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Performance and Structures of the German Science System 2011

Germany in an international comparison,
China's profile, behaviour of German authors,
comparison of the Web of Science and Scopus

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Studien zum deutschen Innovationssystem
Nr. 9-2012

Fraunhofer Institute for Systems and Innovation Research

Karlsruhe, February 2012

This study was conducted on behalf of the Expertenkommission Forschung und Innovation (EFI). The results and interpretations are the sole responsibility of the institute conducting the study. The EFI exercised no influence on the writing of this report.

Studien zum deutschen Innovationssystem

Nr. 9-2012

ISSN 1613-4338

Publisher:
Expertenkommission Forschung und Innovation (EFI)
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Publications in an international comparison

In the last decade, publications in internationally relevant journals covered by the database Web of Science exhibit a substantial suppression of industrialised countries by threshold countries, first of all China. This phenomenon primarily implies a decrease of the share of US-American publications, and there is also a visible effect on Germany. However the German share stabilizes since 2008 and even re-increases a little bit in 2010.

Germany exhibits a citation level clearly above the world average. Disaggregating the citation rate into the indices Scientific Regard (SR) and International Alignment (IA), the SR index of Germany proves to be very high compared to other large industrialised countries including the United States. The indices of smaller European countries are a little bit higher, those of threshold countries generally substantially lower. As to the IA index, Germany is in the fore of the large industrialised countries. Major exceptions are Great Britain and even more the United States which due to their language advantages achieve higher IA scores. The IA indexes of the small European countries appear to be higher than the German ones, those of the threshold countries massively lower.

Comparing the focal points of the disciplinary activities, the large West-European countries show a high similarity and constitute a cluster. The smaller European countries, Great Britain and Canada prove to be near the US-American profile. The Southeast Asian countries represent a further cluster, but China has a separate unique orientation.

China's profile

In the last years, the publication numbers are tremendously growing. The Scientific Regard of Chinas publications developed from a very low level to a level above the world average, but the International Alignment is still clearly below average. The profile of China shows a clear focus on few areas, in particular electrical engineering and computers but also fields related to chemistry, and in these focal areas, also the International Alignment is above the world average. The share of universities in the Chinese publications is very high whereas the relevance of the Academy of Science is still strong, but decreasing.

The behaviour of German authors

German authors have substantially changed their behaviour in the last 20 years. Between 2000 and 2007 they moved from specialist to more mainstream journals and, since the early 1990s, they attempted to have their articles published in journals with a high impact factor. The strong upward trend of the average citation rates linked to a growth of the IA index is primarily due to a growing share of articles published in journals with American editorship, the co-authorship with American researchers, and to the move towards mainstream journals. This change has not affected the SR index. Thus German authors achieve a high Scientific Regard also in journals with higher impact factors.

Comparison of Web of Science and Scopus

Comparing the new large bibliometric database Scopus and the long established Web of Science (WoS), the coverage of Scopus and the WoS differ to a large extent, in particular as Scopus covers a substantial share of articles exclusively. The number of articles and proceedings in Scopus is higher than in the WoS. The main differences are the broader coverage of engineering in terms of articles and proceedings in Scopus as well as its better coverage of Chinese publications. Other developing and threshold countries are also recorded in Scopus to a larger extent. These differences imply different citation rates and derived indicators, but the ranking of countries and the major trends in the WoS are largely reproduced in Scopus. However, some discrepancies in Scopus with reference to the WoS can be observed for the threshold countries. At the moment it can not be stated who has the "correct" values, but a closer look at the database coverage is required. In any case, Scopus proves to be a valuable complement to the WoS, essentially in analyses of engineering and then of threshold countries.

1. Introduction to this issue

The scientific capability of a country is an essential basis for its technological performance, which is why this topic has been regularly analyzed for many years in studies of the German innovation system. The crucial contribution of science to technology development and to providing high level services consists in educating highly skilled personnel whose quality depends to a considerable extent on their research capability. It goes without saying that the results of scientific research are also an essential basis for technological development, although the connections between science and industry are frequently indirect and less obvious, particularly because substantial time lags can frequently be observed between the relevant scientific activities and their impact on technology and services.

Scientific performance is difficult to measure, especially as the structures of the individual disciplines often vary distinctly. Statistical analyses of publications by experts have proved to be meaningful, inasmuch as they are conducted with a particular regard for methodology. The analyses presented here refer not only to science areas with a close link to technology, but to the natural, life, engineering and social sciences as a whole. In this context, the number of publications and citations is analyzed as a performance indicator in an international comparison. Citations are thereby used in particular as an indicator of scientific impact.

In this study, the scientific performance of German authors is analyzed in an international comparison covering the period between 2000 and 2010. In addition, the specific scientific profile of China is examined, as in the last decade China has become a mayor player in science and a closer look is necessary to appropriately assess these activities. In the next chapter, the publication behaviour of German authors, which substantially changed in the last twenty years, is investigated in more detail. Finally, the bibliometrical databases Web of Science and the recently introduced database SCOPUS are compared with regard to their coverage of fields, countries and document types, in order to arrive at a better picture of the new features in Scopus.

2. Methodological basis

The bibliometrical analyses are conducted on the basis of the Science Citation Index Expanded (SCIE) as well as the Social Science Citation Index (SSCI)[1]. Both form a multidisciplinary database with a broad coverage of fields. The searches refer to the natural and engineering sciences, and the medical and life sciences as well as the social sciences. The Web of Science provided by the producer Thomson Reuters primarily covers English language expert journals which is not problematical for most fields, as German scientists also increasingly publish in English-language journals. However, the German engineering and social sciences, where many publications and articles are still published in German, are not sufficiently covered. Generally, economics and psychology represent exceptions in the social sciences, as quite a large share of the articles is already published in English language journals.

In general, the SCIE and the SSCI cover highly cited journals, i.e. journals with high visibility where already the fact of placing a publication covered by the SCIE or SSCI, respectively its publication in a journal covered by the SCI or the SSCI, may be considered as a first quality indicator.

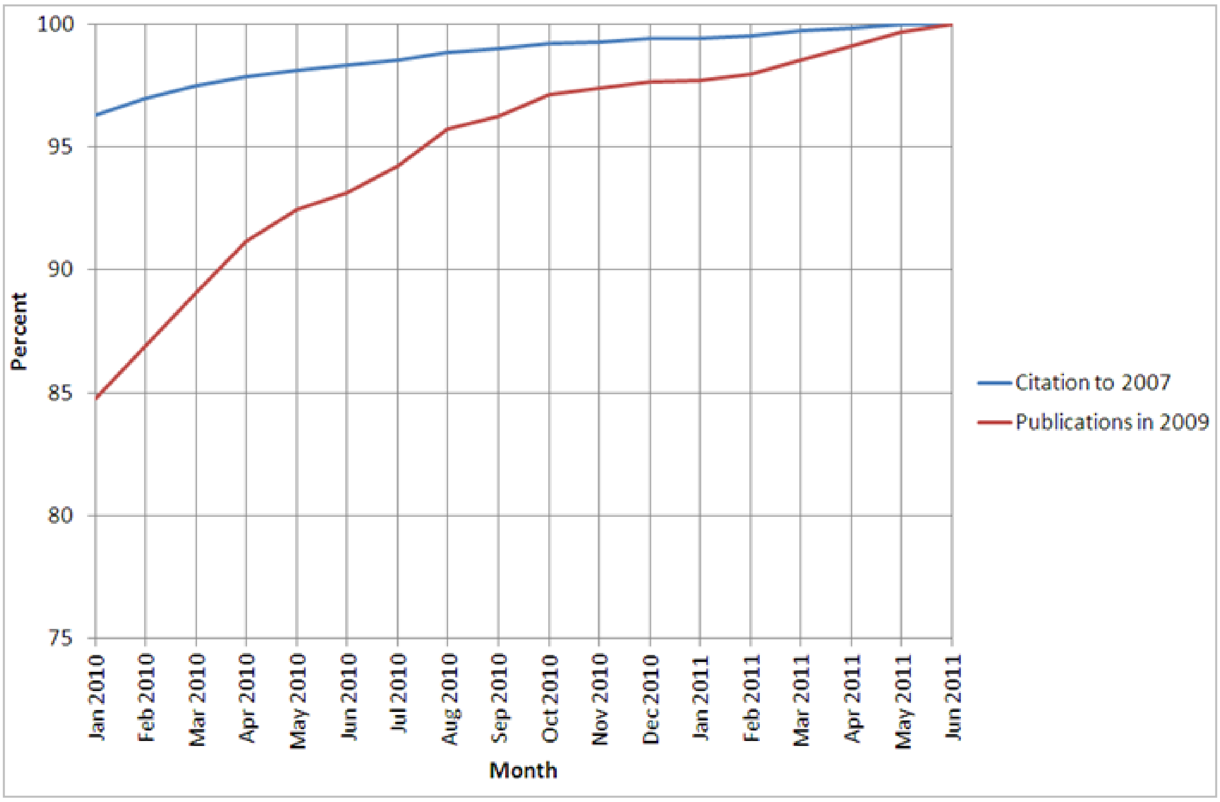
In addition to the absolute number of publications, citations are used as an indicator of scientific performance. To calculate citation rates, the citations of the respective publication year of the article are considered as well as the two subsequent years. A citation window of three years is therefore analyzed. Hence citation rates can only be examined until the year 2008.

In principle, other studies use citation windows of five years. In a methodological perspective, these figures are surely more precise, but they do not allow for really topical results. For this reason citation windows of three years were used in the present context.

In order to check the completeness of the current data, the situation of the publication year 2009 was retrospectively examined. With an update until June 2010 – for the present study for 2010, data until June 2011 were available – the findings show that more than 98% of all citations for 2007 were available in June 2010 and 93% of the publications for the year 2009. The delayed inclusion of publications for 2009 still in April 2011 is due to the fact that some journals transfer their data relatively late to the database producer Thomson Reuters. The citations for 2007 were thus quite complete in June 2010. The sample of publications for the year 2009 was quite large, so that statistically relevant conclusions for 2009 were possible. It can be assumed that in June 2011 the situation for the publication year 2010, respectively the citation year 2008 are similar.

1 The SCIE and the SSCI are subproducts of the database Web of Science (WoS).

Figure 1: Completeness of publications of the year 2009 and of the citations to publications in the year 2007 in the citation window 2007 to 2009, with monthly updates in the period January 2010 until June 2011 in the databases SSCI and SCIE



Source: Web of Science, searches and calculations by Fraunhofer ISI.

Due to the substantially extended coverage of journals in the SCIE and SSCI, it is not useful to compare absolute publication numbers in the context of country comparisons. For instance, the number of journals covered in the databases increased between 2000 and 2008 by 29%, the number of papers even by 34%. Therefore, the distinction between the real increase of publication activities and the extension of the database coverage is only feasible with enormous methodological efforts in the context of trend analyses (Michels/Schmoch 2011). Against this background, the shares of countries in the database and not the absolute numbers were taken into consideration.

A further important methodological decision is whether, in the context of country comparisons, the publication should be counted in a fractional way or by so-called whole counts. Scientific publications are increasingly written by several authors from different countries. For instance, in the year 2006, up to 44% of all publications of German origin were written in cooperation with at least one foreign partner (Hinze et al. 2008). For the whole count analysis, each country appearing in the publication gets the value one, the appearance of several authors from one country is not taken into account. For a fractional counting, the share of a country in a publication is based on the number of participating countries. If, for instance, a publication is written by German and French authors, the fractional counting implies 50% of the publication for each country. With their whole count both countries get the value one. In a mathematical, statistical perspective, the use of fractional counting is obvious, as the sum of the country shares is equivalent to the total number of publications. Therefore the derived indicators can be more easily calculated.

However, a comparison of the results for whole counts with the fractional analysis shows that the shares of the countries in publications differ considerably, as the example for the year 2010 and Table 1 illustrates. Thus the share of the United States in all publications of the database is reduced from 28.0 to 23.9%, the German share from 7.3 to 5.4%, and that of Great Britain from 7.8 to 4.9%. This can be expected mathematically, as all publications are also taken as reference in the whole count analysis.

Table 1: Share of selected countries within all SSCI and SCIE publications of 2010 according to fractional and whole counting and resulting country relations

	Whole count	Fractional	Whole/ Fractional	Whole count	Fractional
USA	28.0	23.9	1.17	2.54	2.41
Japan	6.0	5.3	1.14	0.55	0.53
Germany	7.3	5.4	1.34	0.66	0.55
Great Britain	7.8	4.9	1.59	0.71	0.5
France	5.2	3.9	1.35	0.48	0.39
Switzerland	1.8	0.9	2.12	0.17	0.09
Canada	4.5	3.4	1.34	0.41	0.34
Sweden	1.6	1.1	1.47	0.15	0.11
Italy	4.3	3.3	1.28	0.39	0.34
Netherlands	2.6	1.8	1.41	0.24	0.19
Finland	0.8	0.6	1.41	0.07	0.06
South Korea	3.3	2.9	1.15	0.3	0.29
Brazil	2.6	2.3	1.14	0.23	0.23
India	3.4	3.1	1.12	0.31	0.31
China	11	9.9	1.11	1	1
Other countries	36.1	27.3	1.32	3.28	2.75
Total	126.3	100			

Source: Web of Science, searches and calculations by Fraunhofer ISI.

However, the considered countries are affected to different extents: the share of Japan is reduced by 14%, for Germany the value is reduced by 34%, that of Switzerland even by 112%, but for China only by 11%. Generally, countries that have a high share of co-publications with authors from foreign countries are affected by a strong reduction of the calculated shares if using the fractional counting; in contrast, more isolated countries achieve a relatively higher weight according to fractional counting. This difference is illustrated in Table 1 by the relation between the shares according to whole and fractional counting in column 4. For instance, this relation for China is 1.11, for Germany 1.34 and for Switzerland 2.12. This has a considerable effect on the relation between countries as documented in columns 5 and 6 of Table 1. If China is taken as the reference unit, Germany gets the value 0.66 according to whole and 0.55 according to fractional counting; for Switzerland this relation is 0.17 for whole and 0.09 for fractional counting. Thus the decision to use either whole counting or fractional counting is crucial.

As to the appropriate assessment of the results, one may ask whether this effect of fractional counting is really aimed at. It can be assumed that publications in cooperation with foreign authors have a higher weight than purely national publications. For writing international publications entails considerable efforts to coordinate with the foreign partners. The fractional counting of publications leads to a devaluation of the resulting publications of international collaborations. In order to appreciate these efforts and to avoid the implicit devaluation, it seems more appropriate to use the whole count approach. This also reflects the views of the federal German government formulated in the internationalization strategy (BMBF 2008), to achieve inspiration through cooperation with the international elite.

In addition to the publication numbers of the countries considered, a specialization index is calculated to compare the distribution of publication activities in different fields. For this purpose, the share of publications by country in a specific field is compared to the share of this field within all worldwide publications. If the share of a country in a field is equivalent to the worldwide share, this implies a neutral value of one. Values above one indicate that the publication activity of a country is above the worldwide average in this field. Values below one indicate that a publication of the country in this field is below average. The described relation has a disadvantage, in that its distribution is extremely uneven and that the range of values is between 0 and + ∞. There are transformation methods where the specialization index has a neutral value of 0 and the range of value is between - 100 and + 100; this derived indicator proves to be more illustrative for graphics and interpretation. This so-called RLA index (RLA = Revealed Literature Advantage) is calculated as follows:

$$RLA_{ij} = 100 \tanh \ln [(Publ_{ij} / \sum_i Publ_{ij}) / (\sum_j Publ_{ij} / \sum_{ij} Publ_{ij})]$$

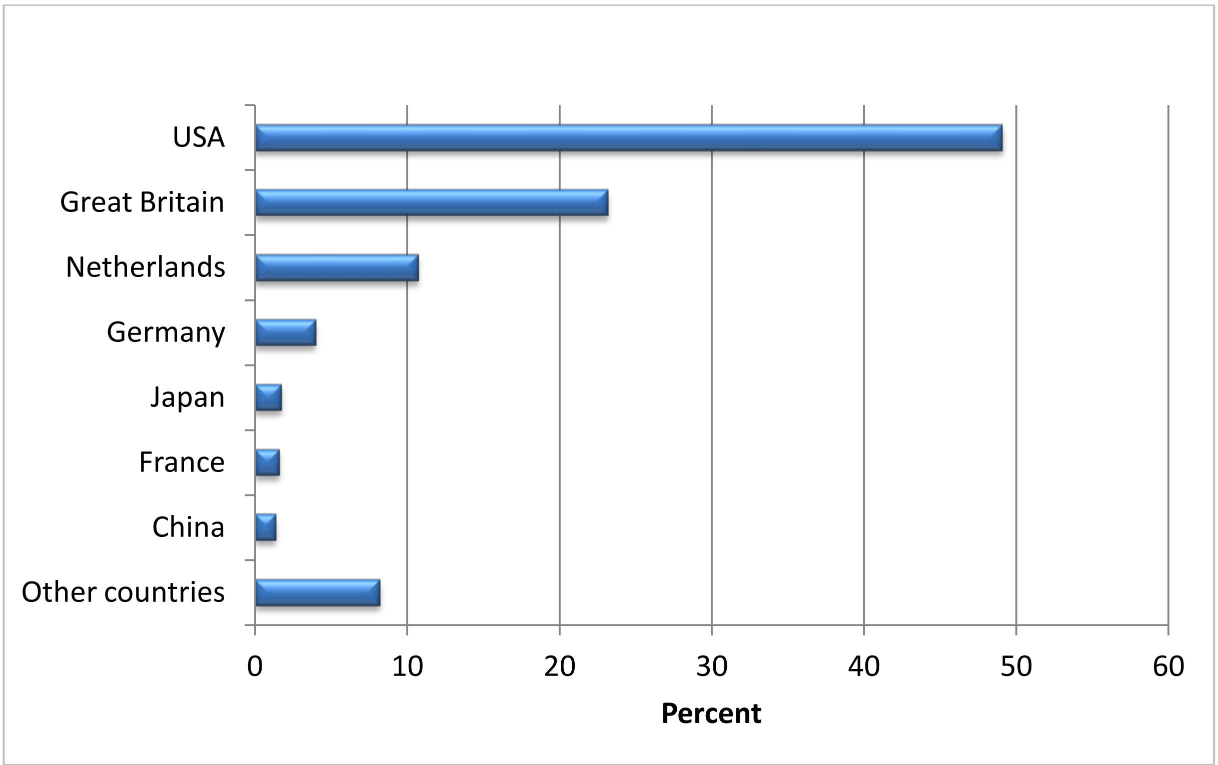
whereby i represents the country and j the field. The RLA index is constructed in such a way that positive values indicate a positive specialization, negative ones a specialization below average, whereby the world average is used as reference.

An additional problem is that the field profiles of the 16 analyzed countries are quite difficult to compare, due to the multitude of data. So-called multi-dimensional scaling (MDS) was used to improve the visualization of the results. A vector of 27 dimensions referring to the specialization in 27 fields is calculated for each country. Then the similarity of all vectors is calculated as Euclidian distance and projected in a two-dimensional space. Therein, the axes have no meaning; however, the local proximity, respectively the distance between different countries indicates the similarity or dissimilarity of the country profiles. Thus it is possible to illustrate the quite complex information of country profiles in a useful way.

