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Bibliometric data study: assessing the current ranking of the People's Republic of China in a set of research fields : final report to the delegation of the European Commission

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Bibliometric data study: Assessing the current ranking of the People's Republic of China in a set of research fields

Final report to the Delegation of the European Commission

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1 Introduction

The Chinese innovation system is one of the most dynamic in the world. The annual growth of GDP per capita of over 7-8% on average during the period of 1993-2003 (OECD 2005: 32), and the growth of the total R&D expenditure (GERD) by 18.6% on average between 2001 and 2003 (Ministry of Science and Technology (China) 2006: 44) are evidence of this development. However, despite catching up considerably in the recent past, China still lags behind the developed industrial nations with regard to the absolute amount as well as the level of many indicators. The share of R&D expenditure in GDP (R&D intensity) amounted to 1.3% in 2003, which means an outstanding position among the developing countries, but still a clear gap compared to the EU-25 (1.8%) or Germany (2.5%). Other countries like the USA, Japan, Finland or Sweden are even close to or beyond the threshold of 3%.

Starting in the late 1990s and as another consequence of the "open door" policy, Chinese policy makers have more and more concentrated their efforts on improving the research and innovation orientation, both of private firms and of public research institutes. However, the new system and orientation bears its fruits only slowly, particularly in high-tech industries. China has set the goal to create "indigenous innovations" to be no longer dependent on technology transfer from abroad. China plans to make technological progress in a number of fields and catch-up with international levels in leading-edge technologies like new materials, nanoscience, information technologies, or aerospace. The intention is to reach the group of worldwide top five countries in terms of the number of patent applications. Furthermore, China has set the goal to increase the absolute number of internationally relevant scientific publications, and also to increase the quality of these publications, measured by the number of citations per publication. The new orientation towards science, technology and research of the Chinese innovation system is one of the motivations to have a closer look at the status quo of scientific output, of its quality, its structure and its cooperation patterns.

It has to be admitted that China is not in the least homogeneous. Besides the numerous ethnic groups and the geographically and topologically vastly differing regions in this country, it is primarily the economic differences within China which lead to a marked heterogeneity. The east coast with the two metropolises Beijing and Shanghai but also other provinces, are clearly further developed than numerous other areas in this huge territorial state. Bearing this fact in mind, this report can only hardly cover this heterogeneity. The analyses of the scientific output presented in this report focus on the national level. However, a list of "hot spots" in certain scientifc fields is able to – at least – reflect some regional discrepancies.

The European Union has a long lasting cooperation agreement with the People's Republic of China in science and technology. China has become an increasingly attractive cooperation partner for the member countries of the European Union. This and the dramatic but unbalanced development, the heterogeneity of the country and S&T development strategies are calling for a more differentiated assessment of the status and the development of the Chinese research system. A more detailed analysis of China in this respect will enable a more differentiated assessment of the relevance and the impact of the scientific cooperation between China and the member countries of the European Union.

The analysis of the Chinese science system presented in this report is based on bibliometric methods. It aims at identifying trends of development and specialization of the Chinese science system, the identification of the major players within a defined set of disciplines and a general assessment of China's scientific performance. Furthermore, the pattern of international collaboration is of specific interest. The following chapter discusses the general developments of internationally relevant publications of Chinese authors and compares them with some selected countries. Structures, profiles and quality issues are also considered. Chapter three analyses the co-publication patterns of Chinese authors with three important regions (North America, Asian-Pacific and EU-27), including the cooperation in selected scientific fields. Chapter four presents a list of the most active publishing research institutions across all fields. Chapter five summarises and concludes. The annex contains detailed descriptions of the methods applied and the lists of top twenty institutions per scientific field.

2 Chinese publication profiles

2.1 Productivity and Growth

Consistent with most S&T indicators of China, also scientific publications in the Science Citation Index show enormous growth rates. The absolute number of total Chinese publications has nearly doubled in the short period 2003-2006. Today China contributes about 9 % to the worlds publication output. This means China meanwhile has reached the same level as countries like the United Kingdom and Germany. However, for these countries the growth rates are considerably lower. An end of the Chinese expansion is not yet visible. In terms of growth, China clearly outperforms these countries and – as can be seen in Table 1 and Figure 1 – it also clearly outperforms the worldwide development as expressed by the total scientific publications covered by the Science Citation Index. While the worldwide publications increased only by 30% since 1997, the number of Chinese publications is 4.5 times higher in 2006 than it was in 1997.

Table 1: Publications of China vs. Global: 1997-2006

Year	Global	China	China's Share	Global Growth Index	China Growth Index
1997	737,267	19,573	2.7	100	100
1998	753,611	22,470	3.0	102	115
1999	767,473	26,361	3.4	104	135
2000	780,949	30,078	3.9	106	154
2001	781,071	35,084	4.5	106	179
2002	799,243	39,189	4.9	108	200
2003	836,715	47,546	5.7	113	243
2004	876,287	58,162	6.6	119	297
2005	918,446	70,575	7.7	125	3601
2006	952,394	84,226	8.8	129	430

STN: SCISEARCH; Fraunhofer ISI calculations.

In terms of relative performance, however, China is still lagging behind the expectancy based on its sheer size. The publication intensities – the number of publications in relation to the size of the population – reaches a level of 65 per one million people, which is more than that of India, but far behind any developed country (see Table 2). The smaller countries like Switzerland, Finland or Sweden as well as the English speaking countries United Kingdom and USA are still ahead. Also in relation to the absolute number of working people (110 per one million labor force), China is still far below the indicator values calculated for the Western Countries and also among the developing countries it is not among the top performers. This means: first of all, China is very important due to its size. However, in relative terms of efficiency and effectiveness, China still cannot compete with most other countries. Though, China will most likely never reach intensities like Switzerland or other small countries simply due to size effects, but there is some room left for improvement of the Chinese science system.

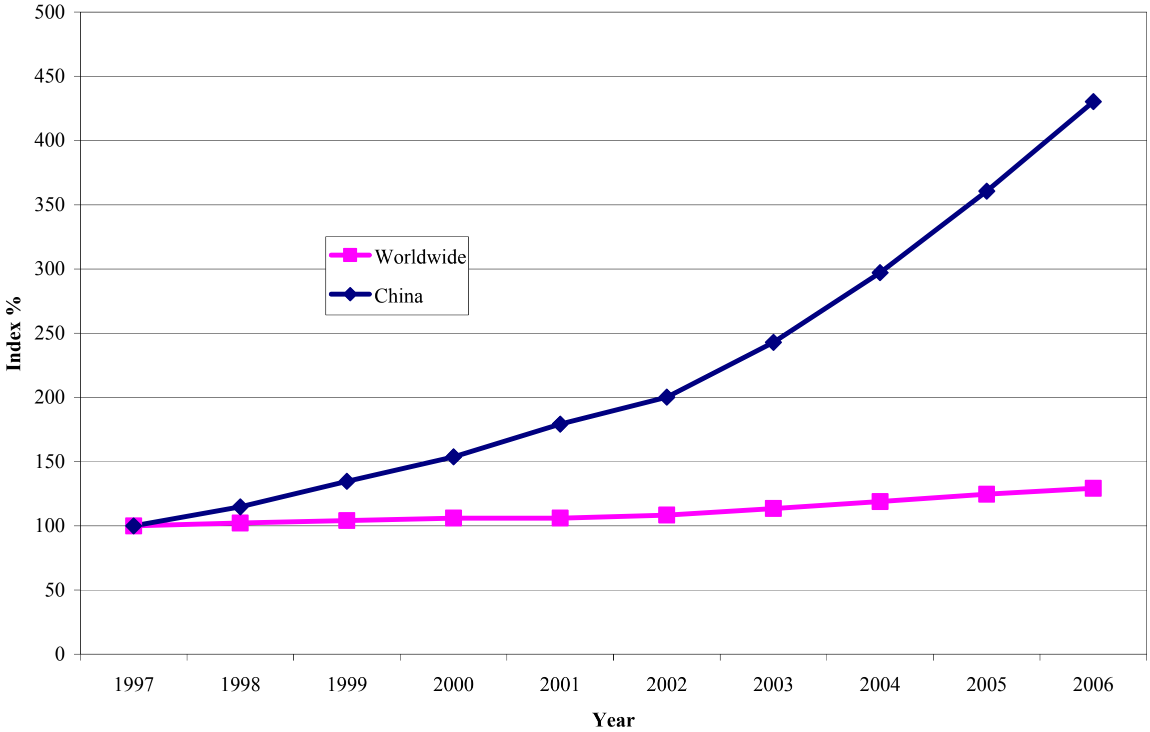
Table 2: Number of total SCI publications per 1. Mio inhabitants or labor force, 2006

	Absolute N of publications	Share of total SCI publ.	Intenisty (Inhabitants)	Intenisty (Labor Force)
EU-27	357287	37.5	726 *	1533
EU-15	331651	34.8	854 *	1787
USA	283474	29.8	945	1868
China	84883	8.9	65	110
United Kingdom	77659	8.2	1283	2594
Japan	77550	8.1	607 *	1165
Germany	76196	8.0	925	1835
France	55386	5.8	876	2008
Italy	43438	4.6	738	1761
Spain	33344	3.5	757	1545
India	28578	3.0	28 +	71 +
Korea (Republic of)	28366	3.0	587	1183
Netherlands	23740	2.5	1453	2837
Switzerland	18059	1.9	2408 *	4046
Sweden	17072	1.8	1880	3655
Poland	14858	1.6	390	874
Belgium	13122	1.4	1244	2817
Denmark	9301	1.0	1711	3203
Austria	9124	1.0	1102	2213
Greece	8974	0.9	807	1839
Finland	8600	0.9	1633	3221
Norway	6785	0.7	1456	2774
Czech Republic	6462	0.7	629	1243
Portugal	6448	0.7	609	1154
Hungary	5059	0.5	502	1191
Ireland	4499	0.5	1084 *	2134
Romania	2780	0.3	128	356
Slovakia	2222	0.2	412	837
Slovenia	2074	0.2	1035	2029
Bulgaria	1695	0.2	240	495
Lithuania	1125	0.1	396	708
Estonia	785	0.1	573	1441
Cyprus	300	0.0	443	783
Latvia	296	0.0	125	351
Luxemburg	209	0.0	452	636
Malta	63	0.0	193	383

* Number of Inhabitants covers the year 2005; + Inhabitants/Labor Force covers the year 2001

Source: OECD: MSTI; ILO: LABORSTA; EUROSTAT: New Cronos; STN: SCISEARCH; Fraunhofer ISI calculations.

