
HU	997	716	544	822	2112	95	969	55	5581
IN	411	474	627	884	3298	178	611	142	6274
IE	739	440	381	300	582	67	426	106	2734
IL	2325	1868	1932	1173	5798	484	3692	135	15782
IT	9074	10000	3737	3897	14931	781	8381	674	47406
JP	7641	9516	5085	3616	12823	314	10997	1185	48002
MX	379	346	716	399	1506	99	566	98	3829
NL	6976	7889	4579	2336	8397	308	7266	920	34503
NZ	1402	524	978	482	586	43	649	483	4757
NO	1497	1293	1227	359	1246	86	1296	659	6781
CN	875	763	923	1237	3188	134	1121	450	7804
PL	734	774	610	1455	5319	261	1345	131	9679
PT	278	339	521	517	892	94	444	68	2796
RO	124	104	28	310	745	58	172	17	1358
SA	125	56	70	56	23	2	284	18	600
SG	182	149	171	229	183	21	677	8	1496
ZA	308	337	544	205	743	39	600	268	2889
KR	545	567	674	564	2471	57	803	63	4993
ES	3524	3405	2876	3367	8873	374	3642	396	24621
SE	7575	6411	4334	1866	6108	140	6777	832	30318
CH	6449	9655	4424	2535	11666	266	8554	754	40623
TW	514	464	390	336	1052	39	643	174	3414
TH	426	389	414	52	27	0	72	25	1429
TR	238	182	250	198	272	18	428	59	1459
VE	115	114	173	126	293	27	103	31	865
YU	102	70	13	71	276	18	28	1	550
US	48198	53582	32021	15209	62864	3322	60896	8592	260652
UK	21360	18335	13345	7029	23142	1029	21941	3010	102036
CZ	436	530	969	1242	1908	82	913	107	5354
SK	184	82	354	322	1298	18	405	44	2386
RU	521	758	1776	2200	14443	702	3090	1071	22444
UA	223	70	84	466	1237	108	247	34	2257
CR	72	76	82	156	360	9	97	5	745
SI	37	80	110	161	579	67	179	1	998
BY	24	162	54	81	316	26	189	3	714
World	78827	85824	59552	38617	115571	6568	98238	14879	451737

Table D2. Citation received in 1996-1998 by papers published in 1996. Domestic papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	490	455	638	500	837	93	488	52	2942
AU	8815	5874	7746	3512	4009	391	4674	1506	32577
AT	2103	2144	1148	979	1320	55	1679	79	7922
BE	2832	2969	2253	1833	2089	151	3194	215	13150
BR	793	790	649	680	1310	156	838	75	4478
BG	41	56	96	308	257	16	126	4	750
CA	17035	11850	12210	8885	6257	477	11914	2737	62128
CL	214	102	224	152	236	25	119	8	967
DK	3496	2526	2452	947	1463	114	1875	254	11386
EG	99	74	54	306	153	7	117	9	700
DE	23020	19295	15577	21084	25546	1363	22116	2377	116300
FI	3998	2611	1858	827	1047	35	1694	187	10806
FR	14857	15767	11386	10773	13296	1303	17950	2084	75847
GR	523	464	404	771	522	43	421	103	2775
HK	853	644	355	764	562	69	381	15	3120
HU	378	224	352	713	545	39	339	30	2261
IN	760	890	1339	4174	3633	201	1872	217	11440
IE	642	599	444	257	211	35	245	25	2229
IL	2812	2584	1824	1168	2618	253	3433	143	12367
IT	11912	12369	4642	6936	7469	695	7338	567	45221
JP	22706	26707	17924	27500	29269	766	29670	1137	135442
MX	406	378	545	260	669	98	294	48	2293
NL	9719	9590	6694	4687	4243	314	6592	708	36676
NZ	1140	961	1577	507	322	13	528	404	4899