Enormous differences in the publication and citation behaviour become visible when the citation rates of different fields of science are observed. For instance, the number of citations in biotechnology is distinctly higher than in mathematics. Therefore citation rates of different fields should not be compared directly. Against this background, the Dutch research group CWTS (Centre for Science and Technology Studies) in Leiden has suggested standardizing the observed citation rates with field- or discipline-specific expected citation rates to achieve comparability. This field-specific average value is determined by calculating the average citation rate for all publications in journals belonging to the field of the publication considered (Van Raan 2004).

This field- or discipline-specific standardization, sometimes called "Crown indicator", is – without any doubt – a substantial improvement on the consideration of pure citation rates. However, it does not taken into account that the databases of Thomson Reuters primarily cover American publications and that they achieve especially high citation rates due to the size of the country and, linked to that, the broad readership and good visibility of American journals. Consequently, the average values of the disciplines are dominated by American averages (Figure 2). It has to be asked whether such a reference is appropriate for a country like Germany that has its own large language area and where many publications are written in German.

Figure 2: Share of publications in the Web of Science by country of journal editors, 2009



Source: Web of Science, searches and calculations by Fraunhofer ISI.

A second problem already described is that the data coverage of SCIE and SSCI was enhanced massively by Thomson Reuters and thus a number of very small journals was added. Small, specialized journals have a smaller readership and therefore have lower citation rates than big, mainstream journals (Michels/Schmoch 2011). In consequence, the field average in recent years consists increasingly of a mix of large and small journals which have quite different citation rates. It is questionable whether the field average can be any longer used as a meaningful unit. In any case, in the field-specific averages, the effects of American dominance and of heterogeneous journal size are intertwined in an unclear way.

Against this background, Fraunhofer ISI has used journal-specific expected citation rates for the reports on the technological competitiveness of Germany commissioned by the BMBF and the Commission of Experts on Research and Evaluation (EFI) (Grupp et al. 2001). The derived indicator "Scientific Regard" (SR) shows whether the publications of a country/ region are cited above average or below average, compared to the other articles in these journals where the considered articles are published. In this way, it can be taken into account that non-American and small journals are cited less frequently, so that in these cases lower reference values are assumed. Vice versa, the reference value for articles in highly cited journals is relatively higher. Here positive indices show, similar to the specialization index, above-average citation rates; values of 0 are equivalent to the world average. The indicator is calculated as follows:

$$SR_k = 100 \tanh \ln (OBS_k/EXP_k)$$

In this formula OBS_k refers to the actual observed citation frequency of publications of country k. EXP_k is the expected citation rate resulting from the average citation frequency of the journals where the authors of this country published their papers.

The differences induced by the calculation of field- and journal-specific expected citation rates are illustrated in Table 2. In the analysis with self-citations[2] ,the USA obtain a field-specific index (F index) of 1.41 compared to a journal-specific index (J index) of 1.15. For Germany, this implies values of 1.31 respectively 1.19. The J indices are mostly lower than the F indices. However, it is decisive that the countries are affected differently. According to the F index, the USA has a rank of 3 and a J index rank of 9. Germany has a rank of 8 according to the F index and a rank of 4 according to the J index. This reflects the improved consideration of the language bias by the J index. Smaller countries, such as the Netherlands where the authors have a generally stronger orientation to English-language journals, are less affected by the differences between the F and the J index in any case.

For the purpose of illustration, the observed citation rates are documented in Table 2 as well. These would again imply a different ranking and in particular favour the USA. Then the good position of the USA could be linked to a pure size effect: Without putting the citation rates in relation to the field- or journal-specific expected citation rates, it becomes apparent that the USA employ a high number of researchers living in this language area who cite each other extensively. It has to be taken into account that the USA have some excellent universities, but also many less research-active ones, so that the lower position with regard to the F or J indices appears to be adequate.

2 As to the relevance of self-citations, see further below.

Table 2: Indices of expected citation rates for selected countries according to different definitions for all fields of the Web of Science, 2007

Country	J index eSC	J index wSC	F index wSC	Obs citations	Rank J eSC	Rank J wSC	Rank F wSC	Rank obs cit
Switzerland	1.15	1.26	1.59	6.2	1	1	1	1
Netherlands	1.10	1.20	1.52	5.8	2	3	2	2
Finland	1.09	1.20	1.34	4.8	3	2	6	8
Sweden	1.09	1.17	1.37	5.2	4	6	5	4
Great Britain	1.08	1.19	1.37	5.1	5	5	4	5
Germany	1.08	1.19	1.31	4.8	6	4	8	6
USA	1.07	1.15	1.41	5.5	7	9	3	3
Canada	1.06	1.16	1.32	4.8	8	8	7	7
China	1.05	1.10	0.83	2.8	9	11	13	13
France	1.04	1.16	1.26	4.5	10	7	9	9
Italy	1.03	1.14	1.21	4.4	11	10	10	10
South Korea	0.97	1.04	0.88	3.0	12	12	12	12
Japan	0.93	1.01	0.96	3.5	13	13	11	11

Index: observed/expected citations
F = field-specific
J = journal-specific
wSC = with self-citations
eSC = self-citations excluded

Source: Web of Science, searches and calculations by Fraunhofer ISI.

The indicator “International Alignment (IA)” shows whether the authors of a country publish in internationally more or less visible journals, compared to the world average. A high share of publications in internationally visible journals documents an intensive participation in the international scientific discourse. Similarly to the SR index, positive values point to an above-average orientation. Values of 0 correspond to the world average. The IA index is calculated as follows:

$$IA_k = 100 \tanh \ln (EXP_k/OBS_w)$$

The same definitions as for the SR index apply. The index w refers to the world in total.

In any case, the decision to prefer journal-specific citation rates allows a better analysis of high citation rates by the SR and IA indices. We can examine whether they are based on scientifically valuable publications, or on a good ranking of a publication, or the placement of a publication in an internationally highly visible journal.

A further methodological question is whether the citation rates should be calculated with or without self-citations – in this context we refer to author self-citation – not journal or country self citation. Here various arguments for or against the inclusion of self-citations are given in the literature (Costas et al. 2010; Glänzel et al. 2004). The arguments against the inclusion of self-citations are that only citations by other scientists can be associated with the concept of impact and that the regional habits regarding the use of self-citations differ considerably. In particular, in Anglo-Saxon countries, fewer self-citations are used than in many other countries; for the year 2007 the share for Germany and France was 27%, for Great Britain 23% and for the United States 21%, respectively. It is not possible to derive any meaningful quality differences from these different shares of self-citations. When the self-citations, are excluded, Germany deteriorates two places in the ranking and lags behind Sweden and Great Britain (Table 2). An argument in favour of including self-citations is that their consideration is essential in new fields. If there are many co-authors, excluding self-citations removes many relevant citations and in particular, the elimination of self-citations is, due to homonyms[3], precarious, so that a certain, however limited, rate of error has to be taken into account. This report follows the recommendation of CWTS to exclude self-citations. In any case, the difference between the two ways of counting is not substantial.

[3] For the purpose of this report, the term homonym is used as defined by Aksnes (2008)

3. Publications in an international comparison

Looking at the shares of selected countries within all publications (Table 3), it becomes obvious that the percentage of Germany is slowly, but steadily decreasing, an effect which can be similarly observed for other large industrialized countries such as the USA, Japan, Great Britain or France. This observation is primarily due to a substantial growth of publications from various threshiold countries, first of all China. However, this phenomenon does not affect all industrialized countries to the same extent: when the publication share of a country in the year 2000 is set to 100, the index for Germany in the year 2010 is 90 (Table 4); in the United States the decrease was somewhat higher with an index of 87, in Japan with 70 however it was considerably higher. The German share stabilizes since 2008 and even re-increases a little bit in 2010. It is remarkable that the publications of Canada, Italy, the Netherlands and Switzerland even increased in the last years. For South Korea the index for the year 2010 is 206, for Brazil 201, for India 169, for South Africa 142 and for China 316. That is the increase of South Africa is substantial, but moderate compared to other threshold countries.

Table 3: Shares of selected countries and regions in the SCIE and the SSCI within all publications (whole counts)

Country/ region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
USA	32.1	31.9	31.7	31.5	31.3	30.9	30.3	29.4	28.7	28.1	28.0
Japan	8.7	8.6	8.6	8.5	8.2	7.8	7.4	7.0	6.6	6.3	6.0
Germany	8.1	8.2	8.1	7.8	7.8	7.8	7.6	7.4	7.2	7.2	7.3
Great Britain	9.3	9.0	8.7	8.6	8.5	8.3	8.3	8.2	7.9	7.8	7.8
France	5.9	5.9	5.8	5.7	5.6	5.5	5.4	5.3	5.3	5.3	5.2
Switzerland	1.7	1.7	1.7	1.7	1.8	1.7	1.8	1.8	1.7	1.8	1.8
Canada	4.2	4.1	4.2	4.3	4.3	4.5	4.5	4.5	4.5	4.5	4.5
Sweden	1.8	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6
Italy	3.9	4.0	4.0	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3
Netherlands	2.3	2.3	2.4	2.4	2.4	2.5	2.4	2.4	2.4	2.5	2.6
Finland	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.8	0.8	0.8	0.8
South Korea	1.6	1.9	2.0	2.3	2.6	2.6	2.7	2.7	2.9	3.1	3.3
China	3.5	4.1	4.5	5.2	6.1	7.1	8.1	8.6	9.2	10.2	11.0
Brazil	1.3	1.4	1.5	1.5	1.7	1.7	1.8	2.2	2.5	2.6	2.6
India	2.0	2.2	2.2	2.4	2.4	2.6	2.7	3.1	3.3	3.3	3.4
South Africa	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
EU-15 countries	35.0	35.0	34.8	34.3	34.1	33.8	33.6	33.2	32.6	32.5	32.4
EU-12 countries	3.1	3.3	3.3	3.4	3.5	3.4	3.5	3.9	4.1	4.1	4.1
EU-27 countries	40.2	40.5	40.5	40.3	40.2	40.1	40.2	40.7	40.9	40.8	40.8
World	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Web of Science, searches and calculations by Fraunhofer ISI.

In comparison to the south-east Asian countries, most of the new, generally east or central European EU-12 countries increased their share of publications between 2000 and 2010 as well, but to a much lower extent than can be observed for the threshold countries mentioned above.

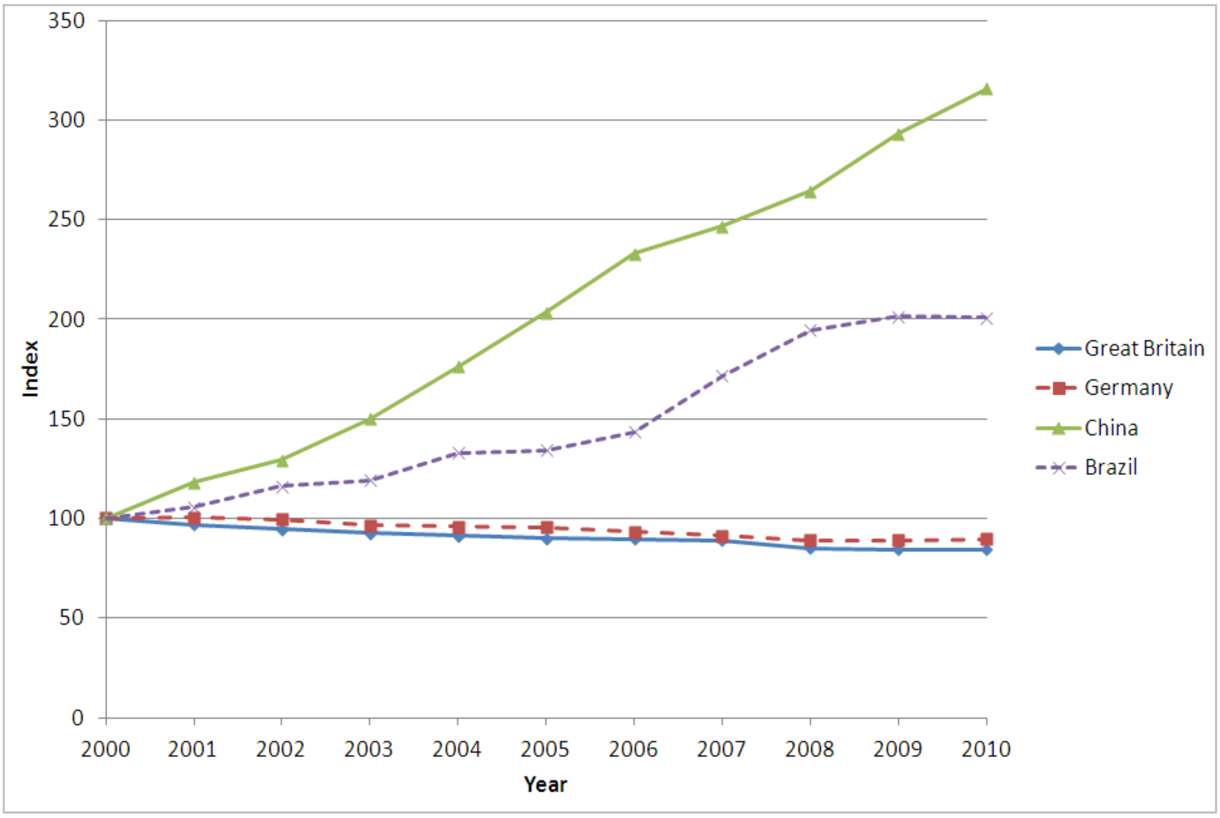
Table 4: Development of shares of selected countries and regions in the SCIE and the SSCI within all publications (whole counts, index 2000 = 100)

Country /region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
USA	100	99	99	98	98	96	94	92	89	88	87
Japan	100	99	99	98	95	90	86	81	76	73	70
Germany	100	100	99	97	96	95	93	91	89	89	90
Great Britain	100	97	94	93	91	90	90	89	85	84	85
France	100	99	98	96	94	93	92	89	90	89	88
Switzerland	100	97	97	100	102	101	104	103	102	104	107
Canada	100	99	100	103	104	108	109	108	108	109	108
Sweden	100	103	102	98	97	96	94	92	89	89	90
Italy	100	104	105	109	110	110	110	112	111	112	111
Netherlands	100	100	103	103	103	106	105	104	103	107	111
Finland	100	104	101	100	99	95	97	94	92	91	91
South Korea	100	117	126	142	159	165	170	167	182	192	206
China	100	118	129	150	176	203	233	247	264	293	316
Brazil	100	106	116	119	133	134	143	172	195	201	201
India	100	106	110	117	120	126	134	150	160	161	169
South Africa	100	105	109	103	107	108	116	123	131	138	142
EU-15	100	100	99	98	97	97	96	95	93	93	93
EU-12	100	106	108	110	114	112	115	125	133	133	132
EU-27	100	101	101	100	100	100	100	101	102	102	102
World	100	100	100	100	100	100	100	100	100	100	100

Source: Web of Science, searches and calculations by Fraunhofer ISI.

These structures are illustrated in Figure 3. To explain the meaning of these basic indicators, Germany and Great Britain were taken as representative for industrial countries, one with a large own language area, Germany, and Great Britain as a typical Anglo-Saxon country. The comparison is interesting, as both countries have similar levels with regard to publication statistics. In addition, Brazil and China were selected for this illustration, as both are threshold countries, but from completely different regions and in consequence with a quite different historical and cultural background of their innovation systems. According to this analysis, the relative share of the established industrialized countries Germany and Great Britain decreased since 2000, but stabilized in recent years. In this period, China exhibits substantial growth. Also the publication share of Brazil doubled in the examination period, however, on a distinctly lower level than of China. In the comparison of Germany and Great Britain, the share of Great Britain in the SCIE and the SSCI is a little bit larger than Germany's despite the fact that Great Britain's population is much smaller. This effect is due to the English language bias in the database favouring Great Britain relative to Germany.

Figure 3: Development of the share of four selected countries within all publications in the SCIE and the SSCI (whole counts, index 2000 = 100)



Source: Web of Science, searches and calculations by Fraunhofer ISI.

In the series of observed citation rates (Table 5), an especially good position of Switzerland, the United States and the Netherlands appears. All three countries improved their already good position further. Other countries were also able to increase their citation rates in recent years, which is largely due to the extended coverage of the database and in consequence the increase in the number of citing articles. This situation is again illustrated by the data for the selected four countries. Great Britain and Germany improved their citation rates steadily, whereby Great Britain is always somewhat higher in respect to the publication numbers than Germany (Figure 4). China and Brazil as well exhibit growing citation rates, whereby the citation rate of Brazil has, however slightly, been decreasing since 2005. It has to be noted that the citation rate of South Africa is the highest within the threshold countries.