Figure 1: Growth Index of publications, 1997-2006



STN: SCISEARCH; Fraunhofer ISI calculations.

Significant growth of Chinese publication activities can be found across all scientific areas. However, differences in the extent of growth emerge when fields aer compared. The highest growth rates since 2001 are visible for the field Computers (see Figure 4). In the earlier period it came second behind Environmental Engineering (see Figure 3).[1] Which, as did the field Ecology and Climate, loose some momentum compared to the development in other fields. Life sciences and related fields like Pharmacy, Biotechnology, Biology and Food and Nutrition, but also Medicine, improved their position in terms of growth rates. Though the publications in most engineering fields doubled in the six years period, these growth rates are still below the average of growth of Chinese publications.

This means, the increase of the number in publications is a general phenomenon in China and covers more or less all scientific fields in the same way. Looking at the growth rates since 1997 (Figure 2) – a period when China's catching up process speeded up and when China's internationalisation successes were lower than today – the hierarchy of scientific fields is slightly different, with environmental and ecological fields being at the top. This means that the shift towards some more applied fields like Biotech but also Medicine – a field that covers also Chinese Medicine, which is closely related to Biotech and Pharmaceuticals and which is of increasing international interest – has taken place after the beginning of the new millennium. Though, China's scientific profile is in a constant flux, a slightly different profile in terms of growth rates and scientific orientation can be deduced from these figures.

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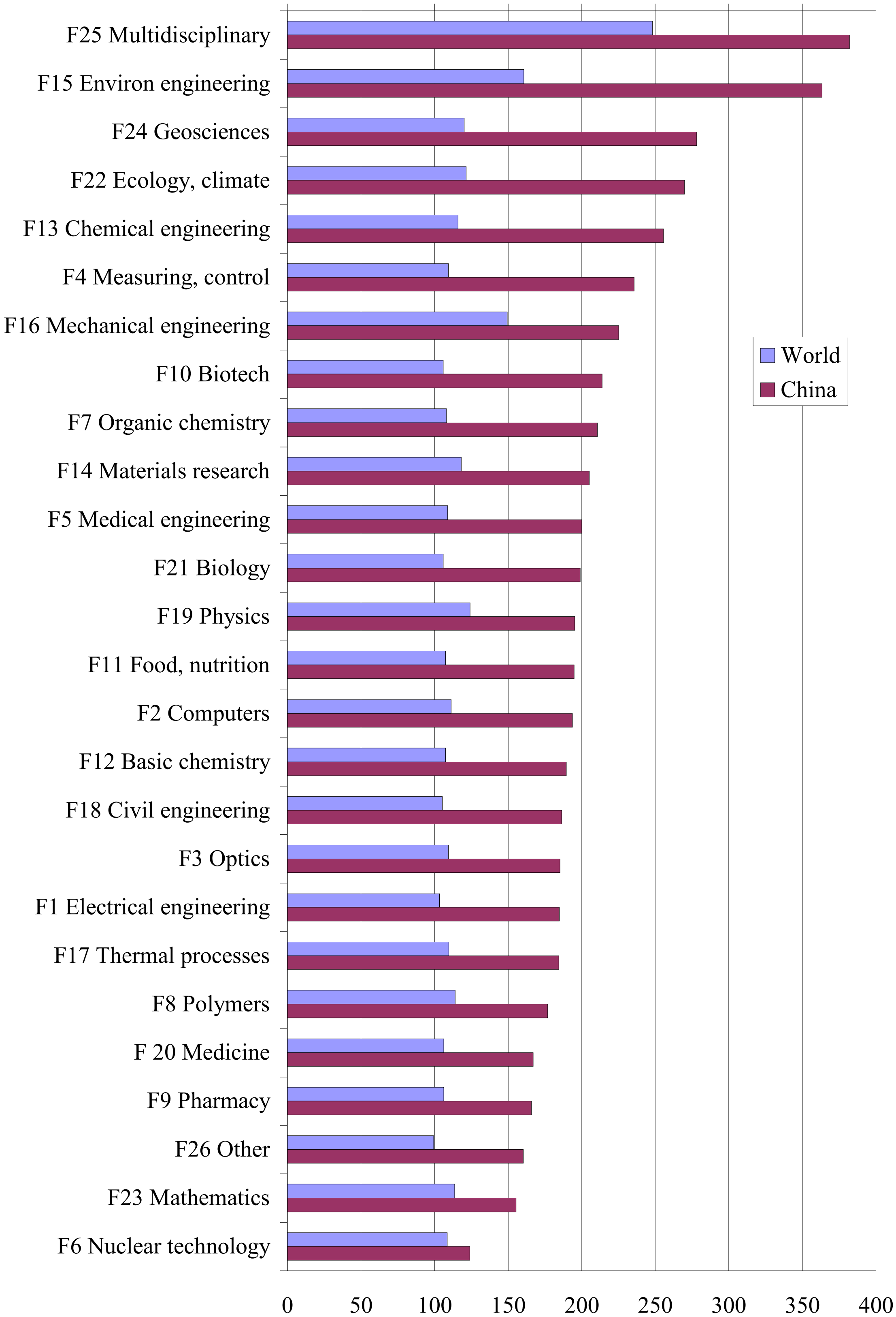
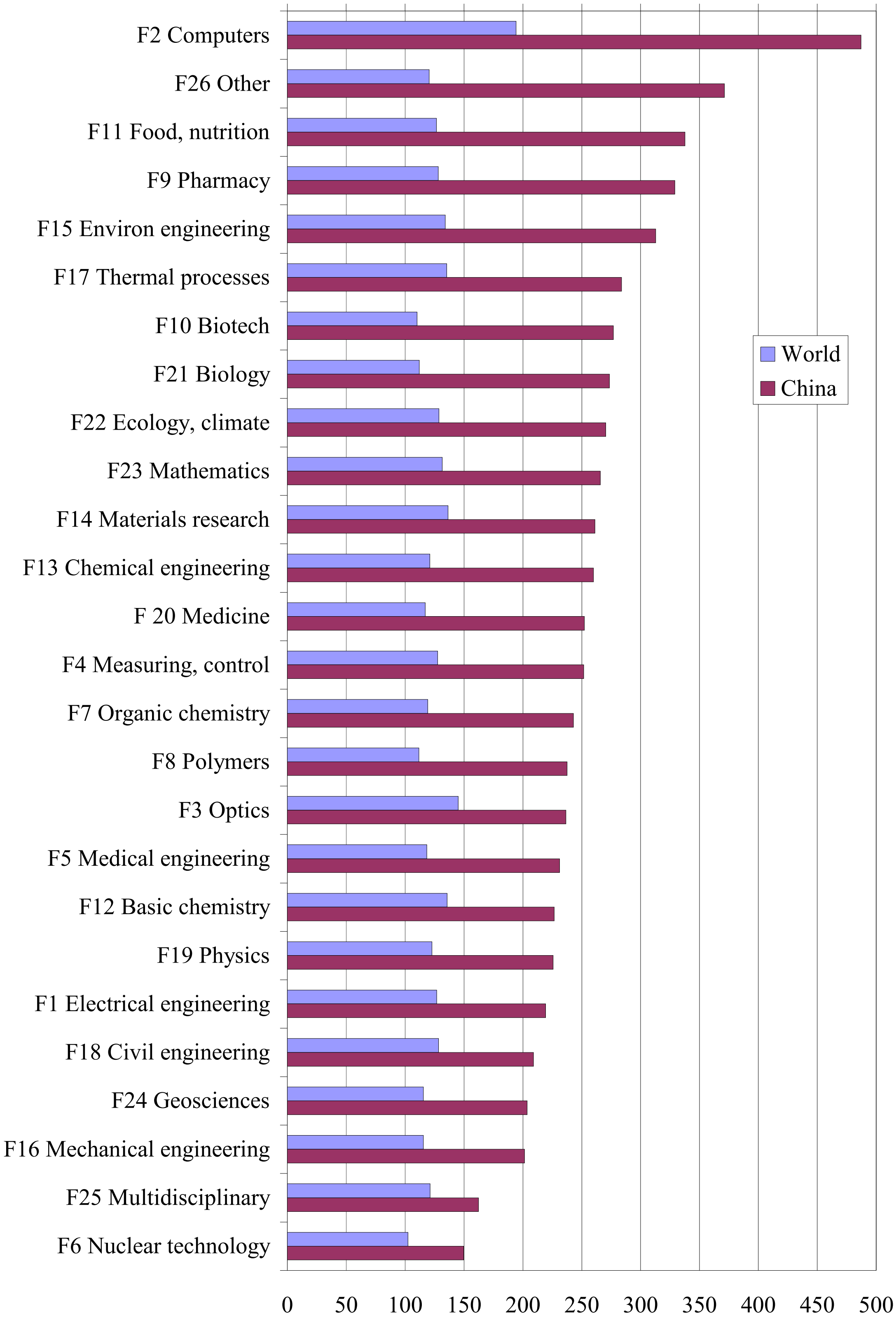
1 In annex 1 the absolute number of publications and the respective shares of worldwide publications are displayed.

Figure 2: *Growth Index (1997=100) of Chinese publications in 26 fields, 1997-2001*



STN: SCISEARCH; Fraunhofer ISI calculations.

Figure 3: Growth Index (2001=100) of Chinese publications in 26 fields, 2001-2006



STN: SCISEARCH; Fraunhofer ISI calculations.