NO	1365	1258	1247	534	341	42	609	391	5101
CN	223	328	479	3296	3687	295	1344	96	8466
PL	350	423	416	1769	1605	122	598	37	4685
PT	231	196	314	315	245	25	219	29	1296
RO	0	9	20	240	231	30	113	1	536
SA	232	142	73	90	88	19	98	7	656
SG	174	245	225	416	273	53	561	19	1751
ZA	651	332	853	523	291	33	242	164	2845
KR	457	694	777	2330	2253	117	1476	34	6964
ES	4760	4178	4993	6992	4463	534	4404	358	26238
SE	8092	5479	4442	3119	2918	113	4312	526	25200
CH	5354	5378	3920	4002	4787	159	5817	442	26989
TW	1707	1422	1533	2219	1711	100	1966	76	9025
TH	112	83	84	26	15	0	30	0	315
TR	610	488	184	575	339	35	221	53	2147
VE	44	67	83	138	70	5	17	7	390
YU	59	74	38	84	92	17	99	6	406
US	209160	191803	130846	81885	127854	6816	200970	23522	865439
UK	38593	30507	22871	14936	17945	1333	28611	3417	140459
CZ	192	174	332	758	350	47	258	52	1922
SK	61	92	186	267	159	14	132	17	779
RU	230	241	1093	3075	5582	294	1621	292	11505
UA	21	64	43	369	672	21	106	15	1217
CR	65	65	37	204	113	1	75	24	491
SI	56	81	73	159	207	27	103	4	597
BY	0	9	6	71	158	12	28	1	269
World	405730	365249	269393	228193	285750	17124	373243	42902	1754162

Table E1. Mean Expected Citation Rate (MECR) of papers published in 1995. International papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	4.279	4.491	3.340	3.231	4.351	2.441	4.550	2.561	3.877
AU	4.339	5.916	3.886	3.758	4.717	1.402	5.404	3.171	4.561
AT	4.094	5.483	4.699	2.800	4.124	1.229	5.661	2.726	4.480
BE	4.269	5.429	4.182	3.149	4.041	1.733	5.829	3.219	4.619
BR	3.879	4.409	3.050	2.803	4.287	1.982	3.783	3.060	4.035
BG	2.065	3.254	3.861	2.562	3.828	1.766	2.948	2.278	3.082
CA	4.726	6.612	3.914	3.746	4.847	1.352	5.791	3.280	4.955
CL	3.870	3.313	3.386	2.702	5.758	1.418	6.162	2.728	4.441
DK	4.008	6.044	3.779	3.707	4.801	1.859	5.935	3.311	4.830
EG	2.255	3.277	2.272	2.327	2.258	0.720	3.188	1.890	2.542
DE	5.020	6.870	4.546	3.632	4.360	1.870	6.255	3.425	5.041
FI	4.806	6.349	3.915	2.960	4.277	1.427	7.152	3.518	4.952
FR	4.719	6.662	4.378	3.463	4.170	1.685	5.745	3.389	4.835
GR	3.401	5.048	3.810	3.445	4.379	1.666	3.727	2.628	4.006
HK	3.342	5.382	2.678	4.433	3.714	1.249	2.621	4.940	3.490
HU	4.492	4.840	4.200	3.192	3.943	1.430	3.895	2.859	3.856
IN	3.552	3.841	2.790	2.720	4.100	1.583	2.546	2.572	3.371
IE	3.711	4.644	3.276	3.259	3.782	1.704	4.716	2.367	3.962
IL	4.704	7.021	4.487	4.739	5.214	1.587	6.194	2.948	5.168
IT	4.703	6.578	4.218	3.847	4.590	1.852	5.604	2.965	4.941
JP	4.453	6.678	4.454	3.359	4.266	1.942	5.344	3.348	4.876
MX	5.356	4.165	3.019	2.809	4.325	2.055	4.121	3.061	3.913
NL	4.337	6.885	4.214	3.609	4.688	1.488	6.706	3.209	5.264
NZ	4.088	5.643	3.093	3.749	4.850	0.996	5.107	3.127	4.120
NO	3.797	6.400	3.553	3.001	4.619	1.952	6.791	3.126	4.688