Table 5: Observed average citation rates for selected countries and regions in the SCIE and the SSCI without self-citations

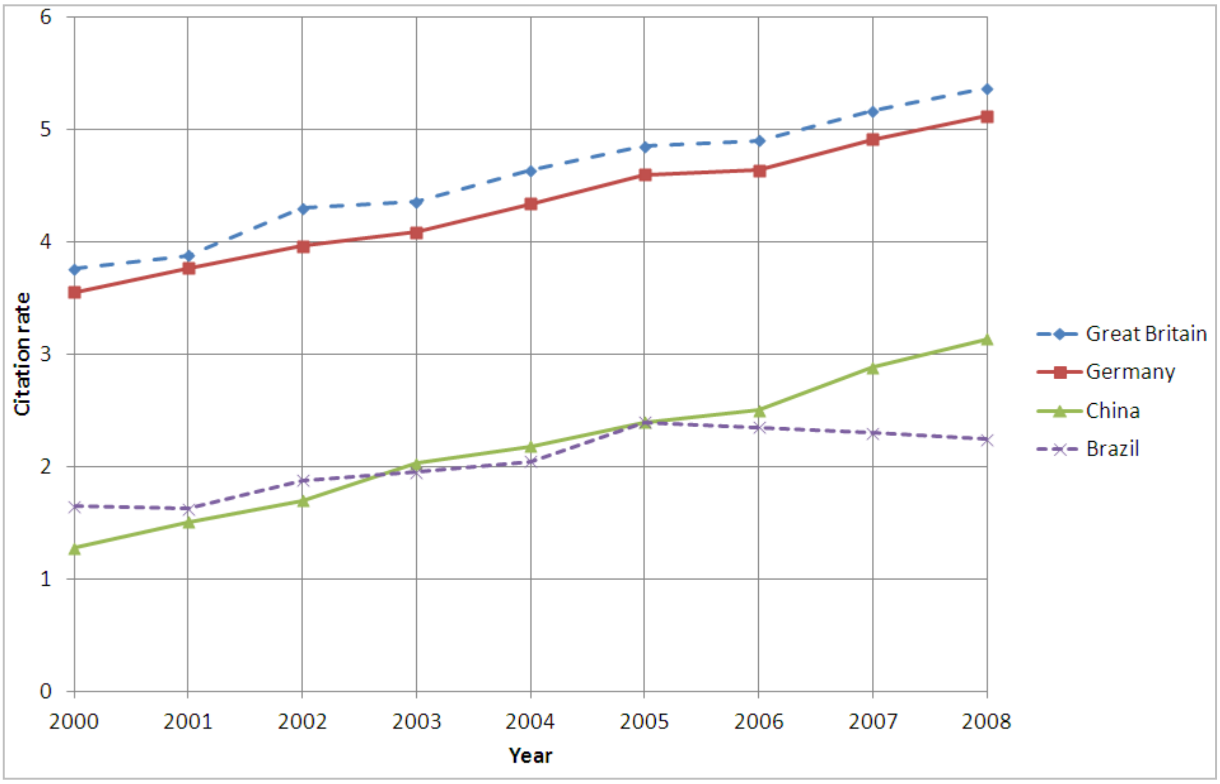
Country/region	2000	2001	2002	2003	2004	2005	2006	2007	2008
USA	4.6	4.8	5.0	5.1	5.3	5.4	5.4	5.6	5.6
Japan	2.7	2.8	2.9	2.9	3.2	3.3	3.4	3.5	3.6
Germany	3.5	3.8	4.0	4.1	4.3	4.6	4.6	4.9	5.1
Great Britain	3.8	3.9	4.3	4.3	4.6	4.8	4.9	5.2	5.4
France	3.3	3.5	3.6	3.7	3.9	4.1	4.2	4.6	4.6
Switzerland	5.2	5.4	5.6	5.4	5.9	6.3	6.1	6.3	6.7
Canada	3.8	3.8	4.0	4.2	4.4	4.5	4.7	4.9	5.0
Sweden	3.9	4.1	4.3	4.5	4.8	5.0	5.1	5.3	5.5
Italy	3.3	3.3	3.7	3.6	3.9	4.2	4.2	4.4	4.5
Netherlands	4.2	4.4	4.6	5.1	5.2	5.4	5.5	5.9	5.9
Finland	3.9	3.7	4.2	4.0	4.2	4.3	4.6	4.9	5.2
South Korea	2.0	2.1	2.2	2.4	2.6	2.7	2.8	3.0	3.1
China	1.3	1.5	1.7	2.0	2.2	2.4	2.5	2.9	3.1
Brazil	1.6	1.6	1.9	1.9	2.0	2.4	2.3	2.3	2.2
India	1.2	1.2	1.5	1.5	1.8	2.0	2.2	2.2	2.3
South Africa	1.9	2.0	1.9	2.3	2.6	2.8	3.1	2.9	3.3
EU-15	3.2	3.3	3.5	3.7	3.9	4.1	4.1	4.3	4.4
EU-12	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.5	2.3
EU-27	2.9	3.0	3.2	3.3	3.5	3.7	3.8	3.9	3.9
World	2.9	3.0	3.1	3.3	3.4	3.5	3.6	3.7	3.7

Source: Web of Science, searches and calculations by Fraunhofer ISI.

Although China exhibits the highest development dynamics with regard to the number of annual publications, its citation rate is still relatively low, despite steady growth. However, the value is meanwhile above the level of the new EU member countries (EU-12) whose citation rate stagnated in the past years.

When determining the indicator journal-specific scientific regard (SR index), the picture is quite different from the observed citation rates (Table 6). For Germany and Great Britain the indices are substantially above of those of Brazil and China and they are quite stable over the course of time (Figure 5). The SR values are at a similar level for Germany and Great Britain. Thus in contrast to the publication shares and the observed citation rates, no advantage for Great Britain can be seen. For China the SR indices in the year 2000 start at a value of about minus 20, i.e., at a level substantially below the world average. In the year 2004, the world average is achieved and also the values increased further since then, but less dynamically. In the year 2008, China's SR index reaches the German and British level. For Brazil, the SR index in the year 2000 started at a level of -25 which is substantially below average. This index increased in the course of time up to -9. For South Africa, the SR indices begin at a negative level as well, but the level is not as low as those of the other threshold countries. Meanwhile South Africa achieves values above average, similar to China.

Figure 4: Observed average citation rates for four selected countries in the SCIE and the SSCI without self-citations



Source: Web of Science, searches and calculations by Fraunhofer ISI.

As for the SR indices, the German figures are similar to those for other leading industrialized countries like the United States, Great Britain, France, Sweden, Netherlands or Finland. Only Switzerland has a substantially better value than Germany within the whole observation period with a level of about 15. It is remarkable that the German index is more or less equal to – sometimes even better than – the American one. At this point, a substantial difference to the observed citation rates becomes obvious where the United States are in a position substantially above Germany's. By comparing the observed citation rates with the SR indices, the assumption is supported that the good (observed) citation rates of the United States are based, to a large extent, on the broad representation of American authors in internationally visible journals, in general US-American ones.

At first sight, Germany's good SR index compared to the US one seems to be surprising. However, it has to be taken into account that in the United States some leading universities like MIT or Harvard contribute to the country's scientific performance, whereas many other universities are primarily oriented to teaching and conduct no or only mediocre research. Therefore, on average, the relatively moderate SR values for the United States seem to be consistent.

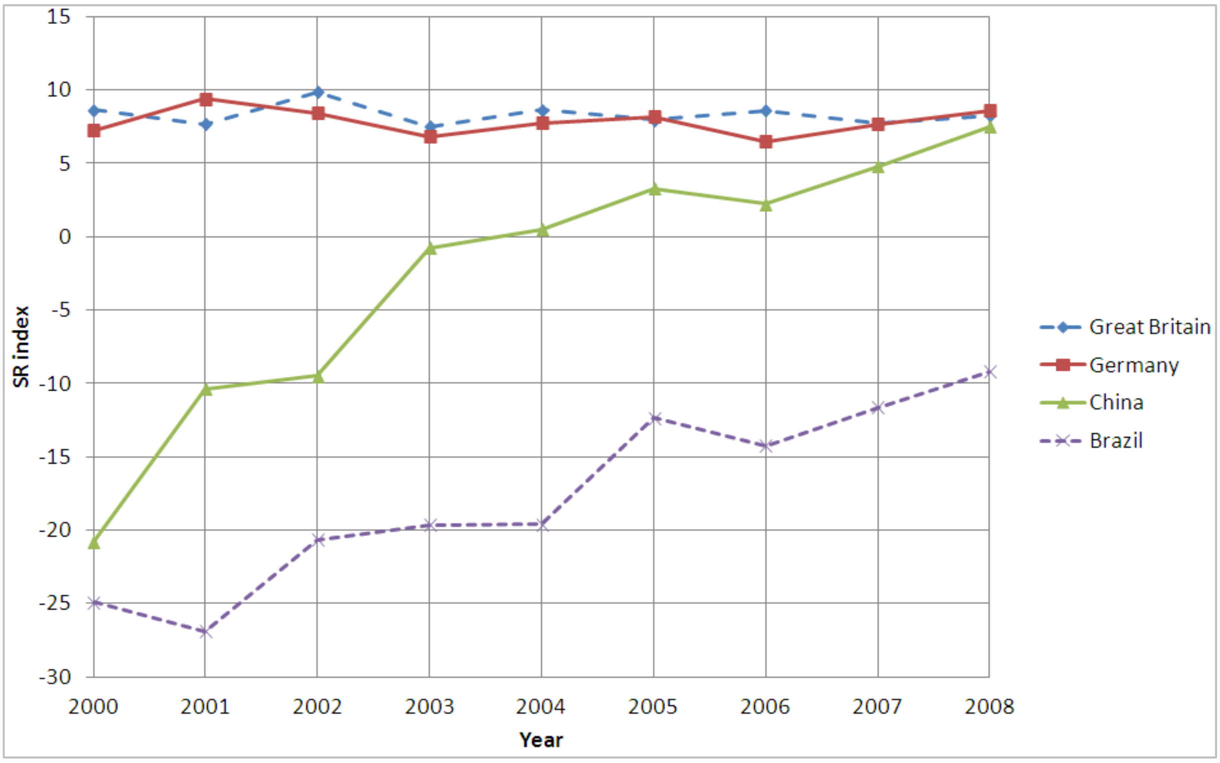
Table 6: Index of the journal-specific Scientific Regard (SR) for selected countries and regions in the SCIE and SSCI without self-citations

Country/region	2000	2001	2002	2003	2004	2005	2006	2007	2008
USA	9	9	9	8	8	8	7	7	7
Japan	-6	-5	-8	-9	-7	-8	-7	-7	-8
Germany	7	9	8	7	8	8	7	8	9
Great Britain	9	8	10	8	9	8	9	8	8
France	3	3	3	2	2	2	3	4	3
Switzerland	17	16	16	14	16	16	16	14	15
Canada	9	3	5	7	5	5	6	6	8
Sweden	9	9	11	11	11	10	11	8	8
Italy	-1	-2	3	-4	0	1	1	3	3
Netherlands	7	10	8	13	10	9	9	10	9
Finland	9	8	13	4	5	4	10	9	10
South Korea	-10	-9	-7	-4	-1	-3	-1	-3	-1
China	-21	-10	-9	-1	0	3	2	5	7
Brazil	-25	-27	-21	-20	-20	-12	-14	-12	-9
India	-23	-27	-18	-17	-15	-12	-8	-10	-7
South Africa	-9	-6	-13	-5	-3	-3	1	-4	5
EU-15 countries	2	2	2	2	2	2	2	2	2
EU-12-countries	-17	-11	-13	-11	-8	-9	-7	-3	-9
EU-27 countries	0	0	0	0	0	0	0	0	0
World	0	0	0	0	0	0	0	0	0

Source: Web of Science, searches and calculations by Fraunhofer ISI.

Calculating the International Alignment (IA-index, Table 7), the index for the United States has a topical value of 34, considerably above the German one at 23. Therefore the higher citation rates for the United States are primarily based on the publication of US-American articles in US-American journals, as these journals have a very high visibility. This holds also for Great Britain with a higher result of 28. Thus the slightly better citation rates observed for Great Britain compared to Germany can be primarily linked to the placement of British articles in internationally more visible journals, in any case. In this context, Switzerland's very high IA index is remarkable, particularly since Switzerland is already well positioned in regard to SR indices. Switzerland's scientific performance proves to be extraordinary in all dimensions.

Figure 5: Index of the journal-specific Scientific Regard (SR) for four selected countries in the SCIE and SSCI without self-citations



Source: Web of Science, searches and calculations by Fraunhofer ISI.

An illustration of the time series for the IA index for the four exemplary countries shows interesting developments. In the whole period, the index for Great Britain is slightly above Germany's whereby a steady increase can be observed for both countries, for Germany starting with 14 in the year 2000 up to 23 in 2008, i.e. the index has nearly doubled (Figure 6). In the same period, the citation rates for Germany also increased from 3.3 to 4.7, so that it can be concluded that this increase is primarily based on the publication of German articles in internationally highly visible journals.

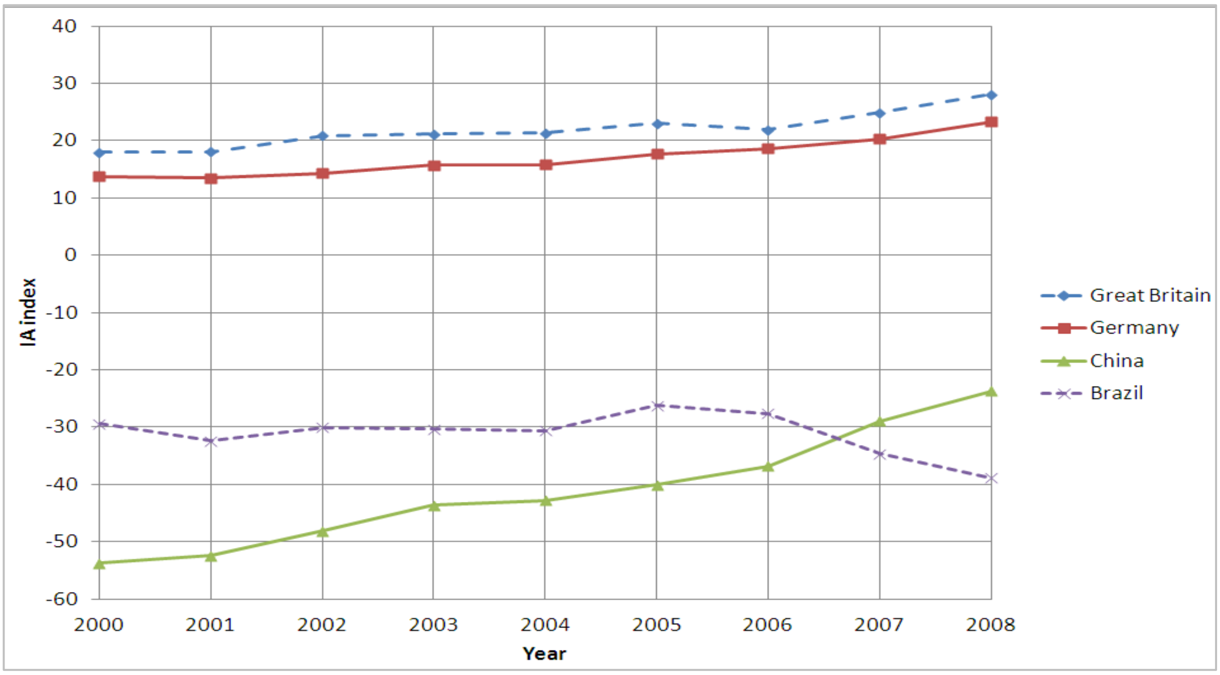
In the case of Brazil, the IA index remained stable and even decreased slightly in recent years. The slow increase of its SR index in the course of time, combined with the decrease of the IA in recent years, explain the slightly decreasing citation rates observed in the last years which are illustrated in Figure 4. In the case of China, the IA index is steadily growing, but with a most recent value of -24 it is still substantially below the world average. As Chinas' observed citation rate increases, both the SR and the IA indices increase as well. The very positive SR index for China in recent years has to be interpreted in combination with the still negative IA index. The above average values of the Scientific Regard index are achieved by publications in journals which have limited international visibility. In this special combination, the meanwhile positive SR indices for China should not be overrated. However, it can be observed in any case that the number and impact of publications from China are steadily improving and in future years the role of China's contribution to science will be qualitatively more substantial. The IA indices for South Africa are also below average, but less dramatically so than the other threshold countries and in more recent years similar to the level of South Korea.

Table 7: Index of the International Alignment (IA) for selected countries and regions in the SCIE and SSCI without self-citations

Country/region	2000	2001	2002	2003	2004	2005	2006	2007	2008
USA	36	36	36	35	34	33	33	34	34
Japan	-1	0	-1	-1	1	0	0	2	5
Germany	14	13	14	16	16	18	19	20	23
Great Britain	18	18	21	21	21	23	22	25	28
France	10	12	10	11	11	14	13	17	18
Switzerland	39	40	38	35	38	38	36	38	41
Canada	18	20	19	19	19	19	20	22	22
Sweden	22	21	20	22	23	23	24	27	30
Italy	14	12	13	13	13	15	15	15	17
Netherlands	30	27	28	30	31	32	33	35	37
Finland	21	14	17	16	16	16	14	18	23
South Korea	-25	-28	-27	-27	-28	-25	-24	-16	-16
China	-54	-52	-48	-44	-43	-40	-37	-29	-24
Brazil	-29	-32	-30	-30	-31	-26	-28	-35	-39
India	-57	-55	-53	-52	-44	-44	-39	-40	-40
South Africa	-32	-32	-35	-29	-24	-19	-16	-20	-16
EU-15	9	9	10	10	10	12	12	13	15
EU-12	-38	-40	-36	-34	-34	-31	-29	-33	-36
EU-27	3	2	3	3	3	4	4	4	4
World	0	0	0	0	0	0	0	0	0

Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 6: Index of the International Alignment (IA) for four selected countries in the SCIE and SSCI without self-citations



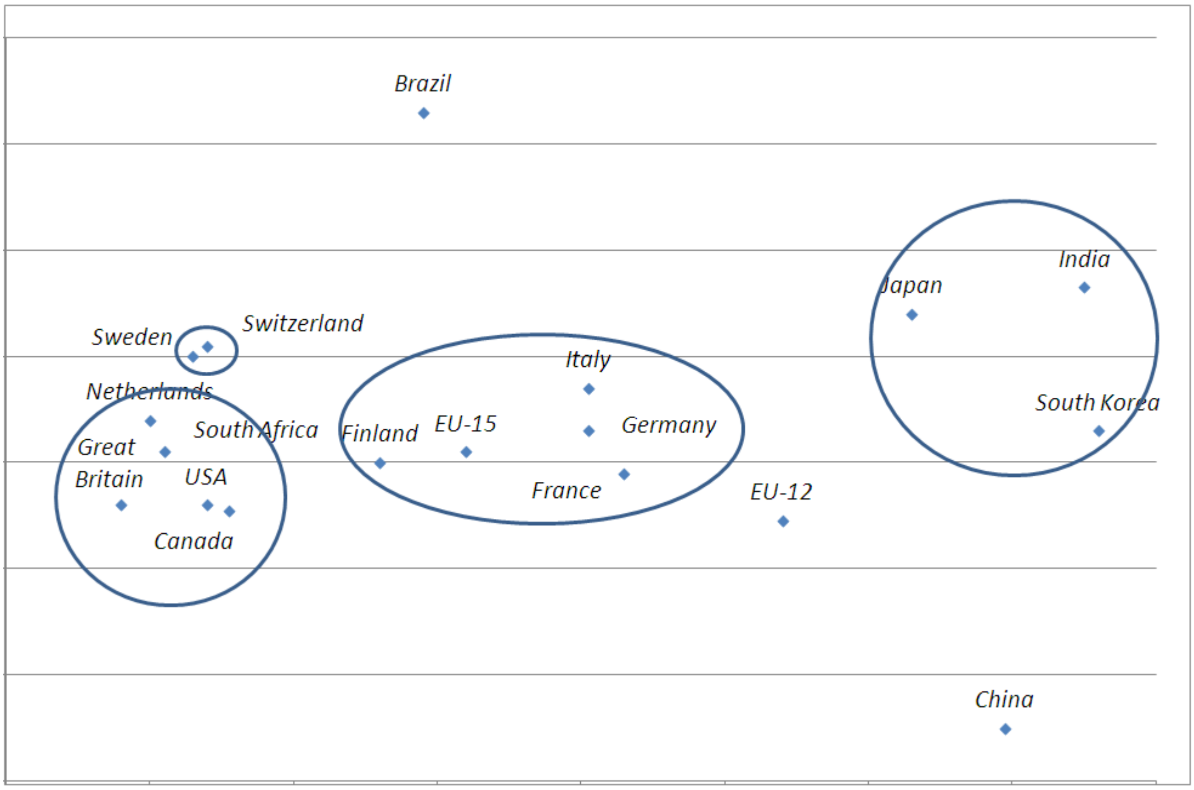
Source: Web of Science, searches and calculations by Fraunhofer ISI.

Disciplinary profiles

Up until now, only the total numbers of publications and citations for the 16 selected countries were considered, but not their disciplinary profiles. As it is difficult to visualize the results for 16 countries and two regions, a so-called MDS chart was generated. The technical details are explained in the methodological chapter above. By this means it is possible to show that a typical west European cluster exists with Germany, Italy, France, Finland but also the EU-27 in total (Figure 7). There is a small cluster of Switzerland and Sweden and an Anglo-Saxon cluster with Canada, the United States, Great Britain, but also the Netherlands can be determined. Interestingly, South Africa belongs to this cluster as well. Obviously, its strong historic links to Great Britain and the Netherlands have a visible impact on the present structure of scientific activities. A further group is formed by the Asian countries Japan, South Korea and India. In contrast, the profile of China is quite different from these three countries and is positioned clearly outside the Asian cluster. Brazil also has a quite special position. Finally, the nine new member countries of the European Union (EU-12 countries) are located at a slight distance to the west European cluster.