2.2 Specialisation of Chinese Science

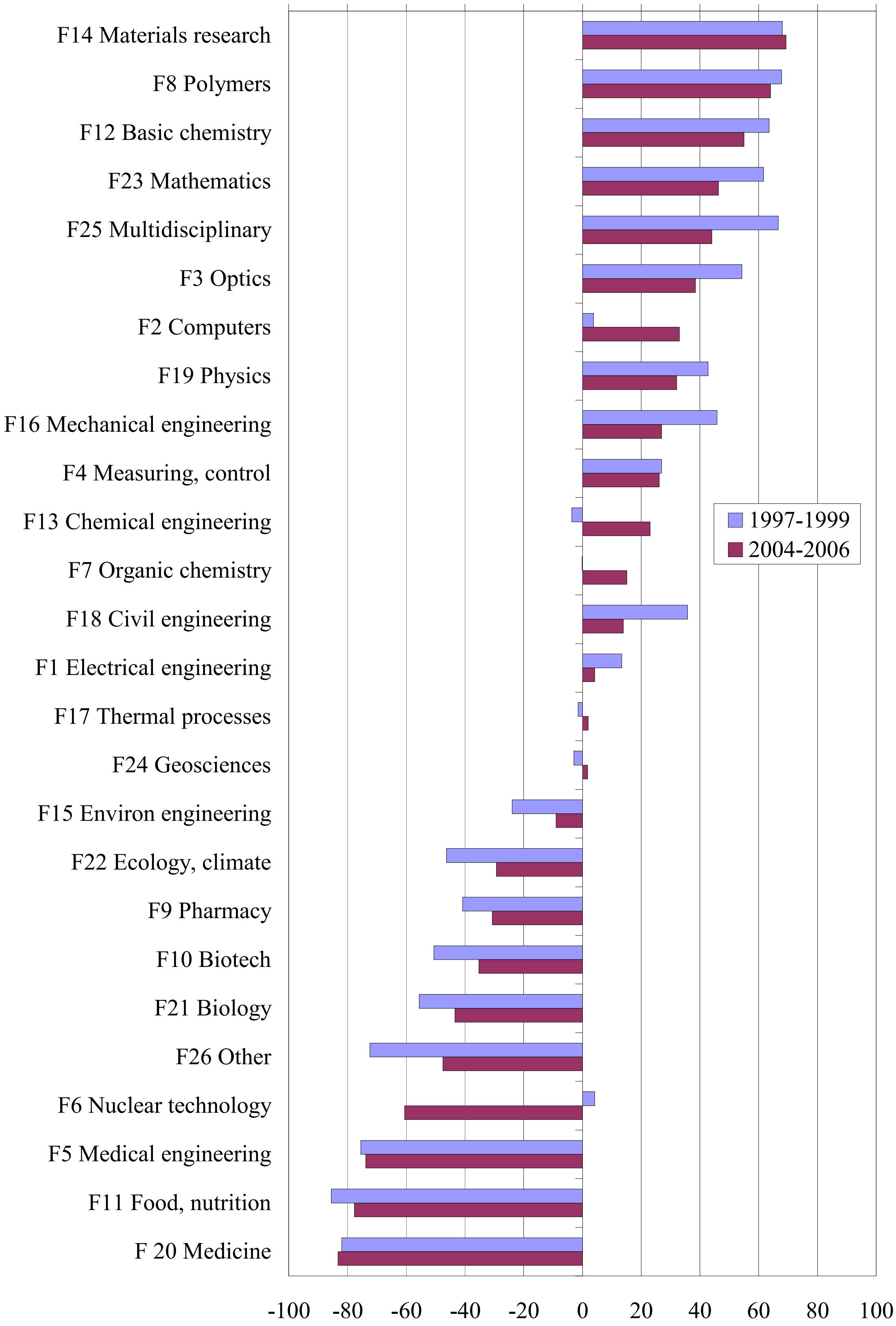
In terms of specialisation[2] – a measure of scientific orientation beyond size effects – China shows comparative advantages in material sciences and polymers (including Nano-Tech) as well as computers, optics, measuring and control (Figure 4). In some basic scientific areas like mathematics, physics or basic chemistry, the Chinese still have positive specialisations – a profile and a heritage that many countries with traditions in Academies of Sciences show (e.g. Russia, Eastern Europe). However, obviously these are the areas where the specialisation index is slowly decreasing as a result of an increased orientation towards applied sciences.[3]

Engineering fields, except for mechanical engineering, reach average values in most cases, reflecting relative activities similar to those of the worldwide publications. In the broad area of life sciences (including medical engineering), the output of the Chinese science system shows comparative disadvantages, especially in the field of medicine. However, as many of these fields were among the fastest growing, these are also the fields with the most positive trends in the specialisation index when the two periods 1997-1999 and 2004-2006 are compared.

[2] The Specialisation Index does not reflect the importance of a scientific field. It rather compares the shares of a certain field within a country with the worldwide shares of this field.

[3] It has to be stressed at this point that the assessment of an increased orientation towards applied sciences is only based on the general observation of changing weights of the fields as they were presented here. Changes towards or away from applications within the fields cannot be analysed here.

Figure 4: China's scientific Specialization (RLA)



STN: SCISEARCH; Fraunhofer ISI calculations.

2.3 Impact of Chinese Science

In order to analyse the impact of Chinese Science, two citation based indicators were calculated. The scientific regard analyses whether a countries publications are more intensely cited within the chosen journal set than are other articles in the same journal set. The results of the analysis are given in Figure 5. For the calculation of the indicator a three year citation window[4] which includes the year of publication itself was used. Therefore the data of the latest available year where an analysis is possible is the publication year 2004.[5] Self-citations were excluded from the analysis. The 'scientific regard'[6] of Chinese publications in the SCI has been below average for a very long time (Schmoch 2007). The totality of SCI publications of Chinese authors of the publication year 2004 are cited on average, which means that they receive the same citation rates like authors from any other country – on average across all scientific fields covered by the SCI. These findings are supported by interviews with experts in the Chinese scientific system that were recently conducted in China as part of an OECD project (Frietsch and Wang, 2007). The Chinese caught up in several technological fields, but a quality gap is still evident in many areas.

The fields with the highest indicator values are Mathematics, Medicine, Chemistry and Mechanical Engineering. Interestingly enough these are those fields with comparatively low growth rates and negative or average specialisation. On the opposite, the most important and fastest growing field Computers seems to have hardly any impact on the international scientific community. Indicator values are clearly below average. In total there is a rather small set of fields where Chinese science reaches citation values above average. Indicating that the impact of Chinese science to date is in many fields still rather limited and can not yet live up to the expectations. However due to the limitations of the data no comparison with more recent data can be provided and thus it remains to be seen whether China will be able not only to compete quantitatively but also qualitatively. Materials Science is regarded on an average level and Polymers are cited above average. Biology, Biotech, Pharmaceutical and Food and Nutrition – all the fields with high growth rates – are cited below the average of international citation rates. The reasons for these patterns might be manifold and for an empirical justification and proof of the following reasoning, the necessary data are not at hand due to database restrictions but also restrictions of time (the three year citation window is the minimum). Furthermore, pure bibliometric and statistical methods are not capable of all the dynamics and idiosyncrasies, so only anecdotic evidence can be given here.

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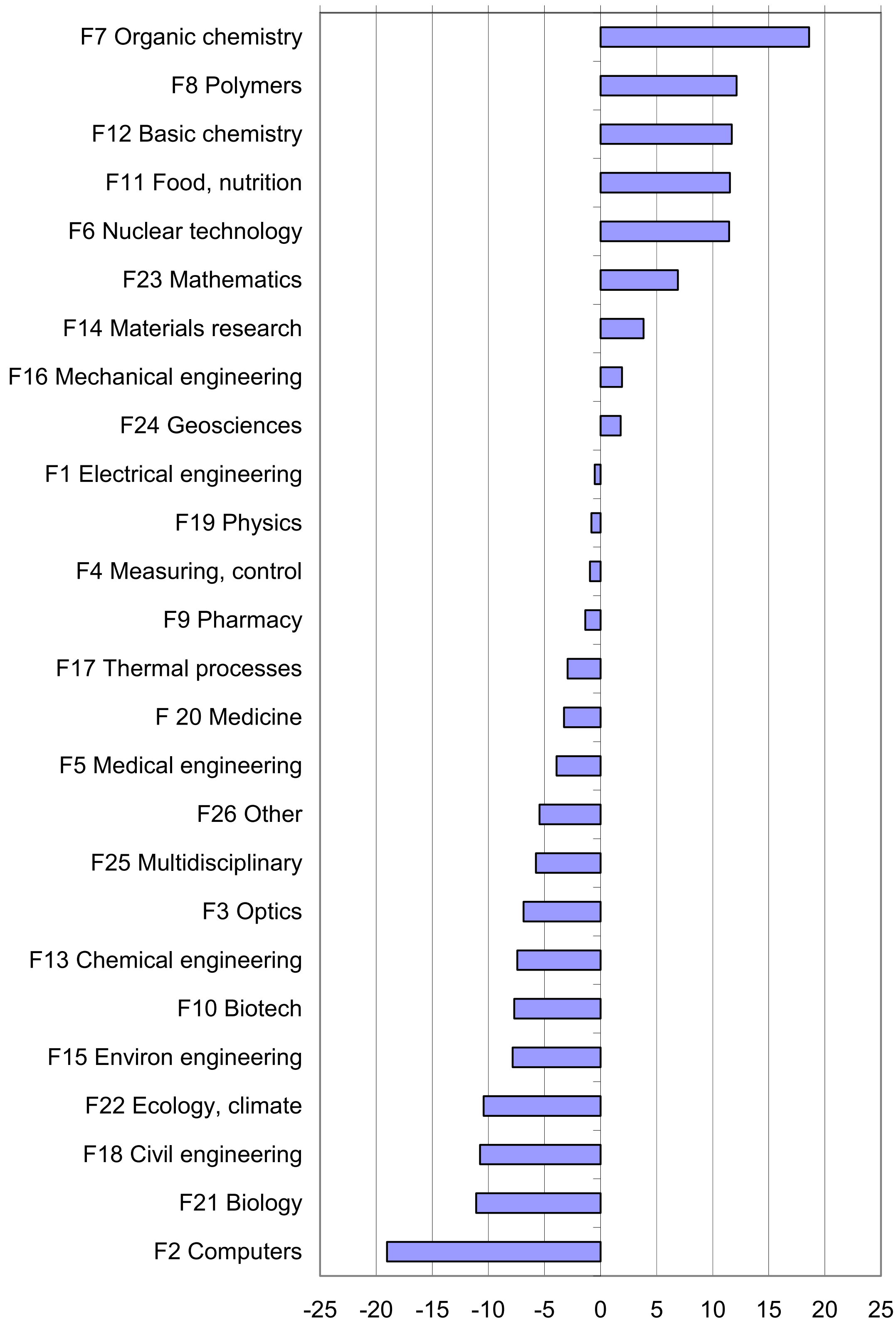
4 A citation window is necessary to give other researchers the chance to read, reflect on and then cite the publication in question (Jin, Rosseau 2004; Moed et al. 2004; Schmoch 2006; van Raan 1988).

5 Be aware that a publication year already includes a certain time lag in relation to the timing when the research was done. The time from the first submission to the date of publication – including a reviewing and editing process – is often one year and more.