CN	3.323	3.534	2.518	2.688	3.322	1.274	2.175	2.828	3.047
PL	3.685	3.615	3.431	2.708	3.684	1.819	3.271	2.495	3.501
PT	4.651	5.043	2.870	3.295	4.028	1.067	4.095	2.538	3.912
RO	5.175	3.329	2.180	2.459	3.396	1.524	2.094	1.811	2.903
SA	2.182	2.662	2.133	1.961	2.819	0.557	1.612	1.200	2.347
SG	5.958	4.587	4.021	3.564	2.064	0.827	3.263	2.033	3.232
ZA	3.472	3.887	2.731	3.542	4.234	1.035	4.867	3.017	3.838
KR	3.391	3.737	3.038	2.762	4.413	1.172	2.235	2.677	3.535
ES	5.054	5.612	3.643	3.595	4.393	1.628	5.014	2.759	4.434
SE	4.158	5.583	4.451	3.696	4.659	1.619	5.618	3.183	4.864
CH	4.796	7.685	4.750	4.061	4.960	2.032	7.835	3.211	5.804
TW	3.024	3.945	3.001	2.955	4.402	1.303	2.727	3.602	3.481
TH	3.462	5.040	2.608	2.478	2.241	0.100	2.719	2.050	3.447
TR	2.054	2.373	2.040	2.515	3.310	0.589	2.407	2.694	2.763
VE	3.986	4.992	2.658	3.248	3.551	1.006	3.376	3.230	3.496
YU	3.064	2.296	2.229	2.094	3.182	0.550	1.757	1.800	2.799
US	4.934	7.552	4.920	3.990	5.275	1.615	6.601	3.565	5.651
UK	4.705	6.715	3.944	3.546	4.423	1.617	6.560	3.310	5.148
CZ	4.069	5.081	2.666	2.937	3.474	1.303	3.184	2.351	3.324
SK	4.337	4.473	2.673	2.140	3.285	1.764	2.852	2.350	3.059
RU	4.371	5.296	4.023	2.469	3.789	1.868	3.463	2.819	3.597
UA	5.587	2.973	1.949	1.892	2.830	2.107	2.075	2.867	2.674
CR	3.969	3.042	2.903	2.862	3.397	0.740	3.463	2.000	3.223
SI	4.642	3.364	3.743	3.171	4.669	2.427	4.891	n. a.	4.462
BY	4.673	3.622	2.748	1.570	2.335	1.467	3.043	0.300	2.327
World	4.505	6.383	4.018	3.371	4.275	1.608	5.436	3.193	4.668

Table E2. Mean Expected Citation Rate (MECR) of papers published in 1995. Domestic papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	2.453	2.664	2.224	2.453	3.190	2.294	2.871	1.604	2.631
AU	2.866	4.430	2.759	3.163	3.265	1.513	3.899	2.613	3.202
AT	2.581	4.149	2.954	2.785	3.141	1.350	4.016	2.203	3.221
BE	3.131	3.864	3.135	3.204	3.346	1.627	3.752	2.443	3.384
BR	2.751	1.813	2.148	2.245	3.333	2.053	2.581	2.042	2.535
BG	1.940	1.663	1.508	2.080	2.121	1.331	1.665	2.078	1.918
CA	3.624	4.590	2.990	3.636	3.436	1.292	3.827	2.678	3.602
CL	1.152	2.162	2.750	1.464	4.241	1.695	3.471	1.140	2.020
DK	2.811	3.392	2.924	3.269	3.937	1.531	4.346	2.510	3.297
EG	2.011	1.306	1.425	1.397	1.478	0.845	1.170	1.290	1.426
DE	2.760	4.131	3.369	3.243	3.461	1.588	4.645	2.905	3.517
FI	3.038	3.955	2.719	2.714	2.936	1.544	3.483	2.237	3.179
FR	2.896	4.136	3.503	3.096	3.157	1.108	4.108	3.118	3.392
GR	1.997	2.367	2.134	2.456	2.876	1.106	2.150	2.099	2.325
HK	2.249	2.652	2.336	3.776	2.602	0.909	1.990	2.455	2.593
HU	2.972	3.221	2.359	2.209	2.630	1.216	2.629	2.496	2.496
IN	1.829	1.837	1.936	2.019	2.630	1.770	2.075	2.197	2.132
IE	2.637	3.208	1.946	3.008	3.373	1.636	2.601	2.129	2.696