To illustrate the meaning of the MDS representation and the documented distance between different countries, the examples of Germany and China are selected because there is a considerable distance between them, as illustrated in Figure 7. When comparing their present specialization profiles, it becomes obvious that the majority of the fields substantially differ as to their specialization (Figure 8). While Germany displays high specialization values in “medical technology”, “nuclear technology”, “biotechnology”, “physics” and “geo-sciences”, the strengths of China are in “electrical engineering”, “computer sciences”, “optics”, “measuring, control”, “organic chemistry”, “polymers”, “basic chemistry”, “materials research”, “mechanical engineering, “physics”, and “mathematics”. In many cases, for instance, “electrical engineering”, “medical technology”, “mechanical engineering”, “mathematics” or “biotechnology", the specialization of Germany and China are totally opposite. In this context it has to be noted that the negative specialization of Germany in "chemical engineering" or "mechanical engineering" can be explained largely by the inadequate database coverage focusing on US-American journals (Schmoch 2005). In these fields, Chinese scientists concentrate more on English-language journals than their German colleagues and in consequence Chinese scientists achieve positive specialization indices.

Figure 7: Result of an MDS analysis in SCIE and SSCI for selected countries and two regions according to their specialization (RLA) of their publications in 27 fields, 2010

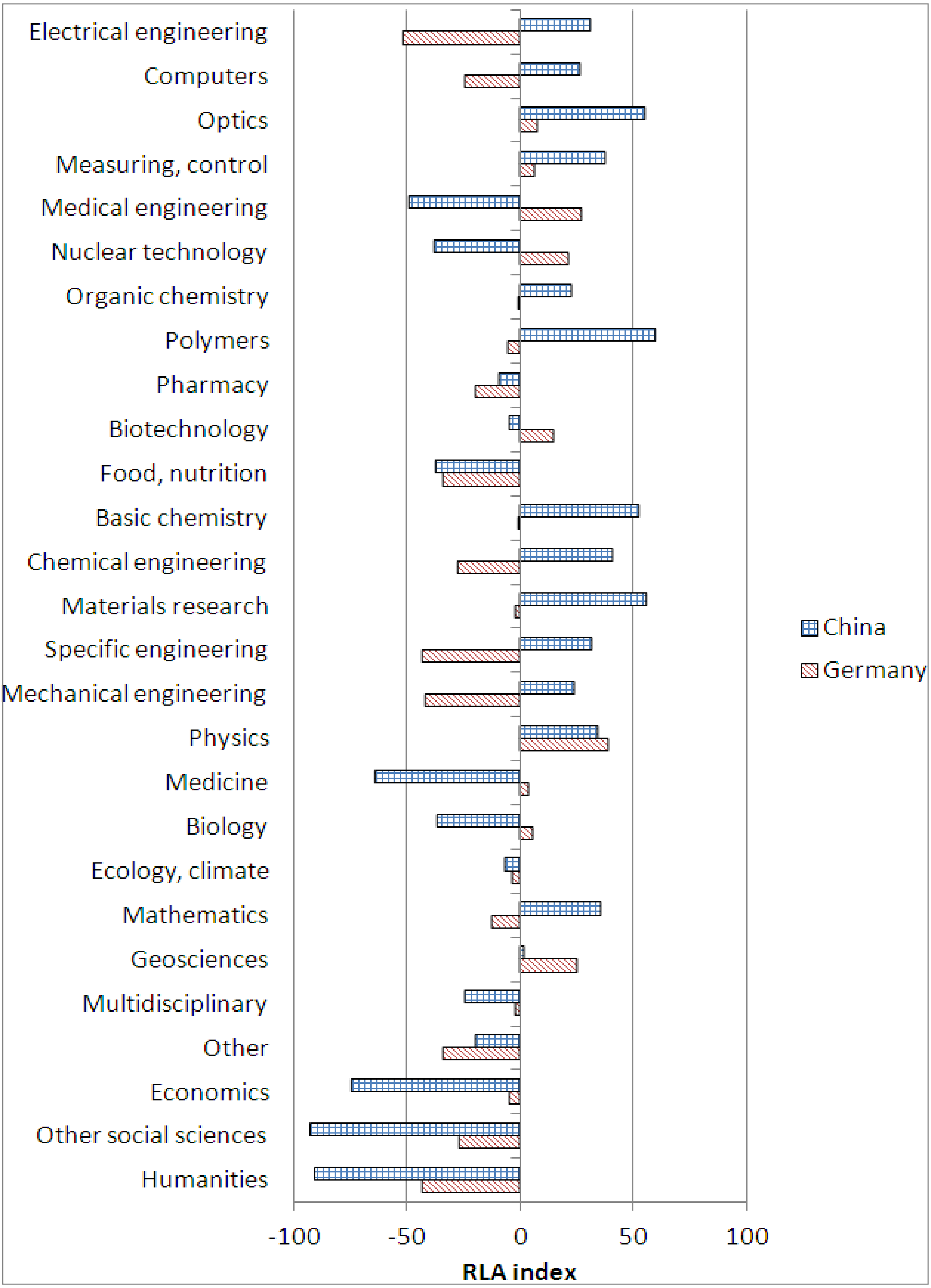


Source: Web of Science, searches and calculations by Fraunhofer ISI.

It is striking that the Chinese profile is also quite distant from those of other Asian countries. Therefore the profiles of China and South Korea are also compared in Figure 9. First there is an obvious similarity of China and South Korea in their focus on "electrical engineering", supporting their technology orientation. Further common positive fields of specializations are "computers", "optics", "measuring, control", "polymers", "basic chemistry", "chemical engineering", "materials research", "specific engineering", "mechanical engineering" and "physics". However, there are distinct differences in "medical engineering", "nuclear technology", "organic chemistry", "food, nutrition", and "mathematics".

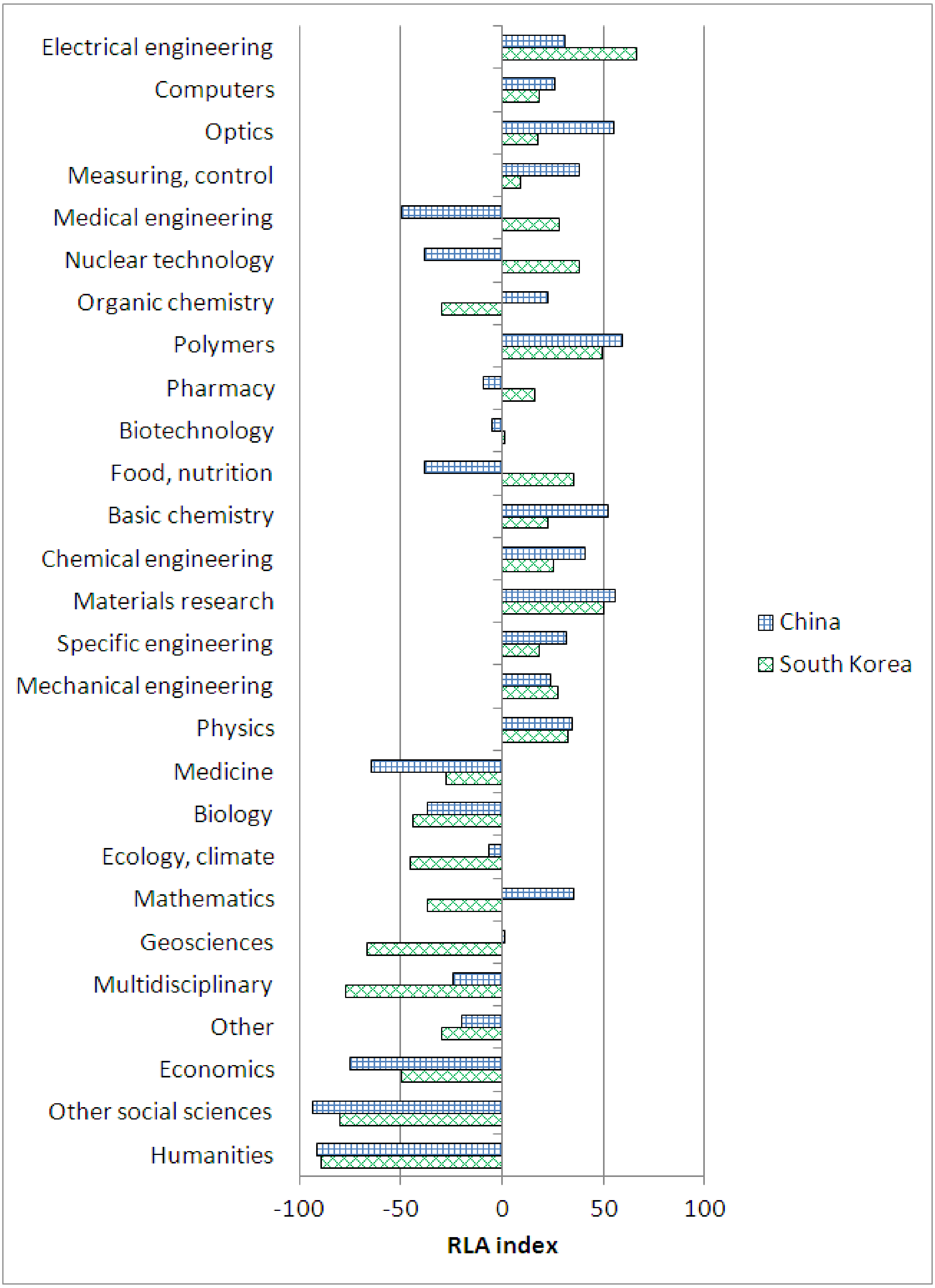
Comparing the profiles of Canada and the United States which are located quite close to each other in the MDS graph, considerable similarities of these specialization profiles show up with regard to positive as well as negative indices, for instance in "medical engineering" (+), "organic chemistry" (-), "polymers" (-), "basic chemistry" (-) or "medicine" (+) and "biology" (+) (Figure 10). Fields with strong differences such as "specific engineering" are quantitatively less relevant.

Figure 8: Specialization of the publications of Germany and China in 27 scientific fields in SCIE and SSCI, 2010 (RLA index)



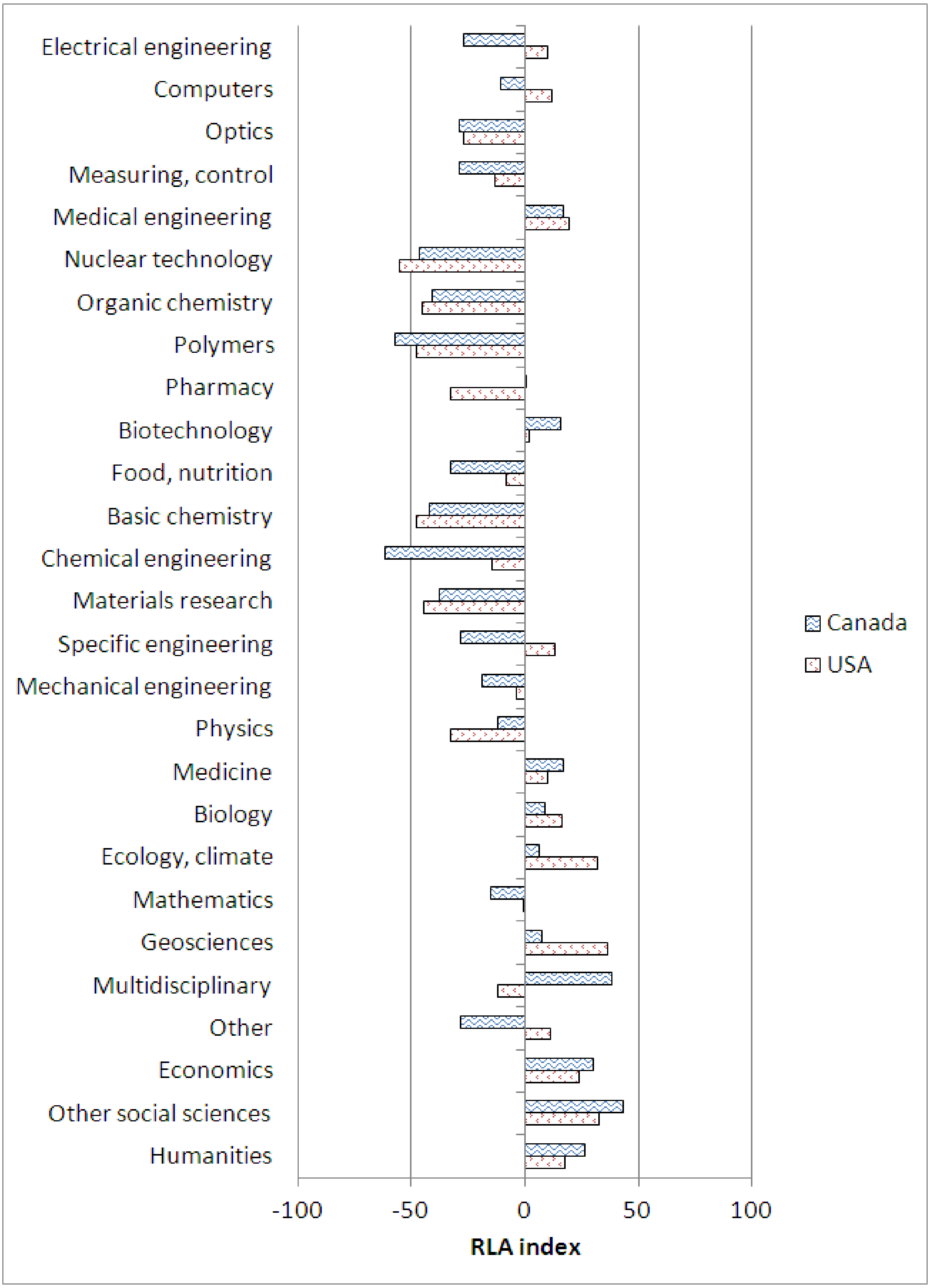
Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 9: Specialization of the publications of South Korea and China in 27 scientific fields in SCIE and SSCI, 2010 (RLA index)



Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 10: Specialization of the publications of Canada and the USA in 27 scientific fields in SCIE and SSCI; 2010 (RLA index)



Source: Web of Science, searches and calculations by Fraunhofer ISI.

4. China's profile

The most important change in the international structure of scientific publications is the tremendous growth of China, implying a visible crowding-out effect in the established industrialized countries (Table 4). The special features of the Chinese scientific profile were already discussed in its comparison to Germany and South Korea (Figure 8 and Figure 9).

In addition, it is interesting to see whether the fields of strong specialization are also those with high impact in terms of the SR and IA indices. In this comparison of indices, the Chinese publications in “electrical engineering” with a high RLA index achieve a high SR index as well, and also the IA index is at the world average, at least (Figure 11). The same observation applies to “computers” and “mathematics”. In “chemical, specific and mechanical engineering” the positive RLA index matches a positive IA index, and the SR index is world average. In “basic and organic chemistry”, the quite high RLA index and the positive SR index are associated with the moderately negative IA index. The general result is that China has a quite focused profile where various fields of science only perform at a low level. But if relevant activities are conducted in a specific field, it generally has a remarkable impact in terms of SR and IA indices.

To obtain an idea of the long-term development, the SR and IA indices of China and Germany are compared in Figure 12. As a first observation, the SR index of China is similar to the German level in 2008, but the distance between the German and the Chinese IA indices remained stable at about 40 index points. As a consequence of this trend, the observed citation rate approached the German one in relative terms, but is still much lower (Table 5). The trend of the IA index shows that a realistic point in time where the Chinese citation rate will achieve the German level cannot be determined. However, this statement refers to the overall level and has to be linked to the rather focused strategy of Chinese scientists. In the fields where the Chinese activities have a special orientation above average, the impact is also substantially higher. Thus the distance of the impact in the overall consideration should be interpreted as the result of the selective Chinese strategy.

A specific instrument to achieve the international level of science is to increase international cooperation with scientists from leading countries. In this regard, the share of international co-publications of Chinese authors remained quite stable in the last ten years. However, this result has to be interpreted against the background of the substantial growth of Chinese publications in absolute terms. The absolute level of co-publications with foreign authors in general grew by the factor 4.5, with American ones even by the factor 5.7. The share of co-publications with American authors (11%) is even higher than with south Asian partners (4%) and it has increased in recent years. The level of co-publications with German researchers is quite low, at 2% and the absolute growth is quite modest with the factor 3.6 compared to the world average. To summarize, although China co-publishes internationally at a relatively low level, it strives to increase its share of international co-publications, in particular with American partners.

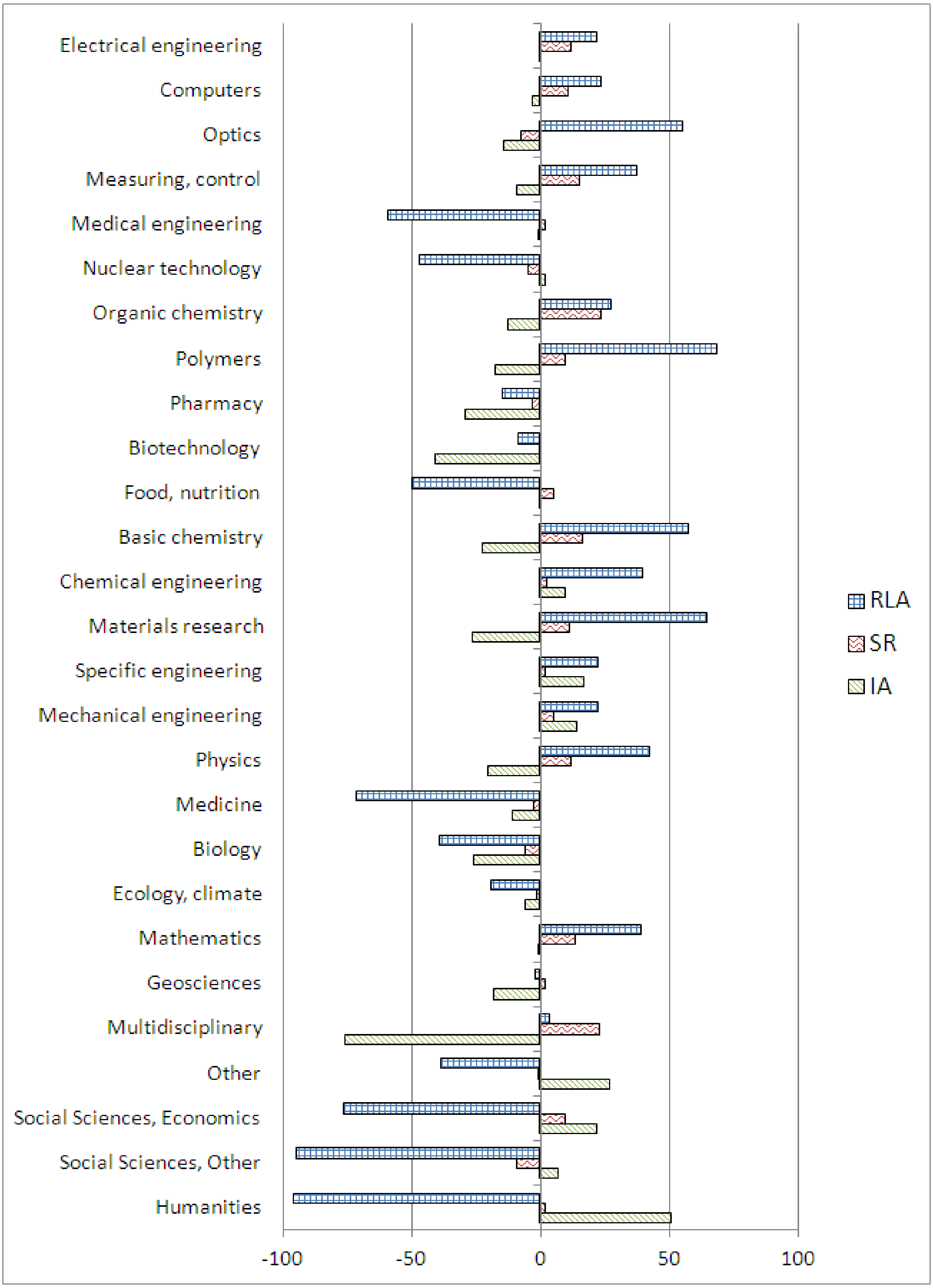
Looking at the organizational structure in Chinese science, a table with the top 20 organizations in term of publication numbers was drawn up (Table 8). The most remarkable finding is that the number of publications of the Academy of Science compared to the universities is moderate, with a share of about 17% of the publications of the top 20 organizations. In most communist countries, the traditional division of labour is for the academies to perform research and for the universities to be exclusively active in teaching. The table of the top organizations illustrates that these old structures are successfully overcome.