6 For the definition of this indicator see Grupp et al. 2001.

Figure 5: Scientific Regard (publication year 2004)

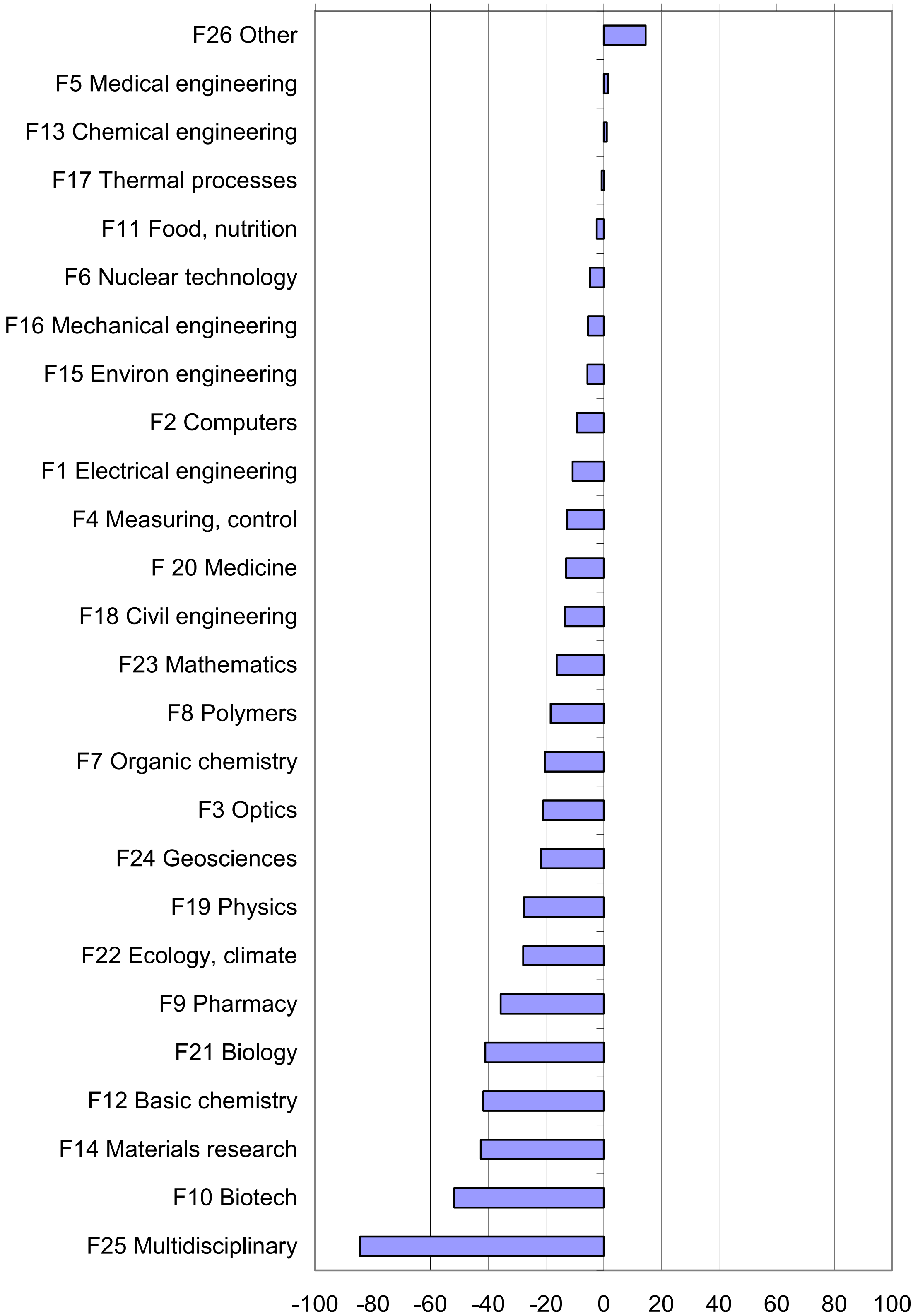


Source: Hinze et al 2008.

On the one hand, the growth rates of Chinese publications in the most dynamic fields are not yet reflected in the publications of the year 2004 as the strongest dynamics was shown in the yers 2004-2006. On the other hand, in a phase of strong and fast increase like in the case of the Chinese science system in this decade it is a challenge to at the same time keep up with the quality and international standards on a broad level. Many incentives and pressures – monetary, institutional and political – exist in the Chinese science system to internationalise and to address the wider international scientific community by means of publications. Not all of them are already ready for the international level (Frietsch, Wang 2007; Jin, Rosseau 2004). However, taking a view from a different angle, given these enormous growth rates concerning the number of publications in a three years period, the quality is already surprisingly high as the indicator values are not too far off the international average rates in a wide range of fields.One should also take into account that the opening of the Chinese system is a rather recent development and for a long time many scientists only published in Chinese. Therefore, one explanation for the average performance might be the language bias, that existed and still exists. To put it in other words, maybe the Chinese scientific output already reached a certain quality level in the past, but most of the results have been published in Chinese. Now they are refocusing and reorienting themselves to an international community and might still have to adjust to the quality requirements they now have to face. An indication for the fact that Chinese publications are not yet fully aligned to the international audience is given in Figure 6, where the indicator of international alignment is presented. The totality of Chinese publications still has an international orientation that is far below the average of the worldwide activities, but in the 1990s these values were even worse. As can be seen, only in the small and general field "Others" a positive international alignment is reached, in some fields China comes up with an average level, but in most areas a clear and strong under-specialisation is visible.

In certain areas like Material Science, Polymers and Nano-Tech or in Biotech and Pharmaceuticals, the Chinese community is still rather nationally oriented. One could also say that they find a large community and enough recipients on a national level so that an international orientation is not yet necessary and pursued. There are enormous successes in the recent years especially in these modern fields of applied sciences. The Chinese just caught up with the international high level and they already reached the top in certain niches, starting from a strong base like in Traditional Chinese Medicine, in green Biotech or certain polymers.

Figure 6: International Alignment 2006 (publication year 2004)



Source: Hinze et al 2008.

3 International Research Collaborations – Co-publications

The scientific and economic performance today – especially in scientific and high-technological areas – is highly dependent on national and international collaborations and co-operations between different actors like universities, research institutes, small and medium-sized companies as well as multinational companies. In the second half of the 20th century and in particular over the past 20 years globalisation has accelerated, and while economic integration is perceived as its dominant feature, other dimensions including R&D but also the social, cultural, political and institutional realms are highly relevant too (OECD 2005). Knowledge production and R&D are seen as key components of this development (European Commission 2007). Internationalisation of S&T can take various forms such as the mobility of researchers, collaboration between partners from different countries, research activities from institutions abroad, informal knowledge exchange, and systematic exploitation and application of foreign knowledge e.g. by being present in other countries for know-how acquisition and networking (Edler et al. 2007). One outflow of internationalisation and complexity is the number of international co-publications, which has increased and which is often used as an indicator reflecting international collaborations. However, one has to take into consideration that co-publications are only a partial indicator to reflect international collaboration as certain types of activities are not covered by this indicator, meaning that not all research carried out collaboratively will eventually result in a common publication.

Table 3: Number and share of international co-publications for selected countries, 2006

	Total publ.	Co-publ.	Shares
CH	17988	10551	58.7%
SE	17023	8316	48.9%
DE	75924	32995	43.5%
FR	55139	23195	42.1%
UK	76173	31432	41.3%
US	282110	73866	26.2%
KR	28307	7173	25.3%
JP	77249	16781	21.7%
CN	84556	17031	20.1%
IN	28434	5321	18.7%

STN: SCISEARCH; Fraunhofer ISI calculations.

Empirically (see also Table 3) it was found by a number of studies that smaller countries (e.g. the Scandinavian countries) have larger shares of international co-publications[7] as the research systems in smaller countries are usually more specialized in certain scientific fields and these countries do not have a similar large pool of research institutes that these institutes or companies can collaborate with (Frietsch 2004; Schmoch 2006). Furthermore, in a small country the competition between research institutes or companies in the same scientific or technological area

[7] To calculate the total number of co-publications, an explicit definition of cooperating countries had to be applied. As a co-publication, any publication was taken into account where an author from the country under observation and at least one author from one of the following countries (excluding the respective country under observation to avoid national co-publications) were involved: the 30 OECD member countries as well as India, Russia, Israel, Brazil and Taiwan.

is supposed to be higher. The same holds for small research fields. In the case of developing research systems higher shares of international co-publications are the rule and this share is reduced, once the system has a certain number of indigenous research capacities and publications. Another general fact to date is that Asian countries – e.g. Japan or South Korea – have international collaboration rates that are below the international average.[8]

Obviously, these general rules hardly fit the Chinese development of the recent years. Though, the share of international co-publications of Chinese authors is on a similar level like that of other Asian countries. But it is varying only between 24% and 27% since 1997 and is therefore persistently high (see the black dotted line in Figure 8), even against the background of a strong increase in total number of scientific publications of Chinese authors. Similar results were found in a study conducted on behalf of the British Embassy (British Embassy 2007). However, the general trend shows a slow downward slope after the year 2002 – a period when the total Chinese publications started increasing very steeply. At least in part the co-publications were not able to keep pace with the total development. To sum up, based on the size, the "Asian", and the growth effects, a lower position and a stronger decline of the share international co-publications would be expected for China. So the Chinese system – given the framework conditions – is surprisingly strongly internationalised.

The largest collaborating region with China in absolute terms is the North American continent with the USA as the most attractive partner in the world – not only for Chinese researchers. Though the absolute numbers do not deviate largely. In the three years period of 2004-2006 under examination here, the co-publications with Northern America account for 29,469, with Asian-Pacific countries the Chinese co-published 24,997 and with the EU-27 the collaboration sum up to 21,115 articles.[9] Figure 5 displays the development of Chinese co-publications over the recent years with the three main actors in the world: Asian-Pacific, North-America and the EU-27. As can be seen, the number of international co-publications increases similar to the number of total publications. Especially the collaborations with North America follow the general trend, whereas Europe and recently also the Asian-Pacific area loosing some ground. Figure 7 presents the share of Chinese publications that is based on international collaboration differentiating between three regions: The expectation would be – based on the above mentioned general rules – that the shares of co-publications decreases over time as the absolute number of Chinese publications increases very steeply and the absolute number of collaborations might not keep pace with this. However, Figure 7 clearly demonstrates that it is hardly the case for China: Sino-North American research collaboration has been rather constant relating to China's total publication during the last 10 years; Sino-Asian Pacific co-publications had their peak in 2002 and the shares are following a negative trend since then. By comparison, the curve of the European-Chinese collaborations is on a permanent downward trend over the course of our observation period. At the beginning the share was at about 8.5% and nowadays reaches a level of about 6.5%, which is a relative reduction of nearly ¼.