IL	2.808	4.190	3.562	4.029	4.338	1.519	4.867	2.377	3.727
IT	3.220	3.674	3.005	3.208	3.181	1.518	3.334	2.332	3.335
JP	3.195	3.842	3.030	3.117	2.884	1.644	3.414	2.663	3.267
MX	3.136	2.711	2.508	1.996	2.618	2.042	2.998	2.785	2.598
NL	3.400	4.842	3.431	3.459	3.587	1.597	4.486	2.621	3.826
NZ	2.431	4.206	2.131	3.152	3.087	0.893	3.683	2.363	2.661
NO	2.783	3.778	2.479	2.714	3.255	1.419	3.118	2.019	2.881
CN	1.181	1.569	2.166	2.158	2.454	1.244	1.663	1.730	2.053
PL	2.696	2.174	2.036	1.868	2.101	1.362	2.028	2.061	2.041
PT	2.897	2.893	2.558	2.735	2.807	0.855	2.499	1.859	2.708
RO	2.090	2.406	2.592	1.069	2.012	0.889	1.483	1.100	1.476
SA	1.931	1.869	1.508	1.706	1.720	1.133	1.221	1.581	1.728
SG	2.057	2.752	2.193	2.632	1.893	0.963	1.661	1.158	2.079
ZA	1.547	2.659	1.848	2.438	2.425	1.270	2.259	2.140	2.000
KR	2.481	2.467	3.016	2.243	2.521	1.590	1.981	2.155	2.373
ES	2.698	3.146	2.841	3.292	3.464	1.477	3.782	2.048	3.130
SE	3.034	4.023	3.345	3.426	3.632	1.331	4.503	2.507	3.561
CH	2.950	6.384	4.104	3.779	3.814	1.667	6.329	2.890	4.331
TW	2.591	3.114	2.503	2.555	2.560	1.212	1.911	2.123	2.470
TH	2.005	2.790	2.066	2.160	2.236	n. a.	1.782	2.900	2.133
TR	1.660	1.698	1.495	1.493	1.865	1.279	1.444	1.749	1.665
VE	3.302	2.791	2.403	2.188	2.575	1.274	2.425	2.233	2.467
YU	2.497	2.420	1.825	1.882	2.228	1.550	1.341	1.771	2.044
US	4.351	6.713	4.563	4.139	4.932	1.434	6.112	3.347	5.086
UK	3.029	4.706	3.380	3.358	3.285	1.322	4.417	2.887	3.622
CZ	2.498	2.945	1.681	1.980	2.275	1.088	1.961	2.226	2.099
SK	1.841	1.748	1.431	1.357	1.669	0.979	1.847	1.871	1.546
RU	0.841	0.749	1.235	0.842	1.338	0.940	1.056	0.646	1.013
UA	2.347	0.710	0.911	1.006	1.108	1.168	1.051	0.888	1.022
CR	2.301	2.289	1.737	2.373	2.827	1.378	1.796	1.669	2.318
SI	2.543	2.566	2.885	2.694	2.522	2.085	2.632	2.533	2.688
BY	1.700	1.027	1.280	0.787	1.100	0.987	0.844	0.169	0.891
World	3.422	4.939	3.460	2.981	3.377	1.379	4.323	2.757	3.693

Table F1. Mean Expected Citation Rate (MECR) of papers published in 1996. International papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	3.801	3.765	3.092	3.018	4.326	2.058	4.282	2.846	3.787
AU	3.778	6.298	3.613	3.480	4.423	1.337	5.648	3.076	4.454
AT	4.067	5.525	4.588	2.793	4.205	1.807	5.391	2.611	4.530
BE	3.699	5.542	3.948	3.303	3.950	1.755	5.408	3.298	4.370
BR	3.316	4.602	2.867	2.790	4.318	1.978	3.723	3.235	3.826
BG	2.452	2.997	3.603	2.831	3.740	1.384	2.969	1.580	3.160
CA	4.505	6.907	4.318	3.850	5.097	1.307	6.569	3.093	5.176
CL	3.874	4.950	3.982	2.431	5.274	1.138	3.594	3.262	4.301
DK	4.057	5.180	3.925	3.746	5.122	1.980	5.735	3.149	4.742
EG	2.167	2.977	2.281	2.258	2.193	0.940	2.318	1.778	2.380
DE	4.662	6.720	4.750	3.605	4.326	1.894	6.377	3.395	4.975
FI	4.346	5.734	3.485	3.303	4.248	1.497	5.389	2.687	4.528