Table 8: Top 20 organizations in China according to the number of publications in the SSCI and SCIE in 2010

Organization	# publications
Chinese Acad Sci (Beijing)	11,665
Zhejiang Univ	4,922
Peking Univ	4,374
Shanghai Jiao Tong Univ	4,317
Tsinghua Univ	4,142
Fudan Univ	3,282
Chinese Acad Sci (Shanghai)	2,954
Sichuan Univ	2,844
Nanjing Univ	2,804
Huazhong Univ Sci & Technol	2,467
Shandong Univ	2,462
Univ Sci & Technol China	2,393
Sun Yat Sen Univ	2,381
Jilin Univ	2,313
Harbin Inst Technol	2,239
Univ Hong Kong	2,186
Xi An Jiao Tong Univ	2,055
Dalian Univ Technol	1,898
Cent S Univ	1,794
Wuhan Univ	1,720

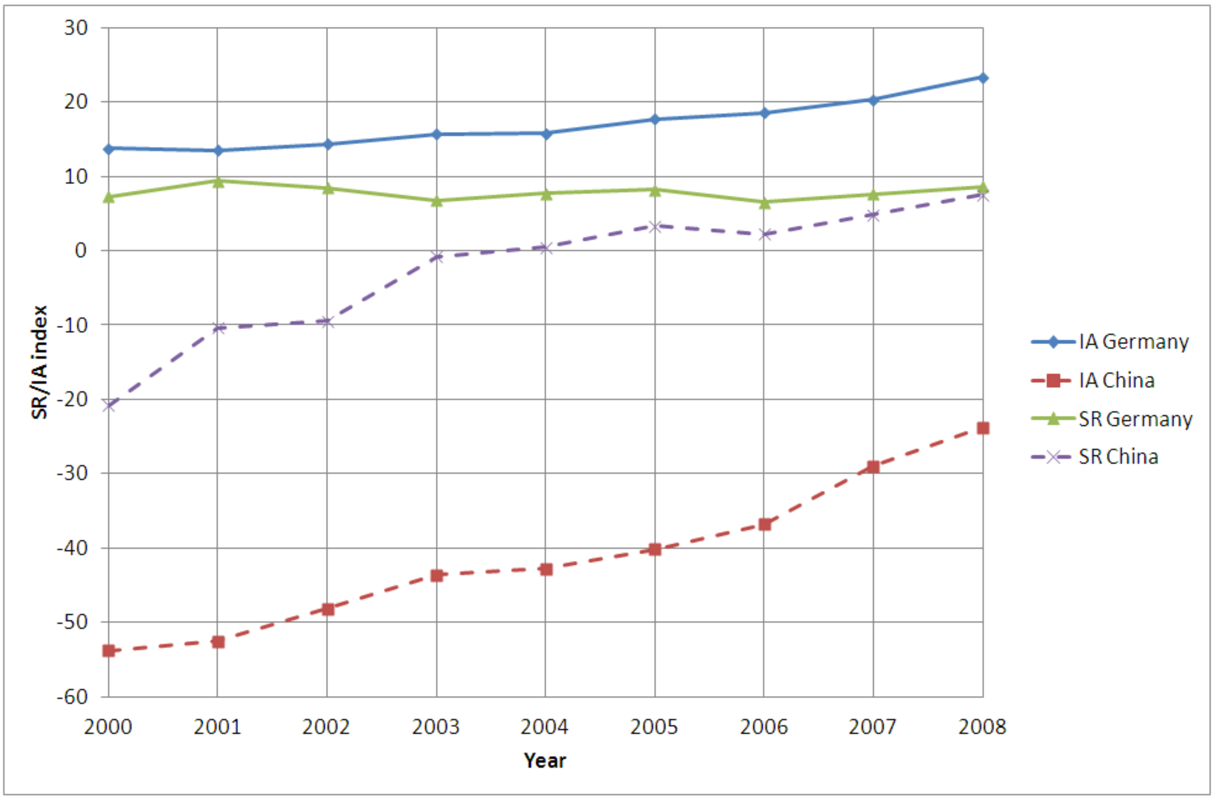
Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 11: RLA, SR and IA indices of China in 27 scientific fields (RLA index) in the WoS, 2008



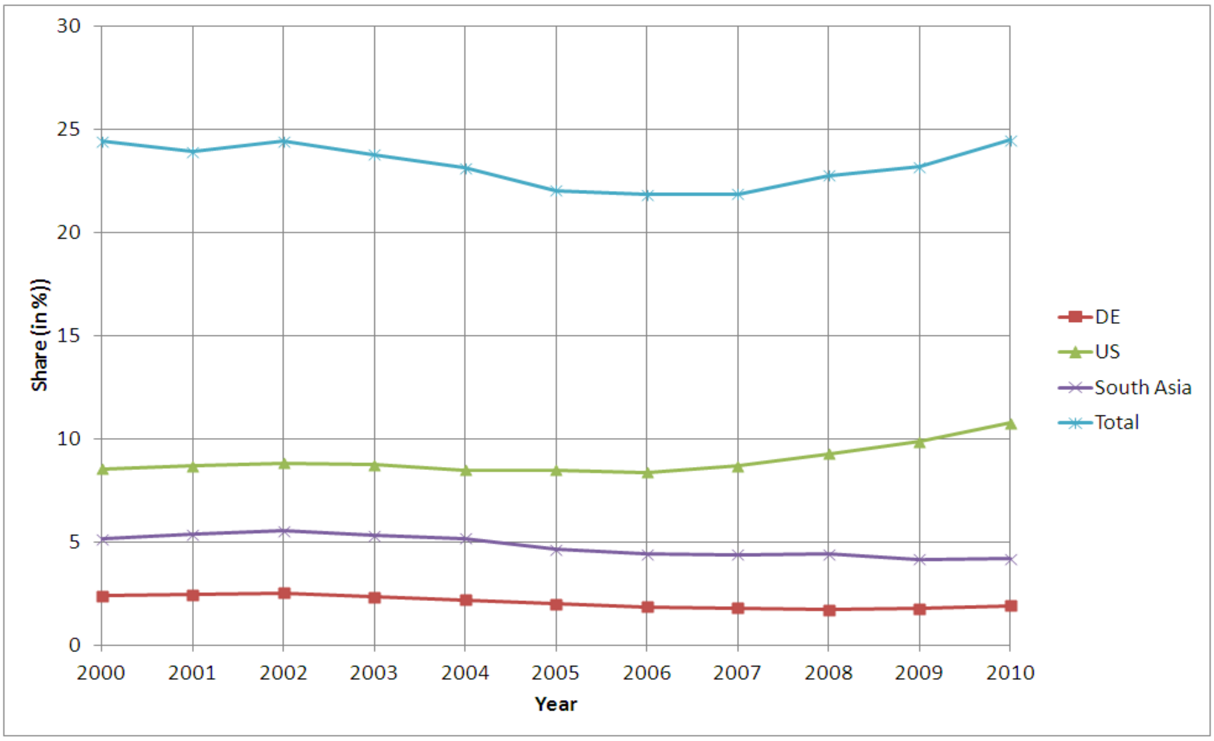
Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 12: SR and IA indices of China and Germany in the SSCI and SCIE without self-citations



Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 13: Co-publications of Chinese authors with foreign authors in the SCIE and SSCI (2008)

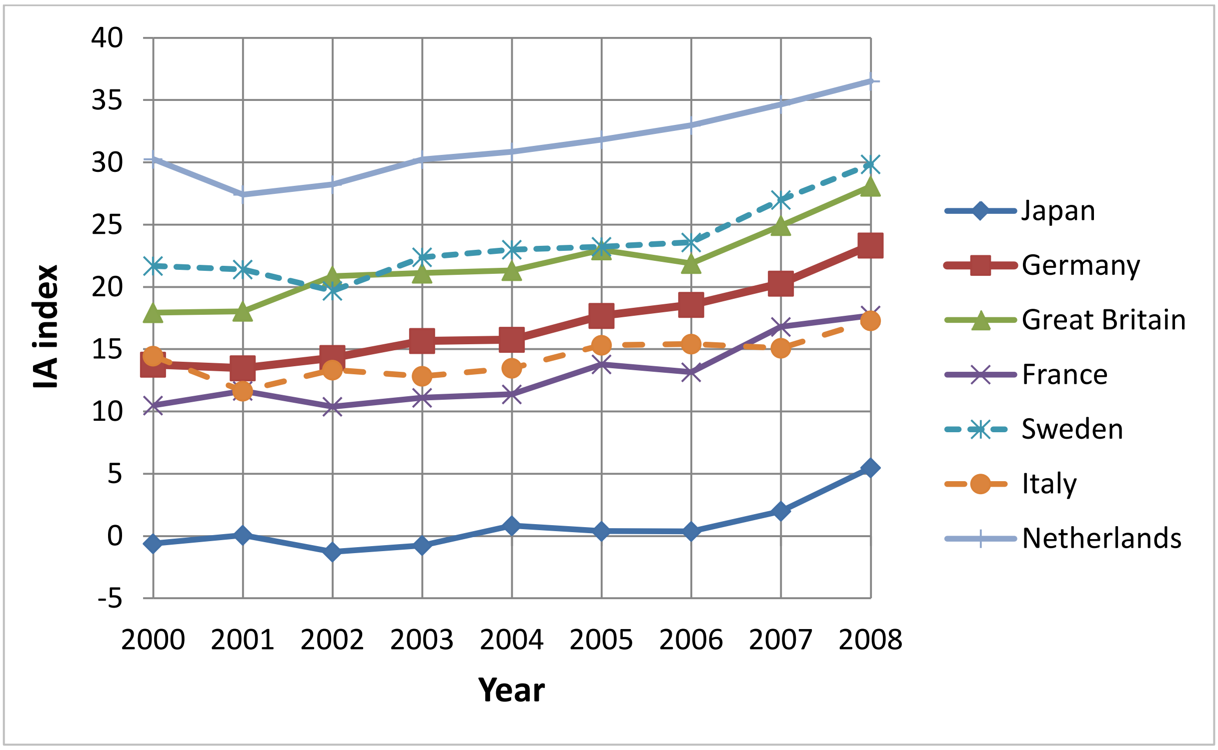


Source: Web of Science, searches and calculations by Fraunhofer ISI.

5. Behaviour of German authors

For many years, the observed citation rate of German authors has increased steadily in the SCIE (Table 5) and more detailed analysis shows that this is reflected in an increase of the IA index, an effect which can be noted for many other countries as well (Figure 14). Thus, although the German citation rate steadily improved, it could not achieve a higher rank in the international comparison. In order to understand the underlying reasons, it has to be taken into account that the bibliometrical performance has become increasingly important for the individual careers of scientists in Germany and in other countries as well. For instance, when applying for a high academic position, it is the default procedure to submit publication lists, indicating either the citation rate or the impact factor of the journal where the articles were published.[4] Thus it is natural that scientists strive to improve their bibliometric performance and discuss appropriate strategies with their colleagues. So the general increase in the German citation rate may be the consequence of a general change in science policy to which the German authors adapted.

Figure 14: IA index of selected countries in the SSCI and SCIE without self-citations



Source: SCIE and SSCI, searches and calculations by Fraunhofer ISI.

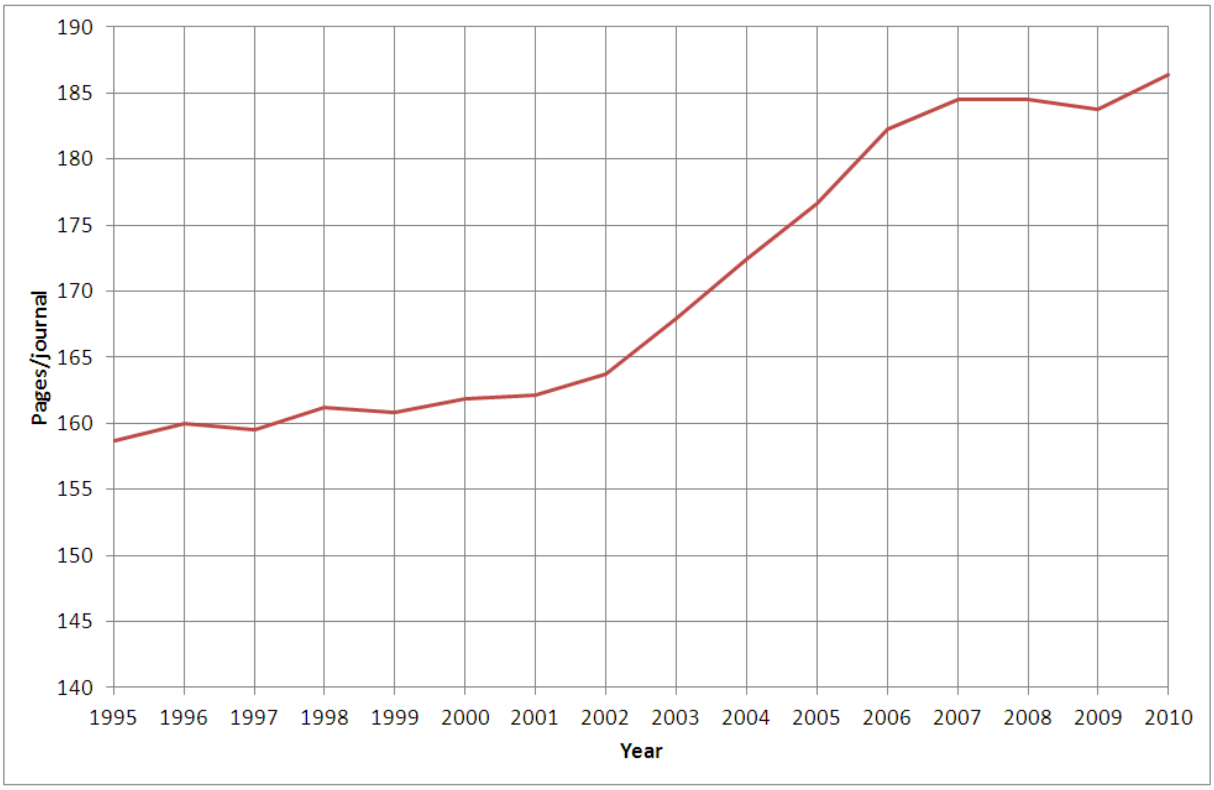
4 In particular, in the medical sciences, the indication of the impact factor is generally asked for, although the impact factor includes no information on the real citation rate of the respective article.

Various options can be followed to achieve higher citation rates:

1. Submitting an article to a more general journal with a larger readership, thus to move from specialist to mainstream journals. This strategy would imply a growing number of annual pages of the journals where the articles are published.
2. Submitting the articles to US-American journals, as these journals have a broader readership and are more highly cited than the world average.
3. Submitting the article to a journal with a high impact factor, thus journals which are highly cited independent of the nationality of their editorship.
4. Aiming at co-publications with highly cited authors, in particular American ones.

To verify the first hypothesis, the average number of pages of the journals where German authors published their articles was analyzed. According to this, the average size of these journals steadily increased, in particular between 2001 and 2007 (Figure 15)[5]. Thus there is strong evidence for a trend towards mainstream journals and a move away from more specialized journals. In the perspective of science policy, one may ask whether this effect of a growing use of bibliometric indicators is really intended.

Figure 15: Average annual number of pages of journals in the SCIE where German authors published their articles



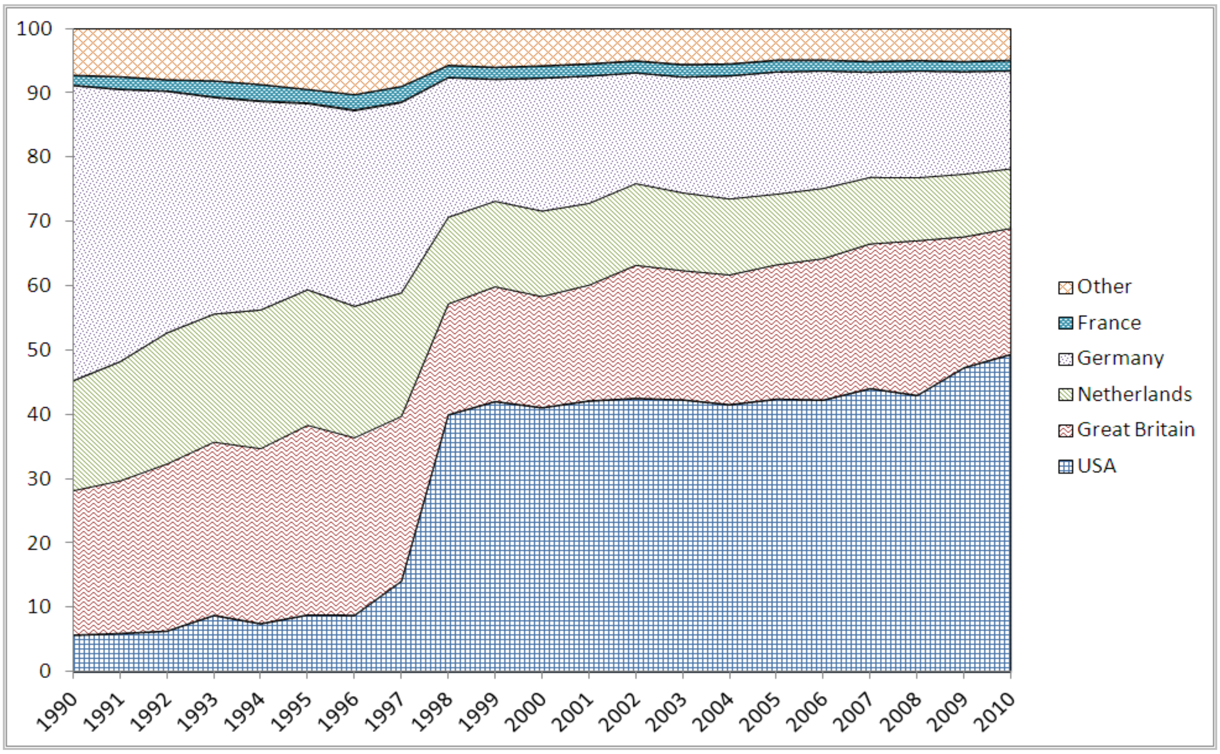
Source: SCIE, searches and calculations by Fraunhofer ISI.