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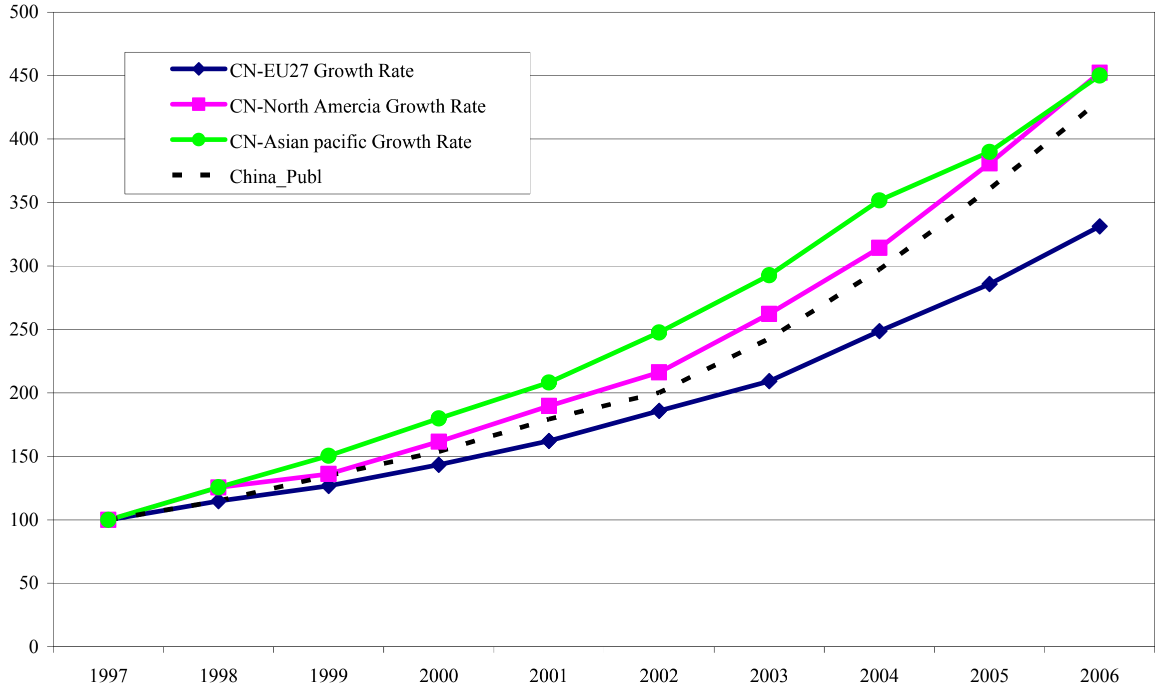
8 This is only checked against the total number of OECD countries (plus a set of selected Asian countries) as these countries are responsible for the bulk of publications in the SCI. If a country has high collaboration rates with other than the selected countries, the total co-publication rate will be underestimated. However, the non-OECD countries are only responsible for about 5-10% of the total publications, which does not leave very much space for absolute numbers of co-publications with those countries.

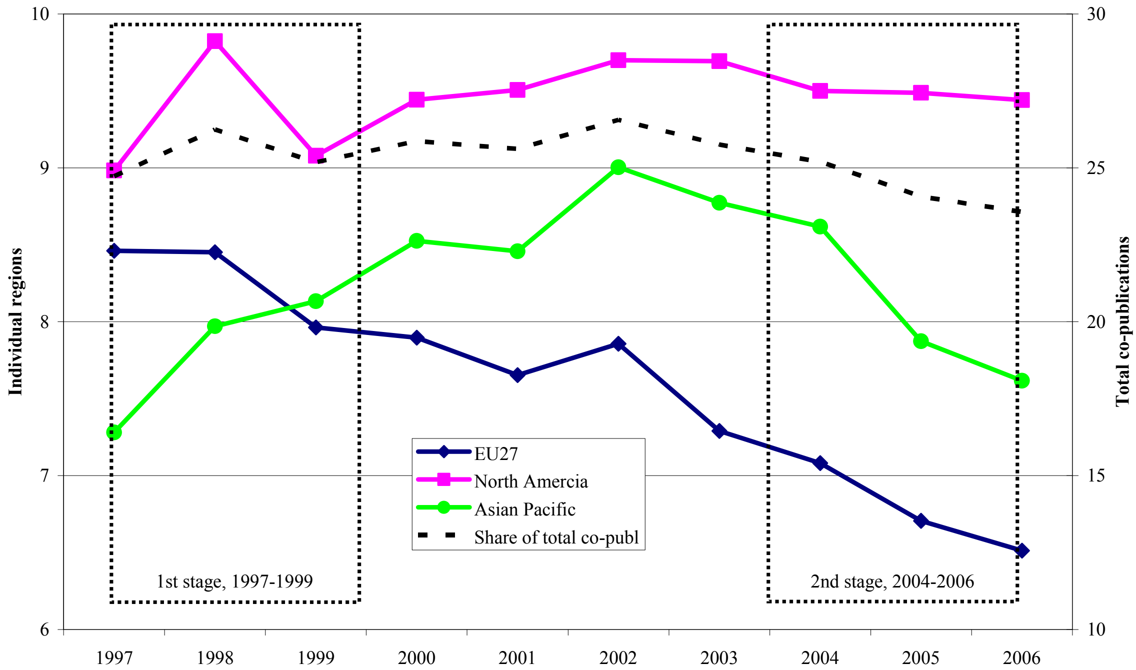
9 The reported figures are the sums across all 26 fields. This includes double counts. The numbers of co-publications in total are: 20,172 (USA), 16,983 (Asian-Pacific) and 14,336 (EU-27).

Figure 7: Index of Chinese co-publications with three regions and total Chinese publications, 1997-2006



STN: SCISEARCH; Fraunhofer ISI calculations.

Figure 8: Shares of Co-publications with three regions in relation to total Chinese publications



STN: SCISEARCH; Fraunhofer ISI calculations.

The reasons for such phenomena might be manifold again, but two general sources can be identified. On the one hand, the exchange activities of research personnel and therefore knowledge network with North America, especially with the US, have been much more intensive than with Europe. This holds for high level of the research elite as well as basic level of students, who are – as returnees – the present and future elite of the Chinese science system. And these exchanges of the past nowadays bear the fruits of collaboration. Even since the USA is more restrictive in its immigration and exchange policy especially with Asia, the advantage of the USA will exist for a long time in the future. One main factor of the sustainable strength of the US is that it has been attracting world talents contributing to its scientific and economic development. In 2003, the number of overseas Chinese students in the US has reached over 90,000 compared to 70,000 in all European countries (Auriol 2006). So if Europe wants to catch up in this respect – and the shares of Chinese students studying in European universities has increased in the recent past – a proactive strategy has to be formulated and pursued, to attract more excellent researchers around the world, including China. One strategy is to provide exchange programs and to set the framework conditions. One important hampering factor is the different languages and also the different educational systems in Europe. The Lisbon Strategy might help to overcome the structural deficiencies in this respect and is therefore a first step into this direction. The fact that many universities offer courses in English is another one, but all this has to be exploited and made public. And then – in a mid- to long-term perspective – the attractiveness of Europe will increase and once it will then also bear the fruits of increase collaboration and exchange of people and ideas on a high level.

The share of Chinese co-publications with Europe is constantly declining. Europe – or to be more precise: some European countries like France or Germany – is very active and very reputated in basic sciences like Chemistry or Physics, as well as in some areas like engineering: a field that is loosing ground – in relative terms – in China in the recent years. As China moves to other more applied research fields, other countries are more reputated and active in these areas and therefore are more interesting as partners for Chinese scientists. The best example might be the ICT sector, where some smaller European countries have a high reputation and many European countries show a sound, but medium specialization. However, in this area, the USA, Japan and South Korea are the most important players and therefore are the most attractive research partners for Chinese researches in this field. The fact that it is a large field does the remaining to keep the shares of co-publications with these countries rather stable.

Table 4 provides data on research collaboration and its dynamics differentiating between fields. Data for two 3-year periods: 1997-1999 and 2004-2006 are displayed for comparison.

Table 4: Shares of Chinese co-publications with three regions: 1997-1999 vs. 2004-2006

Field_Name	CN-EU27			CN-North Amercia			CN-Asian pacific		
	97-99 Pub_Num	04-06 Pub_Num	04-06 % of total	97-99 Pub_Num	04-06 Pub_Num	04-06 % of total	97-99 Pub_Num	04-06 Pub_Num	04-06 % of total
Electrical engineering	183	621	7.7	423	1028	12.7	265	901	11.1
Computers	178	872	5.6	415	1477	9.6	220	1161	7.5
Optics	145	419	7.3	161	420	7.3	144	431	7.5
Measuring, control	184	423	6.7	189	468	7.4	171	497	7.9
Medical engineering	56	205	10.3	78	310	15.5	69	189	9.5
Nuclear technology	83	111	11.9	49	86	9.2	82	138	14.8
Organic chemistry	31	193	3.7	60	230	4.4	75	226	4.3
Polymers	99	290	4.2	124	342	5.0	127	347	5.0
Pharmacy	96	277	5.1	139	521	9.7	178	572	10.6
Biotechnology	374	1195	8.1	495	2308	15.7	361	1048	7.1
Food, nutrition	51	97	6.9	53	229	16.4	36	186	13.3
Basic chemistry	494	1537	3.9	450	1478	3.8	602	1975	5.1
Chemical engineering	85	283	5.6	83	280	5.5	77	347	6.8
Materials research	642	1615	4.4	431	1291	3.5	784	2646	7.2
Environmental engineering	21	85	6.9	21	142	11.6	37	114	9.3
Mechanical engineering	430	1013	6.3	456	1236	7.7	432	1444	8.9
Thermal processes	64	154	5.8	89	234	8.8	52	203	7.6
Civil engineering	78	178	6.8	81	259	9.9	68	253	9.7
Physics	1550	3311	8.3	1409	3919	9.8	1314	3606	9.0
Medicine	902	2223	10.0	1076	4097	18.4	785	2211	9.9
Biology	611	1836	9.3	706	2959	14.9	590	1795	9.1
Ecology, climate	201	650	8.8	274	1204	16.3	178	850	11.5
Mathematics	459	965	7.1	604	1561	11.4	339	981	7.2
Geosciences	250	654	12.3	282	994	18.6	191	672	12.6
Multidisciplinary	425	1396	5.5	424	1720	6.8	418	1707	6.7
Other	167	512	13.3	191	676	17.5	107	497	12.9

STN: SCISEARCH; Fraunhofer ISI calculations.

Table 4 shows in the last three years (2004-2006), China's *total* collaboration with 3 regions tripled compared with the first stage (1997-1999) in every research field. And without exception, in terms of co-publication count, Chinese research collaboration with EU, North America, and Asian pacific increase in every research field.