FR	4.717	6.431	4.578	3.426	4.246	1.784	5.887	3.279	4.796
GR	3.547	5.470	3.203	3.233	4.279	1.618	4.113	2.798	4.089
HK	2.956	3.421	3.048	3.688	3.914	1.080	2.434	2.489	3.282
HU	5.001	4.813	3.926	3.297	4.342	1.714	4.558	2.508	4.185
IN	3.253	4.031	2.807	3.178	3.773	1.758	2.573	2.774	3.446
IE	3.513	4.077	2.544	3.417	3.579	1.733	3.630	2.675	3.416
IL	4.518	6.744	5.209	4.451	5.147	1.655	5.998	2.746	5.103
IT	4.495	6.237	4.104	3.897	4.545	2.010	5.701	2.931	4.861
JP	4.644	6.645	4.188	3.277	4.202	1.688	5.844	3.061	4.877
MX	3.895	4.722	3.023	2.663	4.192	1.808	4.099	2.719	3.708
NL	4.125	6.855	4.346	3.515	4.476	1.619	6.818	3.261	5.075
NZ	4.104	4.331	3.099	3.956	4.419	0.979	4.101	2.914	3.814
NO	3.290	4.349	3.198	2.749	4.646	1.491	4.409	2.924	3.810
CN	3.353	3.389	2.513	2.862	3.562	1.194	2.134	2.533	3.132
PL	3.307	3.296	2.964	2.823	3.466	1.731	3.089	2.265	3.326
PT	3.213	5.175	3.475	3.659	3.653	1.882	3.714	2.532	3.634
RO	3.995	4.876	3.395	2.320	3.183	1.320	2.190	2.120	2.907
SA	2.340	3.388	1.845	2.167	1.922	0.670	3.855	1.625	2.735
SG	3.435	4.552	3.864	3.429	2.022	0.903	2.999	1.920	3.136
ZA	2.448	3.622	2.591	2.563	3.794	1.485	6.227	4.230	3.774
KR	3.638	4.097	3.611	2.722	4.094	1.115	2.487	2.471	3.409
ES	4.615	5.232	3.639	3.772	4.466	1.657	4.874	2.487	4.442
SE	4.007	5.857	4.006	3.744	4.554	1.865	6.126	3.098	4.836
CH	4.542	8.439	5.306	3.951	5.103	1.881	8.022	3.143	5.842
TW	3.432	4.205	3.431	3.248	4.573	1.193	2.500	3.416	3.668
TH	3.157	4.125	2.484	2.213	1.632	n. a.	2.763	1.818	3.246
TR	2.565	3.770	2.492	2.431	2.968	1.105	3.424	2.128	2.986
VE	4.322	3.621	3.138	3.002	3.663	1.583	3.228	2.782	3.661
YU	3.143	2.867	3.019	2.122	3.451	1.908	2.134	1.733	2.875
US	4.865	7.472	4.943	4.073	5.271	1.580	6.825	3.527	5.615
UK	4.448	6.225	4.013	3.595	4.326	1.677	6.300	3.070	4.942
CZ	3.273	3.931	3.154	2.829	3.579	1.375	3.147	2.196	3.228
SK	3.115	2.609	2.998	2.335	3.472	1.324	3.542	1.505	3.085
RU	3.659	4.639	3.907	2.467	3.596	1.909	3.545	2.924	3.464
UA	6.487	2.339	2.433	2.023	2.543	1.890	1.797	2.055	2.434
CR	3.174	3.139	3.532	2.763	3.754	1.045	3.040	3.225	3.213
SI	2.935	3.396	2.587	3.102	4.397	1.881	3.155	1.650	3.564
BY	1.863	3.230	1.859	2.065	2.223	1.500	2.644	1.833	2.428
World	4.329	6.267	4.025	3.403	4.246	1.615	5.497	3.095	4.597

Table F2. Mean Expected Citation Rate (MECR) of papers published in 1996. Domestic papers

Country	MED	BRE	BIO	CHE	PHY	MAT	ENG	ESS	Total
AR	2.287	2.488	2.115	2.643	3.217	2.341	2.441	2.063	2.543
AU	2.746	4.259	2.617	3.100	3.181	1.490	3.655	2.454	3.093
AT	2.697	3.792	2.838	2.650	2.989	1.127	4.234	2.337	3.157
BE	2.883	3.680	2.894	3.276	3.097	1.583	3.423	2.360	3.202
BR	2.465	1.939	2.127	2.489	3.473	1.967	2.522	2.331	2.545