5 For this analysis, exclusively articles in the SCIE were considered, as this is a central part of the WoS.

Clear evidence can be found for the attempt to increasingly publish in journals with American editorship. Looking at the share of editor countries within the publications of German authors, a strong trend towards US journals can be observed (Figure 16). The sudden increase between 1997 and 1998 may be due to a change of ownership and taken as an artefact. However, since 1998 the share of US journals steadily grew by 20% in total, whereas the share of German journals decreased by 30% during the same period. In addition, the share of British journals increased by 10%. There is good reason to focus on American journals, as the citation rate that German authors achieve there is the highest compared to other editor countries (Figure 17). The citation rates in American journals are higher than those in British ones and much higher than in Dutch ones, although the Dutch journals are generally published in English.[6]

It may be assumed that the move towards American journals is substantially slower in the social sciences, as here the domestic language and the analysis of domestic problems may be more important than in the natural sciences. However, the German publications in the SSCI show a similar trend to those in the SCIE and achieve nearly the same share of American journals as the publications in the SCIE. Of course, this observation only applies to articles covered by the SSCI, and the share of non-covered articles in the social sciences may be much higher than in the natural sciences.

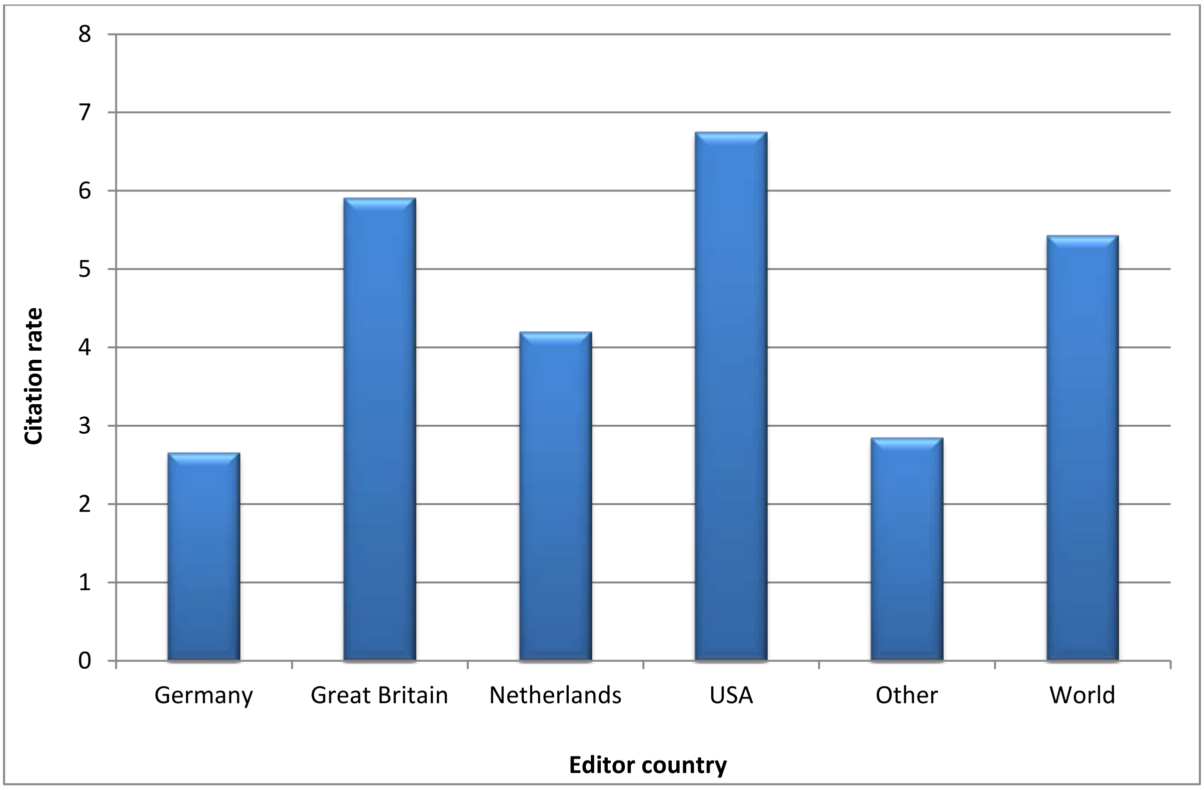
Figure 16: Share of editor countries within publications of German authors in the SCIE (staple diagram)



Source: SCIE, searches and calculations by Fraunhofer ISI.

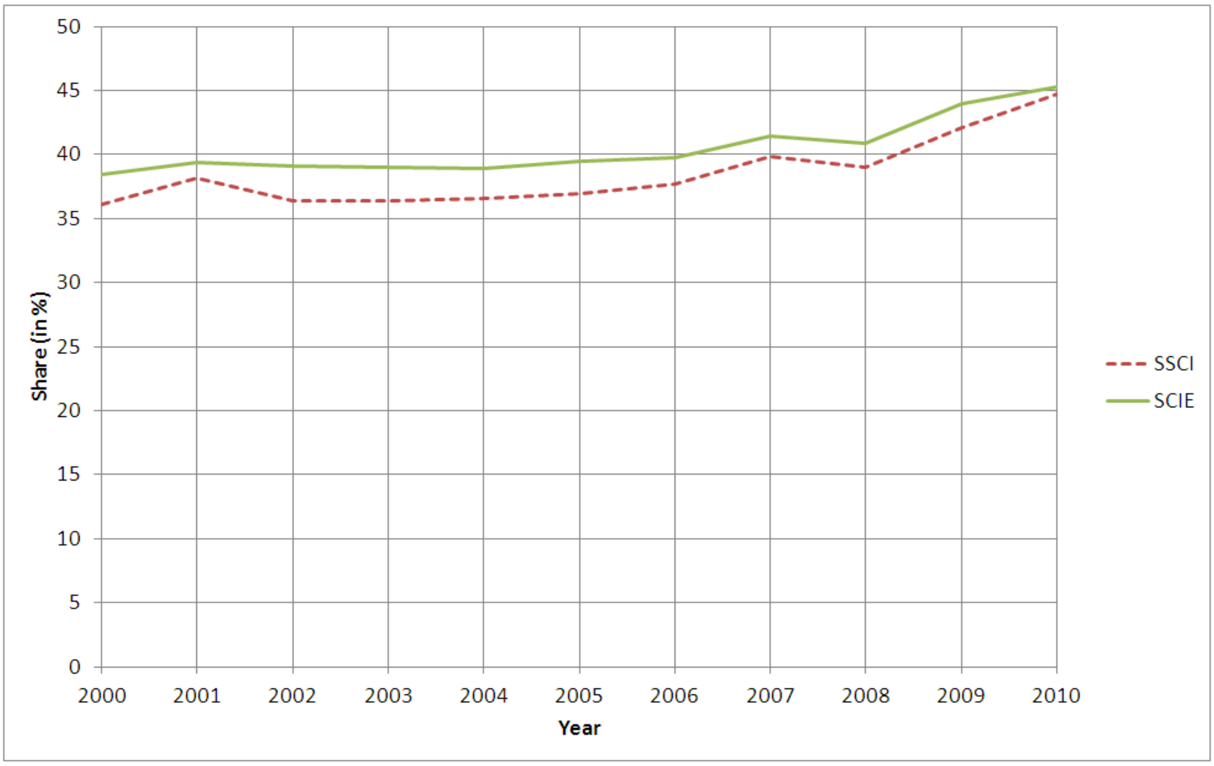
6 The main Dutch publisher is Elsevier.

Figure 17: Average citation rates of German authors by editor country of the publishing journal in the SCIE, 2008



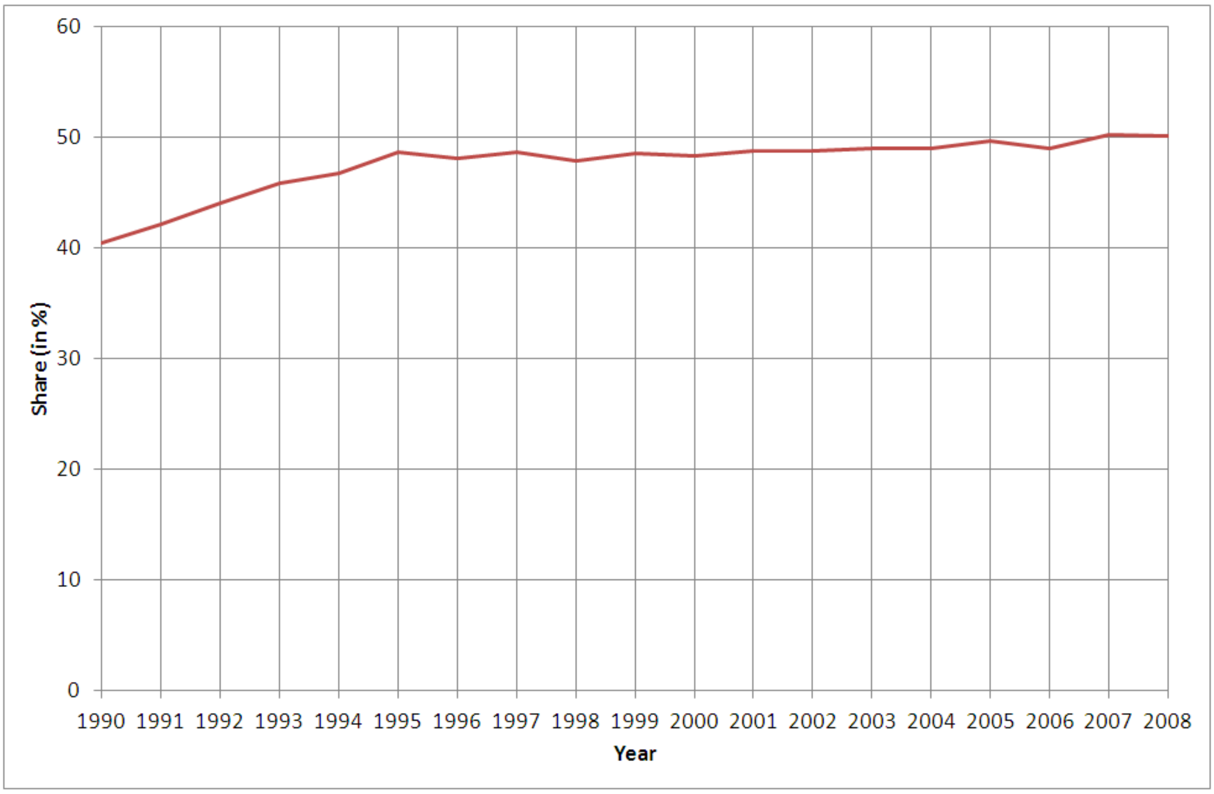
Source: SCIE, searches and calculations by Fraunhofer ISI.

Figure 18: Share of articles by German authors published in journals with the USA as editor country



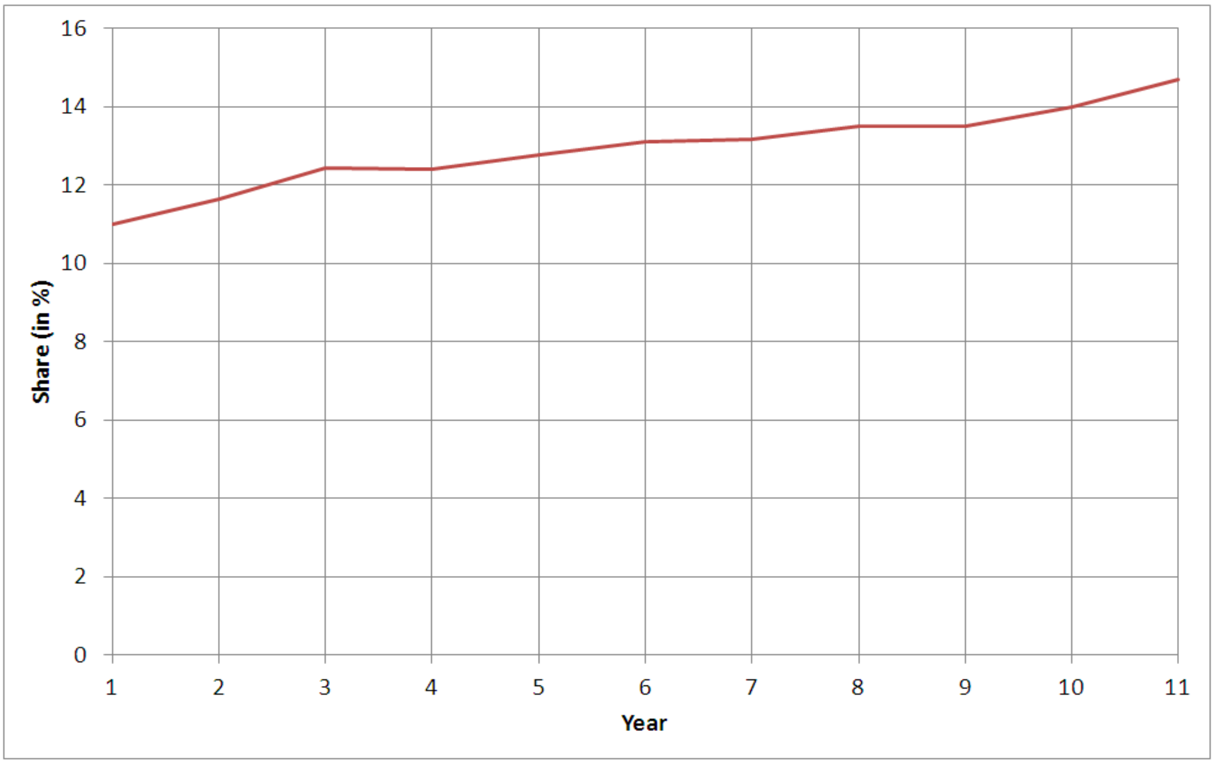
Source: SCIE and SSCI, searches and calculations by Fraunhofer ISI.

Figure 19: Share of articles by German authors published in one of the 10% most highly cited journals per field



Source: Web of Science, searches and calculations by Fraunhofer ISI.

Figure 20: Share of articles by German authors co-published with at least one American co-author



Source: Web of Science, searches and calculations by Fraunhofer ISI.

In order to confirm the assumption that German authors submit their papers to journals with higher impact factors, the share of German papers within the top 10% of the highest cited journals in each field was determined. In this analysis we can find a substantial increase in the early 1990s, but since then the share has grown very slowly (Figure 19). To sum up, the share of German articles in highly cited journals is very high, but is no longer increasing in a substantive way. In any case, this slow increase cannot explain the relevant growth of the IA index since the year 2000.

As a last hypothesis, we checked the share of co-publications with American authors. In general, the number of German publications in the SCIE grew by 30% between 2000 and 2010. In the same period, the number of co-publications with American authors increased by 73%. In total, the share of co-publications with American authors rose from 11.0 to 14.7% (Figure 20). In consequence, a planned move towards co-authorships with Americans can be observed.

All in all, German authors have substantially changed their behaviour in the last 20 years. Between 2000 and 2007 they moved from specialist to more mainstream journals and, since the early 1990s, they attempted to have their articles published in journals with a high impact factor. The strong upward trend of the average citation rates linked to a growth of the IA index is primarily due to a growing share of articles published in journals with American editorship, the co-authorship with American researchers, and to the move towards mainstream journals. It must be mentioned that this change has not affected the SR index. Thus German authors achieve a high Scientific Regard also in journals with higher impact factors.

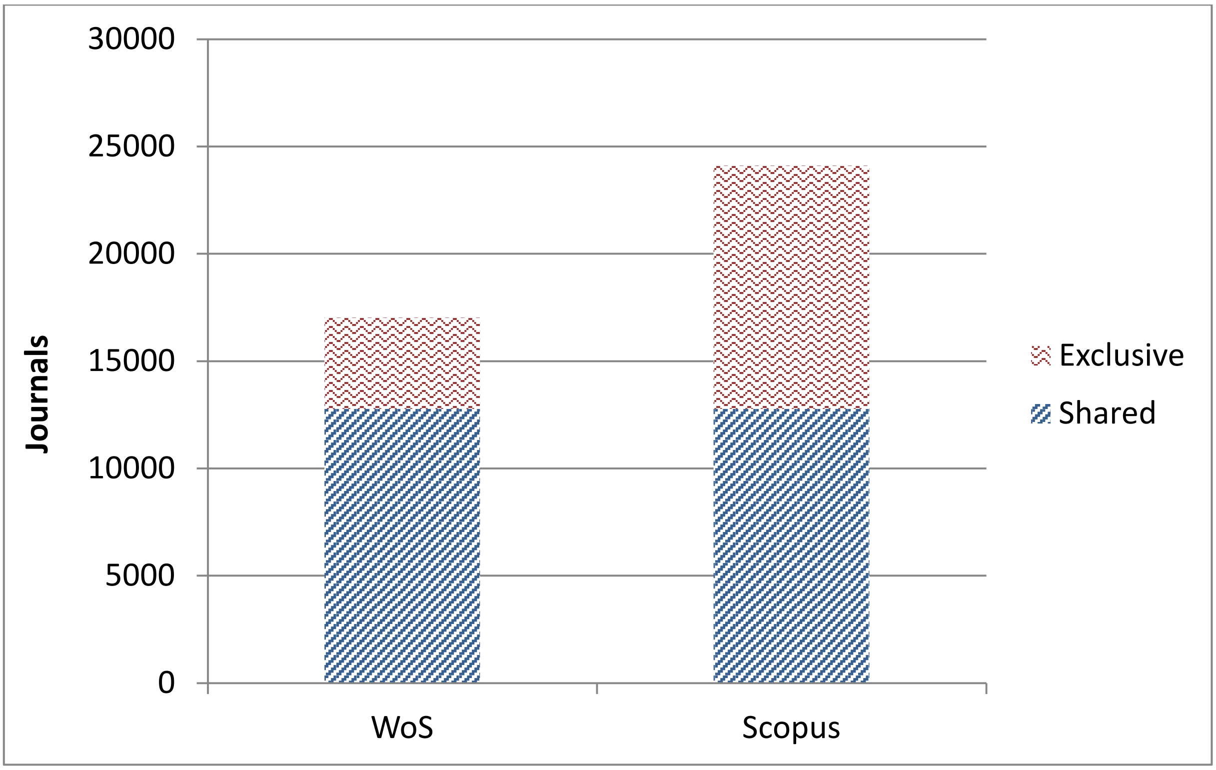
6. Comparison of the Web of Science and SCOPUS

Systematic bibliometrical analyses have been conducted since about 30 years, and for a long period the Web of Science (WoS) of the provider Thomson Reuters (formerly Institute for Scientific Information, ISI) was the only bibliometrical database. In consequence, the analyses with the WoS set standards and are generally taken as the reference. However, since about ten years, the international publishing company Elsevier with headquarters in Amsterdam offers Scopus as the second largest bibliometric database as an alternative to the WoS. Therefore it has to be analyzed whether Scopus is a real alternative or at least a useful complement to the WoS. For this purpose, we will analyze the following items:

1. Present and previous coverage of the WoS and Scopus in comparison
2. Coverage of scientific disciplines
3. Coverage of countries
4. Citation levels

To compare the present coverage of publications in both databases, we looked at the number of journals which are registered in both databases and which are available in only one of them. This different coverage of journals is illustrated in Figure 21. According to this, the overlap between the two databases is quite large: about 74% of the journals in the WoS are also covered by Scopus. However, the share of exclusive journals in Scopus is much higher, with about 47% of all Scopus journals. In contrast, in WoS the share of exclusive journals is about 25%.