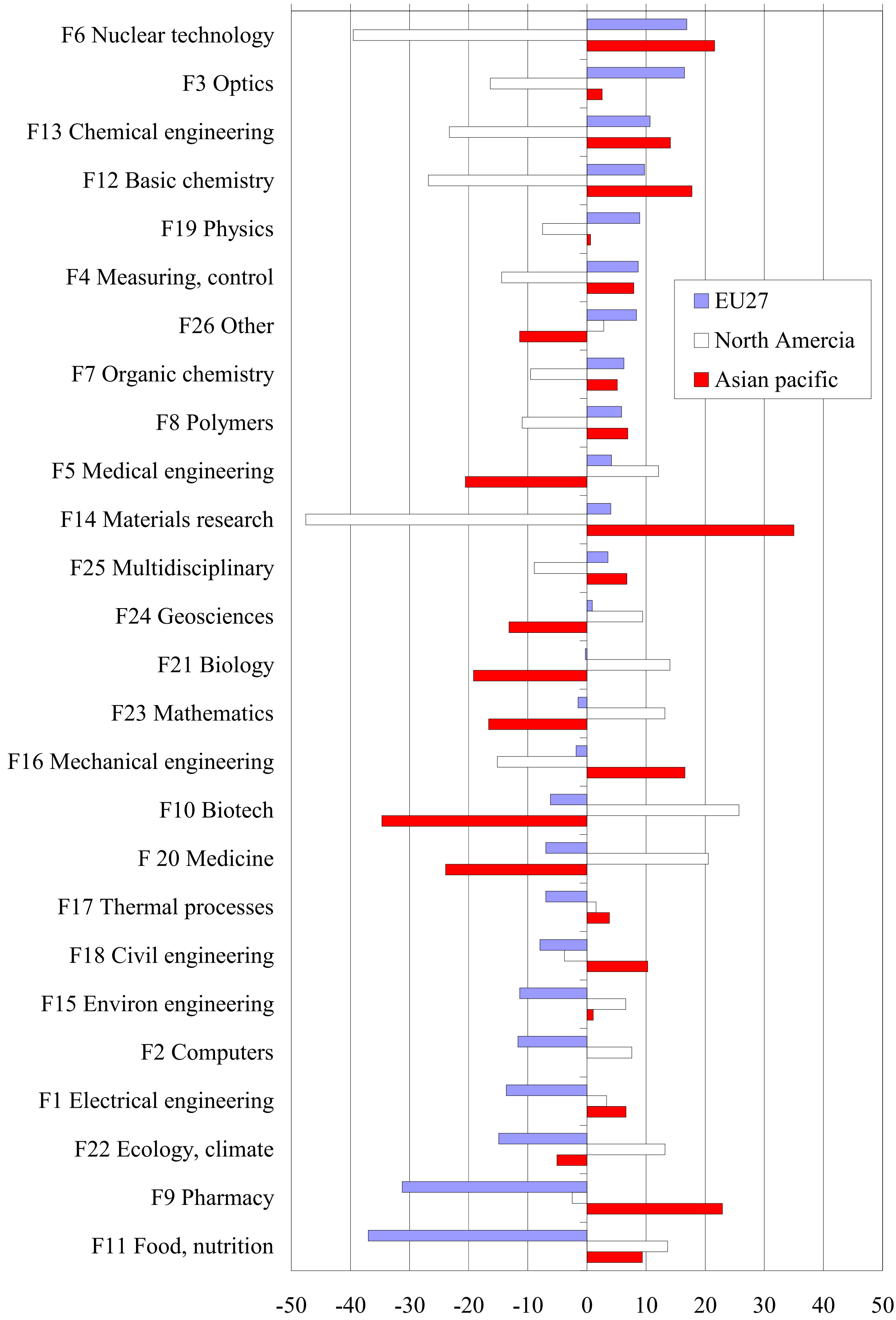
For Sino-EU collaboration, the top 3 intensive research fields are physics, medicine, and biology in the descending order, and this holds true for both 2-stages. By contrast, China-EU co-publication in food, nutrition is relatively stagnent, especially compared with Sino-US and Sino-Asian collaboration in this field. Pharmacy (F9) is another field of weak linkage between China and EU27.

Table 4 also discloses that there are three Sino-EU collaborating fields experiencing fast growth: computer (F2), organic chemistry (F7) and environmetal engineering (F15). But all these growths aer mainly due to the low collaboration bases in the first period. Take environmental engineering for example, it is the area that China's international research collaboration occur least across these 3 regions. And this situation did not change during the two phrases. In the most sensitive research area-Nuclear technology, China seldom collaborates with others. In other words, there is almost no joint research across national board. This probably holds for other countries.

However, in some specific research fields, there exists intensive collaboration between China and European countries when we compare across rows, i.e. different collaborating regions. Figure 7 below demonstrates that In Optics (F3) and Physics (F19), the collaboration intensity between China and the EU27 is much higher than that of the other regions[10]. It also shows that compared Sino-US collaboration, China-EU27 research collaboration is very low in the fields of Pharmacy (F9) and Food, nutrition (F11).

[10] This finding is consistent with that from Evidence Ltd, "Research in China: patterns of international collaboration".

Figure 9: Specializations of 3 regions in China's Co-Publications, 2004-2006



STN: SCISEARCH; Fraunhofer ISI calculations.

4 Chinese Hot Spots

The following table exemplarily shows the data of total Chinese publications on the level of individual research institutions. The list is derived in the way described in the methodology section of the annex. The other lists of institutions in the 26 fields (top 20) are attached in the annex and are also available in electronic format.

The summary sheet of top 10 most productive institutions in each field shows that research productivity is highly skewed among Chinese research institutions[11]. Over 2000 Chinese higher education institutions(HEI)[12], among them 59 universities or research institutes, appear in this list of "hot spots" – the list of most publishing entities. Some comprehensive institutions stand out in this list. For example, Zhejiang University appeared 24 times among those 26 research fields, followed by Tsinghua University (20), Shanghai Jiaotong University (20), and Peking University (18). Some specialized institutions, especially the institutes of Chinese Academy of Sciences (CAS), demonstrate their research competitiveness in specific fields. For instance, Shanghai Institute of Optics & Fine Mechanics (CAS) ranked No.6 in the field of optics, Research Center For Eco-Environmental Sciences (CAS) is the second most productive institution concerning environmental publications, the Institute of High Energy Physics at CAS ranked No.1 in the field of Nuclear Sciences, and Shanghai Institute of Organic Chemistry is the most productive institution in organic chemistry field. In total, these findings emphasizes the role and responsibility of the Chinese Academy of Sciences with its nearly 40,000 persons employed as scientific staff.[13] The Chinese Academy of Sciences is both, basic and especially applied reseach oriented, has a sound technical orientation and is supplying both, high quality research as well as education and training. However, among the more than 100 institutes only a few have the capacities and possibilities to have a broad focus, which makes them appear on this listing very high. What can be derived from this general list: next to the largest and most important four universities – the lighthouses of Chinese academic research – some selected institutes of the Chinese Academy of Sciences play a major role in China's science system. Taking the Chinese Academy of Sciences in total – a consequence not only of a size effect – an outstanding position of this research assosciation has to be acknowledged. On the other hand – this can be seen in the tables in the annex – todays Chinese research system is based on a number of different institutions that are able to reach high ranks in the list of top research performers within this country.

Another observation from Table 5 is that China's research is unbalanced distributed geographically. Those 59 universities or research institutes are located in 19 Chinese cities, most of which are in the eastern coast areas – China's first world area. Beijing and Shanghai, two prominent S&T centers of China host over 40% of these "hot spot" institutions.

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[11] The original affiliation information in SciSearch are listed in abbreviation form. We expanded them to full names and verified by their websites in English version.

[12] The data is based on the website of Ministry of Education of the People's Repubic of China. Electronic version is available at http://www.moe.edu.cn/english/higher_h.htm.

[13] See http://english.cas.cn/eng2003/page/about_03.htm.

Table 5: Summary Sheet for Chinese Top_10 Institutions across all 26 Fields, 2004-2006

Rank	Institution Name	City	Occ. in top-10 list
1	Zhejiang University浙江大学	Hangzhou杭州	24
2	Shanghai Jiaotong University上海交通大学	Shanghai上海	20
3	Tsinghua University清华大学	Beijing北京	20
4	Peking University北京大学	Beijing北京	18
5	University of Science & Technology of China中国科技大学	Hefei合肥	12
6	Fudan University复旦大学	Shanghai上海	11
7	Harbin Institute of Technology哈尔滨工业大学	Harbin哈尔滨	10
8	Zhongshan University中山大学	Guangzhou广州	10
9	Nanjing University南京大学	Nanjing南京	8
10	University of Hong Kong香港大学	Hong Kong香港	8
11	Dalian University of Technology大连理工大学	Dalian大连	7
12	Huazhong University of Science & Technology华中科技大学	Wuhan武汉	7
13	Chinese University of Hong Kong香港中文大学	Hong Kong香港	6
14	Jilin University吉林大学	Jilin吉林	6
15	Xian Jiaotong University西安交通大学	Xian西安	6
16	Wuhan University武汉大学	Wuhan武汉	5
17	China Agricultural University中国农业大学	Beijing北京	4
18	City University of Hong Kong香港城市大学	Hong Kong香港	4
19	East China University of Science & Technology华东理工大学	Shanghai上海	4
20	Hong Kong Polytechnic University香港理工大學	Hong Kong香港	4
21	Lanzhou University兰州大学	Lanzhou兰州	4
22	Sichuan University四川大学	Sichuan四川	4
23	Tianjin University天津大学	Tianjin天津	4
24	Beijing Normal University北京师范大学	Beijing北京	3
25	CAS, Beijing Institute of Chemistry 中科院北京化学所	Beijing北京	3
26	CAS, Dalian Institute of Chemical Physics 中科院大连化学物理所	Dalian大连	3
27	CAS, Research Center For Eco-Environmental Sciences 中科院生态环境研究中心	Beijing北京	3
28	Hong Kong University of Science & Technology 香港科技大学	Hong Kong香港	3
29	Ocean University of China中 国 海 洋 大 学	Qingdao青岛	3
30	Beijing University of Chemical Technology北京化工大学	Beijing北京	2
31	CAS, Shanghai Institute of Materia Medica上海药物研究所	Shanghai上海	2
32	Nanjing Agriculture University南京农业大学	Nanjing南京	2
33	Nankai University南开大学	Tianjin天津	2
34	Shandong University山东大学	Jinan济南	2
35	Southern Yangtze University江南大学	Wuxi无锡	2