BG	2.109	1.680	1.752	2.067	1.936	1.177	1.874	1.590	1.911
CA	3.586	4.571	3.006	3.800	3.568	1.220	4.042	2.464	3.612
CL	1.155	2.396	2.494	1.553	4.363	1.485	3.087	3.100	2.098
DK	2.795	3.418	2.879	3.076	4.067	1.676	4.253	2.416	3.259
EG	1.833	1.344	1.114	1.256	1.464	1.033	1.097	1.367	1.356
DE	2.862	4.131	3.470	3.326	3.299	1.617	4.380	2.997	3.517
FI	3.016	3.592	2.701	2.748	3.167	1.090	3.536	2.158	3.165
FR	2.789	4.046	3.596	3.095	3.117	1.282	4.186	2.756	3.372
GR	2.268	2.278	1.778	2.585	2.822	1.189	1.918	2.601	2.373
HK	2.311	2.763	2.423	3.911	2.867	1.237	1.748	1.580	2.604
HU	2.979	2.437	2.723	2.287	3.041	1.195	2.942	1.642	2.642
IN	1.947	1.848	2.064	2.070	2.672	1.676	1.946	2.226	2.162
IE	2.656	3.247	1.800	3.154	3.470	1.452	2.526	2.040	2.664
IL	2.783	3.979	3.579	3.910	4.177	1.598	4.471	2.801	3.560
IT	3.009	3.616	3.160	3.237	3.231	1.560	3.516	2.323	3.297
JP	3.061	3.632	2.942	3.055	2.850	1.552	3.174	2.524	3.152
MX	2.528	2.386	2.448	2.321	2.540	1.813	2.312	2.542	2.495
NL	3.359	4.421	3.447	3.449	3.439	1.445	4.528	2.655	3.733
NZ	2.187	3.678	2.125	3.033	2.430	0.918	3.053	2.413	2.527
NO	2.584	3.420	2.458	2.880	2.704	0.932	2.934	2.724	2.816
CN	1.192	1.559	2.177	2.183	2.396	1.171	1.575	1.783	2.117
PL	2.065	2.026	2.011	2.049	2.125	1.353	2.044	1.841	2.070
PT	2.670	2.740	2.387	2.614	2.832	1.017	2.107	2.295	2.552
RO	2.211	1.859	2.575	1.105	1.897	0.936	1.441	1.533	1.445
SA	1.550	1.694	1.497	1.657	1.809	0.824	1.402	1.880	1.625
SG	2.043	2.482	2.747	2.828	2.116	0.953	1.911	1.589	2.278
ZA	1.369	2.483	1.945	2.693	2.826	1.293	2.141	2.954	2.022
KR	2.097	2.149	2.999	2.367	2.554	1.561	1.915	2.334	2.360
ES	2.721	3.346	2.873	3.312	3.546	1.368	4.001	2.067	3.202
SE	2.930	3.674	3.322	3.578	3.741	1.403	3.998	2.619	3.392
CH	3.009	5.695	4.106	3.860	3.789	1.653	6.175	2.584	4.258
TW	2.209	2.985	2.791	2.563	2.338	0.929	1.830	2.343	2.367
TH	2.085	2.385	2.110	2.152	1.533	n. a.	1.558	0.900	2.092
TR	1.575	1.839	1.571	1.626	1.893	1.236	1.425	2.004	1.695
VE	1.989	2.454	2.392	2.489	2.965	1.577	2.240	1.830	2.350
YU	1.592	2.208	2.000	1.995	2.210	1.877	1.354	2.433	1.891
US	4.349	6.370	4.591	4.317	4.927	1.494	6.114	3.458	5.050
UK	3.070	4.476	3.290	3.366	3.211	1.531	4.212	2.657	3.561
CZ	2.183	2.180	1.637	1.494	2.072	1.229	2.036	1.663	1.746
SK	1.454	1.272	1.283	1.109	1.764	0.891	1.855	1.324	1.344
RU	1.522	0.683	1.300	0.869	1.187	0.861	1.023	0.718	0.992
UA	3.374	0.910	1.116	1.004	1.039	0.958	0.814	0.812	0.980
CR	1.921	1.875	1.550	2.261	2.415	0.956	2.398	2.933	2.114
SI	2.279	3.185	2.298	2.356	3.126	1.527	1.827	2.180	2.515
BY	2.400	1.114	0.609	0.950	1.123	1.473	0.628	0.164	1.035
World	3.393	4.672	3.458	3.074	3.315	1.412	4.234	2.763	3.645

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