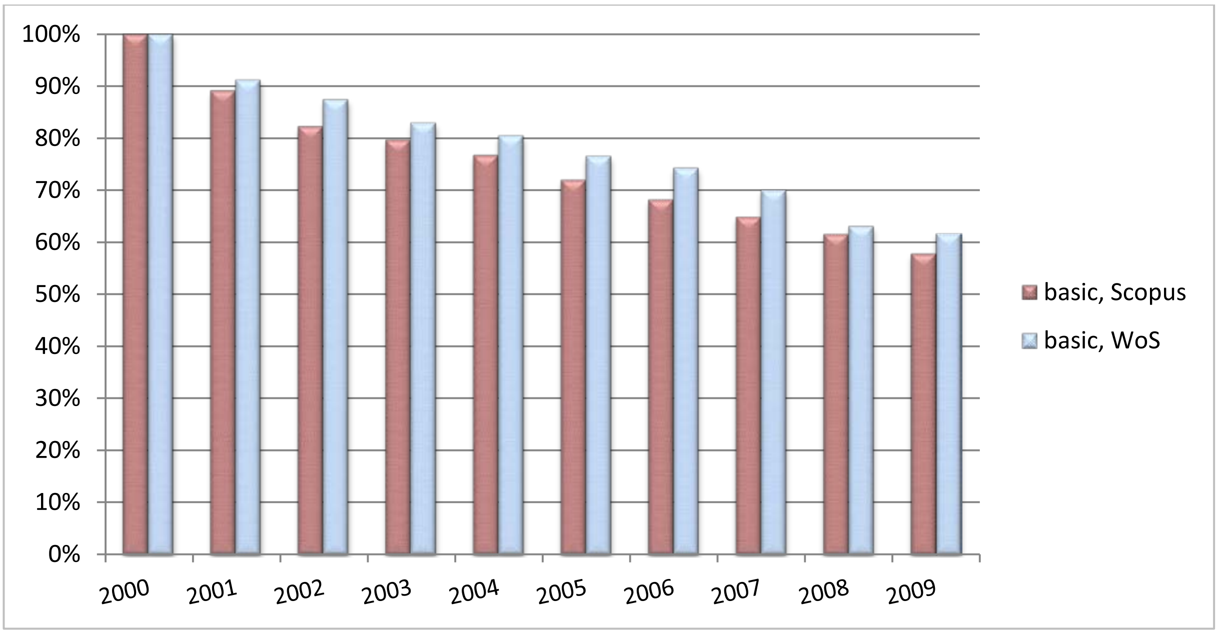
Figure 21: Number of journals in the Web of Science and in Scopus



Source: Web of Science, Scopus, searches and calculations by Fraunhofer ISI.

The content of both databases changes from year to year, i.e. new journals get in, some journals disappear and some journals reappear over time. However it could be argued that the relative high share of exclusive journals in Scopus can be traced back to a more intense fluctuation of journals. Figure 22 shows that both databases have a similar share of basic journals.

Figure 22: Alteration of the journal set in Scopus and WoS (Value in year 2000=100%)

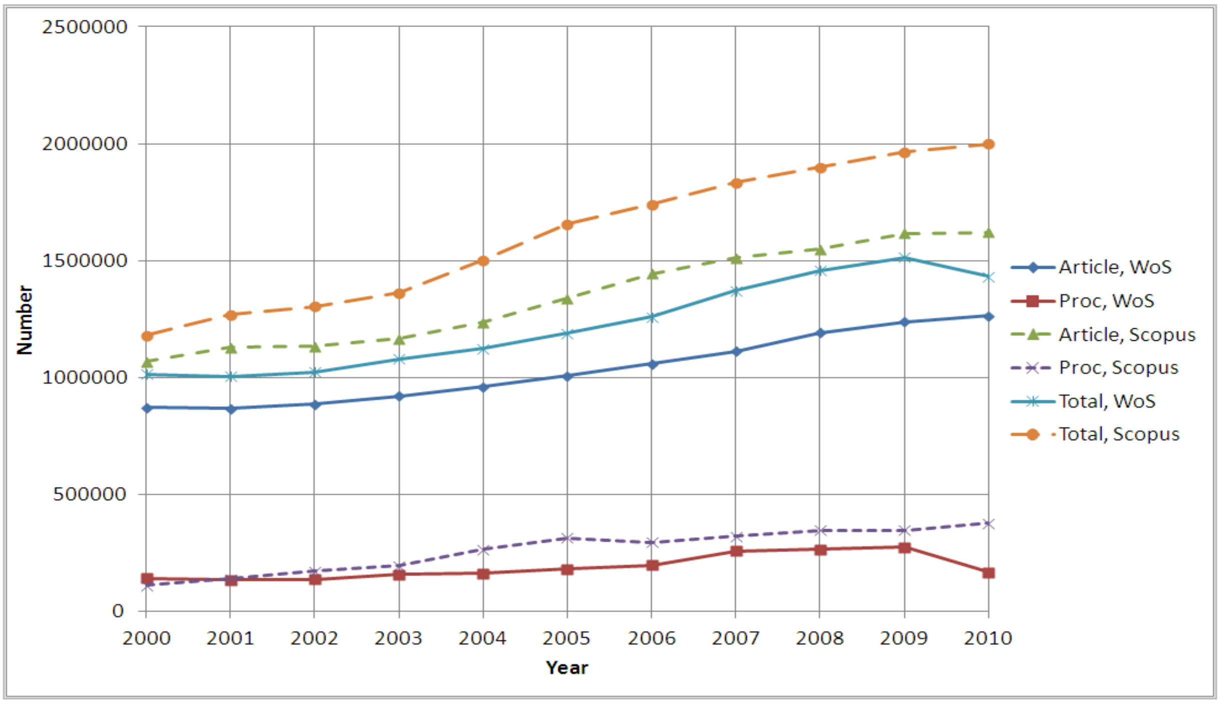


Source: Web of Science, Scopus, searches and calculations by Fraunhofer ISI.

If we transfer these results on the level of articles, we can sum up, that due to this large share of exclusive journals and respectively to the share of exclusive articles in Scopus, the results of the analysis in terms of publication numbers or citation rates cannot be identical.

When the development of publications in Scopus and the WoS is compared, the number of articles, letters, notes and reviews in Scopus is substantially higher than in the WoS, with a share of about 28% in 2010 (Figure 23). In all the years, the number of proceedings in Scopus is also higher than those in the WoS. Since 2000, the two databases have increased tremendously, obviously they compete in terms of coverage, but the WoS never reached the size of Scopus.

Figure 23: Number of journal publications and publications in proceedings in the Web of Science and in Scopus



Source: Web of Science, Scopus, searches and calculations by Fraunhofer ISI.

In 2010, the number of articles, letters, notes, and reviews altogether in the WoS was about 1,264,000 in total and the number of proceedings 168,000. The sum of articles, letters, notes and reviews in Scopus achieved in the same year 1,621,000, the proceedings 379,000.

When observing the differences of coverage by disciplinary fields, the situation in each field has to be considered in detail. For example, in "electrical engineering", the number of publications as well as proceedings is higher in Scopus, in "physics" the number of articles, letters, notes and reviews and also of proceedings in the WoS is higher than in Scopus (Figure 24).[7] The most remarkable advantages of Scopus in terms of publication numbers can be found in the fields of "computers" and "biotechnology". In particular in "computers", the number of proceedings is much higher than in the WoS. This is adequate, as in computer science the proceedings are much more important than in other fields and are considered equivalent to articles. In the social sciences, the coverage of Scopus is broader than in the WoS by about 25%, in economics even by 90%, while by contrast the articles in Scopus in the humanities represent only about a quarter of those in the WoS.

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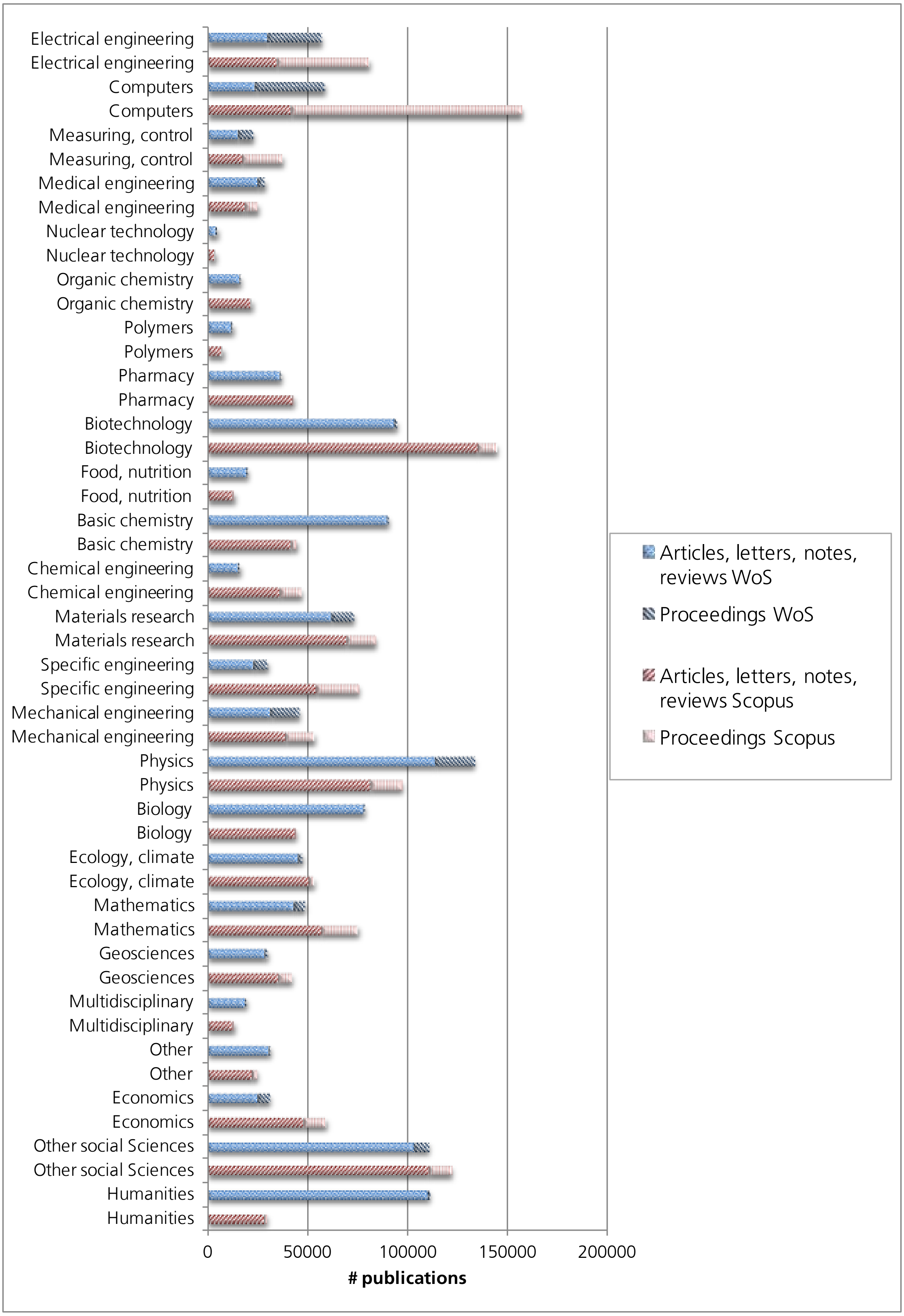
7 For the compilation of Figure 24, the classification codes of the providers of Scopus and the WoS were used to define the specific fields. Of course, their content is quite similar, but not identical. Further, the classifications were counted in a fractional way, as many articles are classified by several codes, in Scopus much more frequently than in the WoS. Therefore an adequate comparison can only be made by fractional counts. The results of Figure 23 are therefore based on fractional counts.

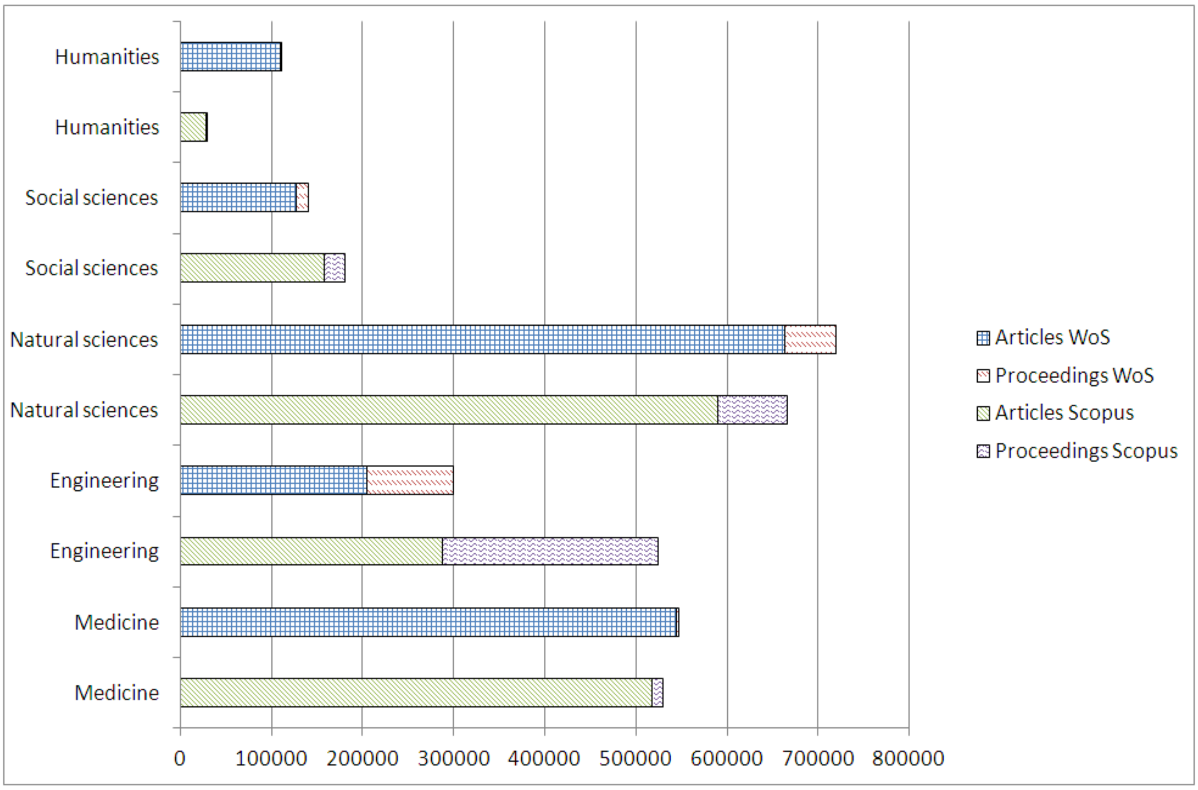
Figure 24: Publications in the Web of Science and Scopus for selected fields, 2010



Source: Web of Science, Scopus, searches and calculations by Fraunhofer ISI.

In the broader perspective of disciplinary areas, the natural and medical sciences are covered by the WoS somewhat better than in Scopus (Figure 25). In the engineering sciences, the coverage of Scopus is much better than in the WoS, in particular the number of proceedings is substantially higher. This latter aspect is very important for analyses in engineering, as the relevance of proceedings is much higher in this field than in other areas. The substantial differences in the total number of publications are primarily due to the broader coverage of engineering in Scopus.

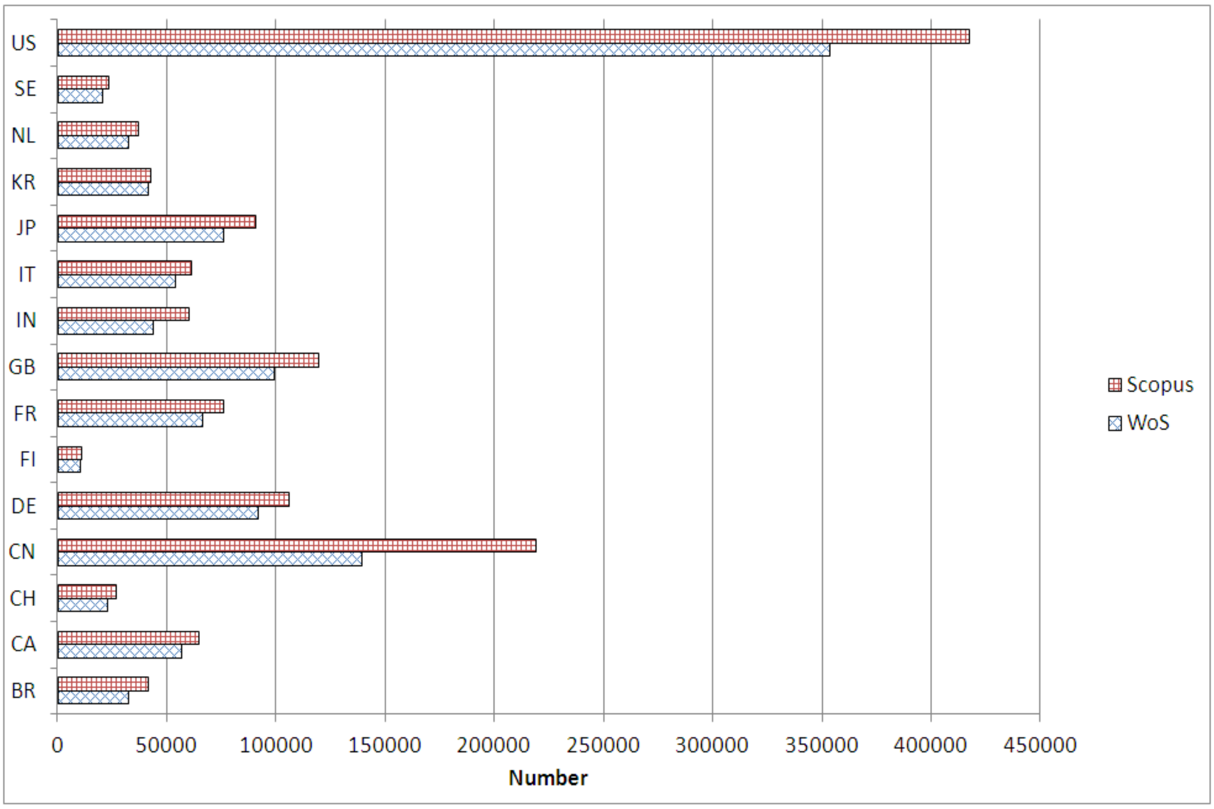
Figure 25: Publications in the Web of Science and Scopus for disciplinary areas, 2010



Source: Web of Science, Scopus, searches and calculations by Fraunhofer ISI.