Rank	Institution Name	City	Occ. in top-10 list
36	China Institute of Atomic Energy 中国原子能科学研究院	Beijing北京	1
37	China University Geosciences Wuhan 中国地质大学（武汉）	Wuhan武汉	1
38	CAS, Cold and Arid Regions Environmental and Engineering Research Institute 中科院寒区旱区环境与工程研究所	Lanzhou兰州	1
39	CAS, Guangzhou Institute Geochemistry 中科院广州地球化学研究所	Guangzhou广州	1
40	CAS, Institute of Geographic Sciences and Natural Resources Research 中科院地理科学与资源研究所	Beijing北京	1
41	CAS, Inst. of Geology and Geophysics 中科院地质与地球物理研究所	Beijing北京	1
42	CAS, Institute of High Energy Physics 中科院高能物理研究所	Beijing北京	1
43	CAS, Institute of Physics 中科院物理所	Beijing北京	1
44	CAS, Institute of Plasma Physics 中科院等离子体物理研究所	Hefei合肥	1
45	CAS, Shanghai Inst. of Optics & Fine Mech. 上海光学精密机械研究所	Shanghai上海	1
46	CAS, Shanghai Institute of Organic Chemistry 上海有机化学研究所	Shanghai上海	1
47	CAS, Shanghai Inst. for Biological Sciences 上海生命科学研究院	Shanghai上海	1
48	Donghua University 东华大学	Shanghai上海	1
49	Huazhong Agricultural University 华中农业大学	Wuhan武汉	1
50	Northwestern Polytech University 西北工业大学	Xian西安	1
51	ShenYang Pharmaceutical University 沈阳药科大学	Shenyang沈阳	1
52	South China University of Technology 华南理工大学	Guangzhou广州	1
53	Southeast University 东南大学	Nanjing南京	1
54	Shanghai University 上海大学	Shanghai上海	1
55	Tongji University 同济大学	Shanghai上海	1
56	University of Electronic Science and Tech. of China 电子科技大学	Chengdu成都	1
57	University of Science & Technology of Beijing 北京科技大学	Beijing北京	1
58	Xidian University 西安电子科技大学	Xian西安	1
59	China University Geosciences Beijing 中国地质大学（北京）	Beijing北京	1

STN: SCISEARCH; Fraunhofer ISI calculations.

5 Summary and Conclusions

The Chinese research system underwent massives changes in the past – a statement that also holds for total country as such in many aspects – and is still in motion and in a constant flux. Within the last ten years a strong increase of the output – in terms of publications registered in the Science Citation Index (SCI) – is visible. Especially in the recent years since the beginning of the new century, a second boost is evident that comes along with massive structural changes. Chinese authors have been able to more than double the shares of total publications in the SCI between 2000 and 2006. China accounts for about 9% of total SCI publications, which is similar to countries like the United Kingdom or Germany. However, in relative terms – e.g. in relation to inhabitants or labor force – the Chinese output is still very low, reaching publication intenstities that are similar to India. Even taking the hughe size effect of these countries into account, the absolute numbers are still far beyond the expected values derived from the experiences based on other science oriented countries. On the other hand, this might be a promise – or a threat – to the future and raised the expectation of further growing publication output of China.

China's profile is still influenced by its tradition, with a clear focus on theoretical or basic oriented areas like Chemistry, Mathematics or Phyics. The structural change of the recent years that came along with the massive expansion of publications on a broad level, were especially evident in areas that are more application oriented or that can be characterized as areas of applied research. The whole systems seems to move towards applied research orientation, a finding that is backed by the fact that the Chinese National Natural Science Foundation – which more or less exclusively funds basic research projects – only accounts for 3-5% of total Chinese S&T budget. The main areas of Chinese activities and the specialisation of the Chinese profile reveals some strength in Material Sciences/Nanotechnology as well as the Computers field and related areas. Average values can be found in most of the engineering fields, whereas the broad field of Life Sciences does not belong to the relative strengths of China. The quality of the output of the Chinese research system of today is on an international average level, while the international orientation still leaves room for improvement.

As a consequence of the enormous increase of Chinese publications of the recent period, also the absolute number of international co-publications – publications with at least one author with a foreign address in the team – considerably increased. The share of these co-publications of the total number of publications is thereby surprisingly persistent and high, given the facts that large countries, Asian countries and growing countries usually collaborate less, or the increase is usually smaller than the total increase, respectively. About ¼ of all Chinese publications are co-authored by a foreigner. The analysis of collaborating regions – we analysed North-America, Asian-Pacific and EU-27 – reveals similar absolute numbers of the three areas, while the trends are clearly different. The total number of co-publications is increasing, but the shares of North-American collaboration partners is rather stable and high, while Asian-Pacific and especially EU-27 are loosing ground very fast. The reason might be found in the structural change of the Chinese research system that favours applied research fields, where North-American researchers, especially from the US, have a high reputation and a comparative advantage. Europe is more well known – also in China – for its strong and sound basic research orientation and its reputation in these areas. Furthermore, the exchange of students and research personnel with the US may also have a high impact on these shares. Chinese scholars stay in the US and collaborate with Chinese researchers at home or – once they returned to their home country – they do not only bring research excellence to China, but also ties to researchers in their home countries, resulting in networking effects that support future develpoment and performance.

The analysis of "hot spots" – the most active publishing research institutions – reveals a broadly scattered, but also solid and sound research landscape in China, with some "lighthouses" at the top and a lot of inferior institutions on the following positions. Across the whole range of fields, four universities (Zhejiang, Jiatong, Tsinghua and Peking universities) and especially the Chinese Academy of Sciences with its more than 100 institutes, with its univeristy and its graduate school were outstanding the vast number of about 2,000 publishing entities that were found in the Science Citation Index, located in China. However, in certain selected fields, some specialised and well performing institutions light up so that the assessment of a broad foundation is justified.

Appendix 1: Methods

For the analysis the Science Citation Index (SCI), an international multidisciplinary database, was used. The SCI is widely acknowledged and accepted for evaluating research institutions and analyzing research performance of regions or countries. The SCI covers about 5.900 of the most significant and relevant scientific journals from a wide range of scientific and technology fields.[14]

The data was retrieved online via the host STN. Scientific publications for the period 1997-2006 were retrieved. Only the so called citable items namely articles, general reviews, notes and letters were included in the analysis. Chinese and worldwide publications were collected by discipline. A classification scheme differentiating between 26 disciplines (Appendix 1) was used. A publication was attributed to Chinas soon as at least one author with a Chinese address[15] was given. The same holds true for assigning publications to other countries when performing the co-publication analysis. Thus, multi-authored publications were assigned to each country given in the address field. Here, the full-count method was applied.

A variety of indicators describing the Chinese science system and its scientific performance were constructed: Indicators are based on publication and citation counts. The following indicators were used:

a) The productivity of the Chinese science system is reflected by absolute publication numbers.

b) Specialization patterns of Chinese publication activities are analyzed using the RLA indicator (Relative Literature Advantage). This indicator reflects whether a country engages in a certain field above or below the international average. The RLA is calculated in the following way:
$RLA_{ij} = 100 \tanh \ln [(Publ_{ij} / \sum_i Publ_{ij}) / (\sum_j Publ_{ij} / \sum_{ij} Publ_{ij})]$
with:
Pij= No. of Publications of a country i in field j
ΣiPij= No. of Publications of all countries in field j
ΣjPij= No. of all Publications of country i
ΣijPij= No. of all Publications of all countries

The RLA index bound to values between ±100 and includes the neutral value zero. Positive values indicate a specialization above world average, negative values a specialization below world average. An advantage of this indicator is that possible distortions of the database coverage with regard to the analysis of absolute publication numbers can be compensated.

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[14] Not all scientific areas are covered in SCI to the same extent. The major focus of the SCI is on the life sciences while the engineering sciences are less well represented (Schmoch 2004). However, the SCI is a valid dataset to assess the current status of Chinese research activity.

[15] In terms of geographical coverage, this includes mainland China, two Special Administrative Regions (Hong Kong and Macao, but not Taiwan area.

c) Citation based indicators were used to reflect quality or impact of research[16].

In particular the journal-standardized "Scientific Regard" (SR) and the "International Alignment" (AI) were calculated. (Grupp et al. 2001). The Scientific Regard indicates whether the publications of a country/region are more or less frequently cited than the publications in the journals which they are published in. Positive indices point to citations scores above the average; values of zero correspond to the world average. The relation to the specific journals compensates the disadvantages of countries which have a less good access to highly visible English language journals. The indicator of Scientific Regard is defined as follows:

$$SR_i = 100 \tanh \ln (OBS_i/EXP_i).$$

with:

EXP_i= the number of expected citations for publications of a country i,

OBS_i=the observed citations of country i.

The number of expected citations EXP_i has to be determined on an article-by-article base and measures the average citation frequency of the selected journals.

In contrast to the Scientific Regard, the International Alignment shows whether the authors of a country publish in internationally visible or less visible journals, again with relation to the world average. A high share of publications in internationally visible journals indicates an intensive participation in international scientific discourses. Similar to the SR index, positive IA indices show an International Alignment above average. The IA index is calculated as follows:

$$IA_i = 100 \tanh \ln (EXP_i/OBS_w).$$

with:

EXP_i= the number of expected citations for publications of a country i,

OBS_w=the observed citations worldwide.

Co-publication data was collected to analyze patterns of collaboration of Chinese scientists.In particular Chinese co-publications with three selected regions (Asian countries, North America, and EU27) are identified. The analysis was carried out by discipline.