With regard to the coverage of countries by the WoS and Scopus, the higher number of articles in Scopus is also transformed into a higher number of papers per country (Figure 26). However, the countries are affected differently. The industrialized countries have about 10 to 15% more publications, e. g., Germany 15%. The USA has even 18% more publications while Great Britain has 21%. The additional number of articles is more pronounced for developing and threshold countries. The additional share for Brazil is 28%, for India 38%. The most remarkable difference can be stated for China with 57% in 2010. The main exception is South Korea with 3% only. Thus the major difference of country coverage is the much broader inclusion of Chinese publications. The substantial recording of publications of English-language countries such as the USA and Great Britain is similar in WoS and Scopus, i.e. there is a high weighting of English-language countries with reference to all publications covered in the database.

Figure 26: Articles of selected countries in the Web of Science and Scopus, 2010



Source: Web of Science, Scopus, searches and calculations by Fraunhofer ISI.

For a more detailed comparison of the Web of Science and Scopus in terms of citations, various analyses were conducted in Scopus similar to those carried out with Web of Science in chapter 3. The analyses did not begin before 2005, as in the first years the coverage of journals in Scopus was quite unsystematic, and according to the provider a major improvement was introduced in 2004. To be on the safe side, the analyses in this report start in 2005.

The shares of countries within the total database, comparable to Table 3 for WoS, are described in Table 9. As a general observation, the shares of the industrialized countries in Scopus are lower than in the WoS, primarily due to China's much higher share. The other threshold countries have a similar share in Scopus to that in WoS in 2010, but already have higher shares in Scopus in 2005. Here the WoS has increased its coverage in the last years.

As to the observed citation rates in Scopus, comparable to Table 5 for WoS, the average citation rates in Scopus are at a comparable level to the WoS, but somewhat lower in all years. For instance, in 2005 the world average citation rate in Scopus was 3.0 compared to 3.5 in the WoS, and in 2008 3.4 compared to 3.7 in the WoS (Table 10). This difference should not be interpreted in terms of different quality or impact, but rather as a different coverage of journals. Thus an explanation may be the broader coverage of journals in engineering where the citation level is generally lower, the more extensive inclusion of journals in threshold countries, or perhaps the inclusion of more specialised journals which are generally less cited due to a smaller readership.

The effects on single countries may be explained best by the example of Germany, Great Britain, Brazil and China similar to Figure 5 for the WoS. In the case of the industrialized countries Germany and Great Britain, the level of the observed citations is a bit lower than in the WoS, but their ranking is identical and the trends are the same (Figure 27). For Brazil, the citation rates in Scopus are almost identical to those in the WoS, but the rates for China are clearly lower, although the trend of an increasing level is identical. Without a detailed analysis of the reasons for China's lower citation rates, it may be assumed that the latter are based in Scopus to a larger extent on citing papers by other Chinese publications in Chinese journals. Besides, India achieves similar citation rates in Scopus as in the WoS, South Korea higher rates. Again, this should not be interpreted in terms of impact, but just in terms of different journal coverage. In consequence, any conclusion as to the "correct" level of citation rates has no real methodological basis.

Table 9: Shares of selected countries and regions in Scopus (without humanities) within all articles world-wide (whole counts)

Country/region	2005	2006	2007	2008	2009	2010
USA	31.0	30.0	29.4	28.6	27.7	27.3
Japan	8.9	8.6	8.3	8.0	7.3	5.9
Germany	8.0	7.8	7.6	7.4	7.2	6.9
Great Britain	8.7	8.7	8.6	8.2	8.0	7.8
France	5.4	5.3	5.2	5.2	5.1	5.0
Switzerland	2.1	2.1	2.1	2.1	2.0	1.7
Canada	4.5	4.4	4.5	4.4	4.4	4.2
Sweden	1.8	1.7	1.7	1.6	1.6	1.5
Italy	4.3	4.3	4.4	4.3	4.2	4.0
Netherlands	2.5	2.5	2.4	2.4	2.4	2.4
Finland	0.8	0.8	0.8	0.8	0.8	0.7
South Korea	2.1	2.2	2.4	2.6	2.7	2.8
Brazil	2.2	2.5	2.7	2.8	2.8	2.7
India	3.2	3.3	3.5	3.6	3.7	3.9
China	11.9	12.7	13.0	13.6	14.2	14.3
EU-15	30.3	30.5	30.3	30.3	30.1	29.4
EU-12	3.7	3.8	3.8	4.0	4.0	3.8
EU-27	36.4	37.1	37.2	37.7	37.9	37.8
World	100.0	100.0	100.0	100.0	100.0	100.0

Source: Scopus, searches and calculations by Fraunhofer ISI.

Table 10: Observed average citation rates for selected countries and regions in Scopus (without humanities) without self-citations

Country/region	2005	2006	2007	2008
USA	5,2	5,1	5,2	5,5
Japan	3,2	3,1	3,3	3,4
Germany	4,4	4,2	4,6	4,7
Great Britain	4,6	4,4	4,7	5,0
France	4,1	4,0	4,3	4,4
Switzerland	6,0	5,7	5,9	6,3
Canada	4,5	4,5	4,8	5,0
Sweden	4,9	4,7	5,1	5,4
Italy	4,2	4,0	4,2	4,7
Netherlands	5,3	5,2	5,6	5,9
Finland	4,5	4,2	4,6	4,9
South Korea	3,2	3,2	3,3	3,4
Brazil	2,4	2,1	2,2	2,3
India	1,9	1,9	2,1	2,2
China	1,3	1,5	1,9	2,2
EU-15	4,0	3,9	4,0	4,3
EU-12	2,2	2,2	2,4	2,6
EU-27	3,6	3,5	3,6	3,8
World	3,0	3,0	3,1	3,4

Source: Scopus, searches and calculations by Fraunhofer ISI.

Of course, the differences between Scopus and the WoS in the average citation rates and the specific citation rates for countries also affect derived indicators such as the SR or IA indices. In the case of the SR indices, the level and trends for the industrialized countries Germany and Great Britain are similar to the WoS, for the threshold countries the levels are higher and the trends are similar (Figure 28). The same observation applies to India and South Korea (Table 11).

As to the IA indices, the level of Germany and Great Britain are substantially higher than in the WoS (Figure 29, Table 12). This could be expected, as the world average citation level in Scopus is lower than in the WoS and with reference to the average level, the citation rates of Germany and Great Britain are relatively higher. The ranking between Germany and Great Britain is the same as in the WoS. This statement also applies to China and Brazil. The trends of the WoS are reproduced in Scopus, but the IA indices of China are substantially lower than in the WoS. This effect may be linked to the broader coverage of Chinese journals in Scopus, so that a higher share of Chinese publications is recorded in journals with lower Impact Factors.[8]

To summarize, the levels and trends of citation indicators in Scopus largely reflect the results in the WoS. The world average level is a bit lower than in the WoS, the ranking between industrialized countries is reproduced, the level of threshold countries differs sometimes, depending on the specific database coverage for the country analyzed.

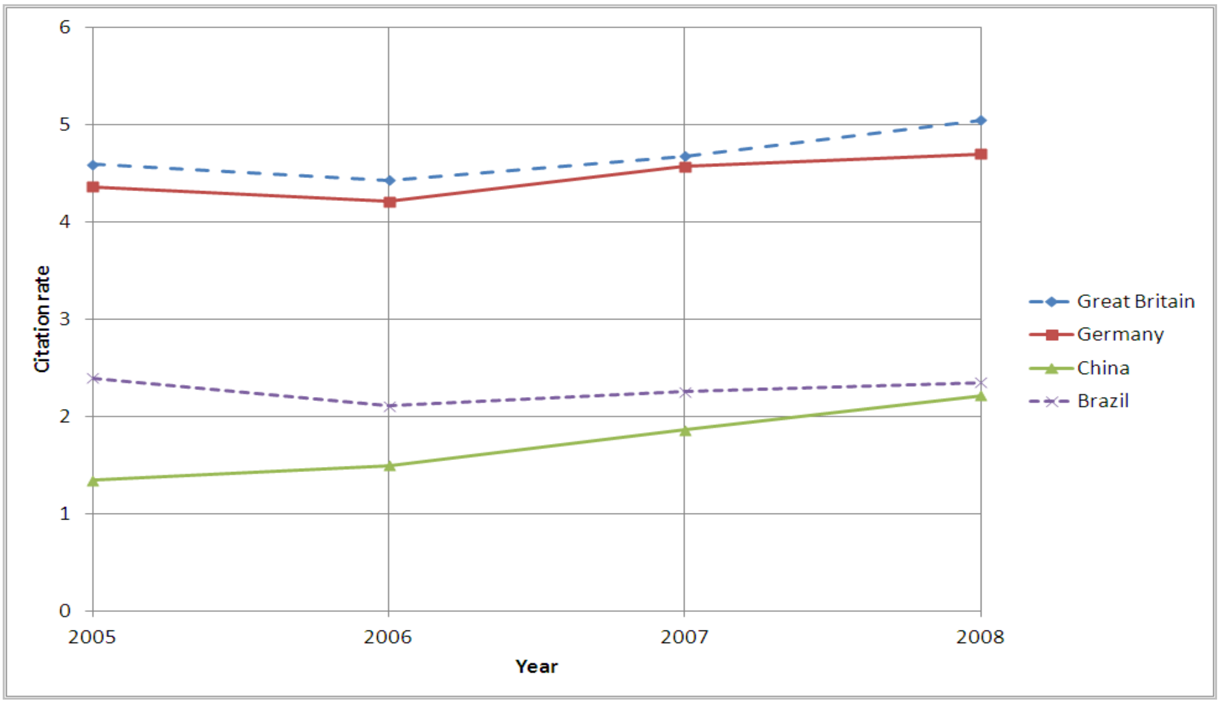
Table 11: Index of the journal-specific scientific regard (SR) for selected countries and regions without self-citations in Scopus (without humanities) without self-citations

Country/region	2005	2006	2007	2008
USA	8	8	8	7
Japan	-7	-6	-6	-7
Germany	9	8	11	8
Great Britain	8	9	8	9
France	5	5	6	5
Switzerland	18	17	16	16
Canada	7	8	9	9
Sweden	13	10	11	10
Italy	4	2	5	10
Netherlands	10	10	13	12
Finland	8	6	10	6
South Korea	-2	-1	-2	-1
Brazil	-5	-7	-6	-4
India	-7	-8	-6	-5
China	5	4	7	10
EU-15	3	3	3	3
EU-12	-4	-4	-1	3
EU-27	2	2	2	1
World	0	0	0	0

Source: Scopus, searches and calculations by Fraunhofer ISI.

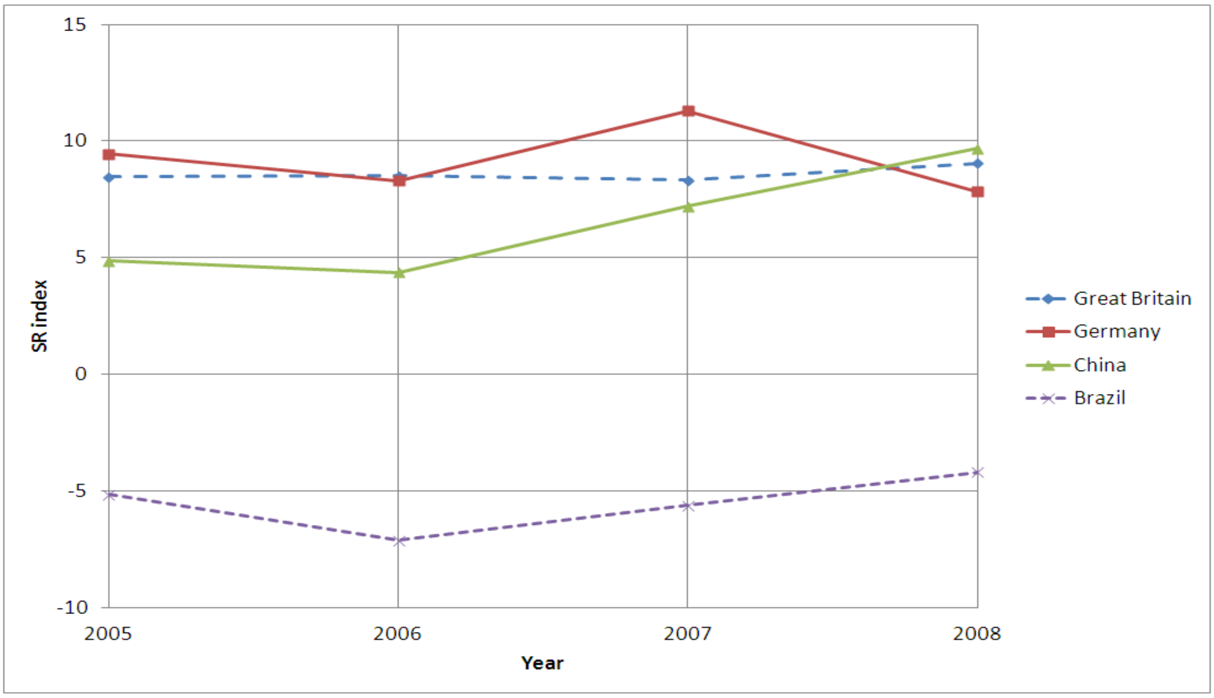
8 Of course, the Impact Factor is exclusively calculated on the basis of journals already covered by Scopus. Furthermore, the correct compilation of references in the Chinese language may be insufficient.

Figure 27: Observed average citation rates for selected countries in Scopus (without humanities) without self-citations



Source: Scopus, searches and calculations by Fraunhofer ISI.

Figure 28: Index of the journal-specific Scientific Regard (SR) for four selected countries without self-citations in Scopus (without humanities) without self-citations



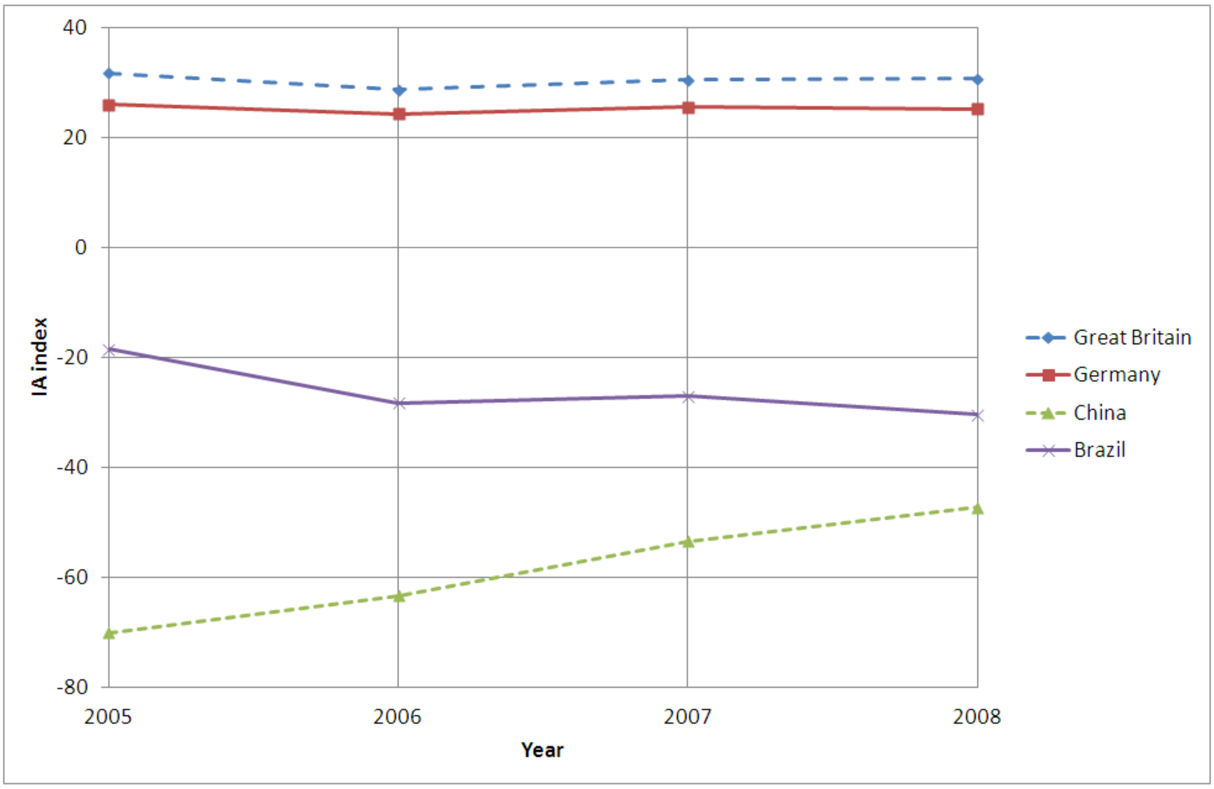
Source: Scopus, searches and calculations by Fraunhofer ISI.

Table 12: Index of the International Alignment (IA) for selected countries and regions without self-citations in Scopus (without humanities)

Country/region	**2005**	**2006**	**2007**	**2008**
USA	43	41	41	40
Japan	12	9	10	9
Germany	26	24	25	25
Great Britain	32	29	30	31
France	26	23	25	23
Switzerland	45	43	44	45
Canada	30	31	32	30
Sweden	34	32	36	36
Italy	27	25	24	23
Netherlands	42	42	42	42
Finland	30	27	28	31
South Korea	8	6	6	3
Brazil	-19	-28	-27	-31
India	-40	-35	-32	-34
China	-70	-63	-54	-47
EU-15	23	21	22	21
EU-12	-27	-26	-25	-29
EU-27	15	12	13	11
	0	0	0	0

Source: Scopus, searches and calculations by Fraunhofer ISI.

Figure 29: Index of the International Alignment (IA) for selected countries and regions without self-citations in Scopus (without humanities)



Source: Scopus, searches and calculations by Fraunhofer ISI.

All in all, the coverage of Scopus and the WoS differ to a large extent, in particular as Scopus covers a substantial share of articles exclusively. The number of articles and proceedings in Scopus is clearly higher than in the WoS, where the main differences are the broader coverage of engineering in terms of articles and in particular proceedings as well as of China. Other developing and threshold countries are also recorded in Scopus to a larger extent. These differences imply different citation rates and derived indicators, but the ranking of countries and the major trends in the WoS are largely reproduced in Scopus. However, some discrepancies in Scopus with reference to the WoS can be observed for the threshold countries, but no statement as to the "correct" values can be made, but a closer look at the database coverage is required. In any case, Scopus proves to be a valuable complement to the WoS, first of all in analyses of engineering and then of threshold countries.

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