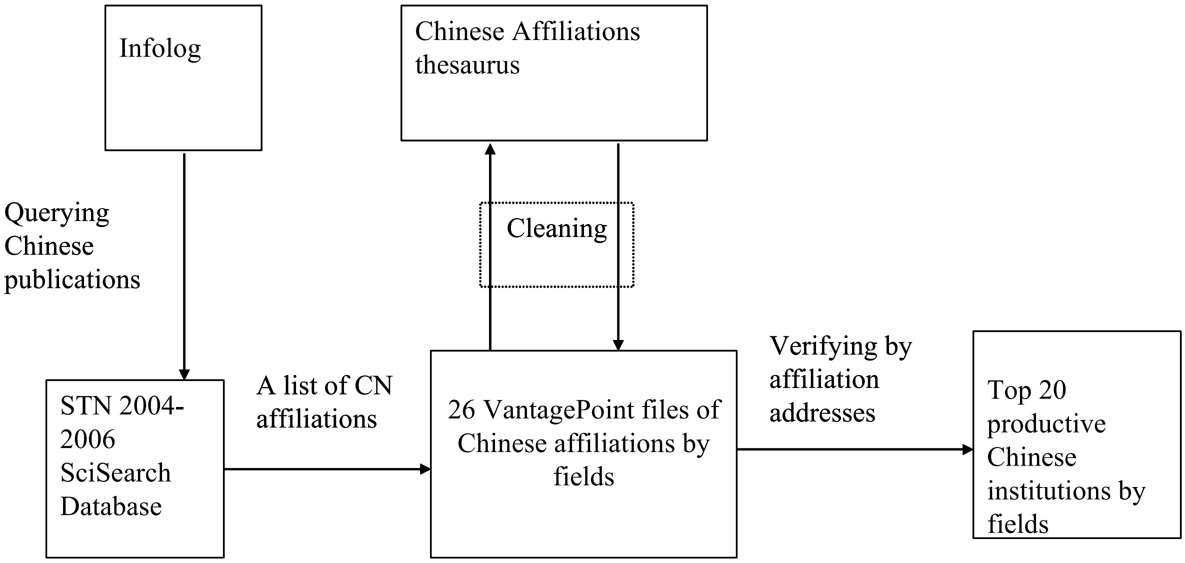
Bye collecting the data for a period of time it became possible to look at changes over time and thus the dynamics of the system.

In addition, in order to identify the major players, a list of Chinese research institutions active in the various fields was collated. In order to identify the top research institutions, all names and full address of Chinese organizations, which ever published in 2004-2007 were collected. After a thorough process of cleaning, a "star" list, i.e. a list of "hot spots" – of Chinese organizations in terms of productivity was obtained.

Figure 1 below demonstrates this information retrieval process. A description of the cleaning process will be given in the next section.

16 For a more detailed discussion of citation indicators as measures to reflect research quality or impact see Moed (2005).

Figure 10: Flow Chart of Data Retrieval and Cleaning



Affiliation Records Cleaning

Data cleaning is a very sensitive issue in bibliometric analysis. Despite the importance of a "consistent and standardized set of indicators" (van Raan 2004) to be used for further analysis, potential fallacies of such methods are seldom explicitly mentioned or addressed (Calero et al, 2006; Wallin, 2005). Bibliographic database mainly serve the purpose of research topic information retrieval (Hood & Wilson 2003).Thus, for a long time little attention was paid to correctly and comprehensively providing authorship related information across different journals, this includes and the information given concerning the affiliation of the authors. If bibliometrics is used for policy oriented analysis as analyzing national or regional systems of science this issue is of major concern. Thus, a lot of effort has to be put into accurately representing authors and their affiliations, which requires thorough data cleaning as address information is not presented in a standardized way.

While cleaning the data for the present analysis we found a large number of inaccuracies, like the inconsistent use of Chinese affiliations names. Besides spelling errors in the affiliation name, the most important inaccuracies occur due to translation variations. If we simply *collapse all* affiliations with the same English name, two types of faults appear: positive fault and negative fault. Table A-1 explains the nature of these inaccuracies in more detail. Three fault sources as well as the possible consequences are discussed.

Table A-1: Common Error Sources for Identifying Top Research Institutes

	Type I Error Source		**Type II Error Source**		**Type III Error Source**	
Description	The same affiliation has various versions of English names.		Different affiliations contain the same English names.		Different affiliations have the same English names.	
Examples	Chinese	SciSearch	Chinese	SciSearch	Chinese	SciSearch
	北京大学	Peking Univ; ***Beijing Univ***	北京大学 北京科技大学 北京邮电大学	***Beijing Univ*** ***Beijing Univ*** Sci & Technol ***Beijing Univ*** Posts & Telecommun	济南大学（山东）； 暨南大学（广东）	***Jinan University***
	中国科学院	CAS; Chinese Acad Sci; ***Academia Sinica***	浙江大学 浙江科技大学 浙江财经大学	***Zhejiang Univ*** ***Zhejiang Univ*** Sci & Technol ***Zhejiang Univ*** Finance & Econ	中国科学院（中国） 中央科学院（台湾岛）	***Academia Sinica***
	中山大学	Zhongshan Univ; Sun Yatsun Univ; Sun Yat Sun Univ Sun Yat Sen Univ Sun Yet Sen Zhongshan Univ;	南京信息工程大学 南京大学 南京理工大学 南京航空航天大学	***Nanjing Univ of*** Informat Sci & Technol ***Nanjing Univ*** ***Nanjing Univ*** Sci & Technol ***Nanjing Univ*** Aero & Astronaut	中国地质大学（北京）； 中国地质大学（武汉）	***China Univ Geosci***
Potential Consequence	Negative fault: Under estimates the research capacity of our targeting institution without complete main name variations.		Positive fault: Over estimates the research capacity of our targeting institution Negative fault: lose the sight of other institutions' research. This kind of error is especially serious when other institutes which usually have longer names are important research universities.		Positive fault: Overestimates the research capacity of our targeting institution.	

In practice, these three errors co-exist and intertwine with each other, thus making achieving correct counts more difficult. A good example for Type I and Type II Error is Peking University (北京大学), one of the most important Chinese universities. There are two English names of

北京大学: Peking University and Beijing University. For large datasets, there are two options to achieve a correct publication number of Peking University:

1) records containing Peking University in its corporate source, or

2) records containing Peking University or Beijing University in its corporate source.

The first method (Error Source I) will bias against 北京大学 since it neglects a major name variations, while the second method (Error Source II) will bias favoring 北京大学. As the political and cultural center of China, Beijing is the host of many prestigious universities and research institutions, many of which start with "Beijing University" in their English names such as Beijing University of

Posts and Telecommunication, Beijing University of Technology, Beijing University of Chemical Technology, Beijing University of Science & Technology, *et* al. More important, most of these institution themselves are productive institutions. Thus, in order to correctly assign the publications to the affiliation attention has to be paid in the data cleaning process.

To illustrate Type III error, there are two "Jinan University" due to the homophones in Chinese: one is in the Shandong province, and the other is located in the Guangdong Province. Also, there are two "China University of Geosciences" located in Wuhan and Beijing respectively, both of which are leading institutions in the field of geosciences (F24).

Similar problems occur in relation to the Chinese Academy of Sciences, one of the major Chinese knowledge producers. Its common abbreviation in the SCI is Chinese Acad Sci, but in many cases it is also abbreviated as CAS, or Academia Sinica. To get the correct publication number for CAS as well as institutes under CAS, we need to include CAS and Academia Sinica. However, due to historical reasons, there is another Academia Sinica in Taiwan[17] which should not be counted for CAS.

To get the reasonably accurate list of Chinese research institutes, the above mentioned problems were taken into account. For Type I Error we developed a comprehensive Chinese affiliation thesaurus to capture name variations; for Type II Error regular expression of VantagePoint[18] were used in order to differentiate between the different organizations which contain fragments of the same names; and finally, we verify our grouping by affiliation address targeting on Type III error, assuming different institutions, including those homophones that have different addresses. Through the above cleaning process, the institutional lists for 26 fields were compiled separately. The results are displyed in section 3.

[17] From the download of SciSearch records, we find instances of "Taiwan" and "Peoples R China" coexist in the field of Corporate Source.

[18] Vantage Point is a software tool to automatically and semi-automatically identify similar and identical text. Besides, some other functions of this software are available, which are of minor interest in this context (e.g. mapping or analysing networks).

Appendix 2: The fields and their definition

Table A-2 List of 26 Scientific Fields

No.	Field name
1	Electrical engineering
2	Computers
3	Optics
4	Measuring, control
5	Medical engineering
6	Nuclear technology
7	Organic chemistry
8	Polymers
90	Pharmacy
10	Biotechnology
11	Food, nutrition
12	Basic chemistry
13	Chemical engineering
14	Materials research
15	Environmental engineering
16	Mechanical engineering
17	Thermal processes
18	Civil engineering
19	Physics
20	Medicine
21	Biology
22	Ecology, climate
23	Mathematics
24	Geosciences
25	Multidisciplinary
26	Other

Table A-3 Search Strategies

No.	Key terms of SCI Category Codes
1	electrical & electronic engineering; telecommunications
2	computer science
3	optics; photographic technology
4	instruments; spectroscopy; remote sensing; automation; control; robotics; photogrammetry
5	engineering, biomedical; medical laboratory technology; radiology; neuroimaging
6	nuclear science & technology
7	chemistry, organic
8	polymer science
9	pharmacy; chemistry, clinical; drugs
10	biochemistry; biochemical; genetics; biotechnology; cell biology
11	food science; nutrition
12	chemistry *not* (organic, clinical, medicinal); electrochemistry
13	engineering, chemical
14	mineralogy; metallurgy; materials science *not* (paper, textiles)); crystallography
15	engineering, environmental
16	engineering *and* (industrial, manufacturing, marine, mechanical, aerospace, agricultural; multidisciplinary; ocean; petroleum (from basic chemistry)); mechanics; material science *and* (paper, textiles); transportation; aeronautics
17	thermodynamics; energy
18	engineering, civil; mining; construction and building technology
19	astronomy; physics *and* (particles, atomic, condensed, fluids, mathematical, applied, nuclear, multidisciplinary); microscopy; acoustics;
20	cytology; surgery; ophthalmology; orthopedics; otorhinolaryngology; dentistry; odontology; ergonomics; rehabilitation; critical care; emergency medicine; public health; anatomy; histology; pathology; medicine; allergy; andrology; anesthesiology; oncology; cardiovascular; vascular; dermatology; endocrinology; gastroenterology; geriatrics; hematology; immunology; infectious; mycology; pediatrics; psychiatry; respiratory; rheumatology; toxicology; virology; urology; tropical; transplantation; clinical neurology; gynecology; abuse; physiology; neurosciences; parasitology; veterinary; health care; medical informatics; biomaterials; nursing
21	biology ; biomethods; botany; zoology; ornithology; plant; entomology; reproductive; freshwater; microbiology; biophysics (from materials)
22	meteorology; ecology; environmental sciences; water resources; limnology; oceanography; aquatic; biodiversity
23	mathematics; statistics
24	geography; geology; geological; geophysics; geosciences
25	multidisciplinary sciences (not engineering, physics)
26	paleontology; archaeology; agriculture; agricultural; horticulture; fisheries; forestry; agronomy

Appendix 3: *Star List of Chinese Research Institutions by Scientific Fields*

F1: Electrical engineering

Rank	N of pub 04-06	Institution Name, City
1	287	Shanghai Jiaotong University, Shanghai
2	218	Tsinghua University, Beijing
3	179	Xidian University, Xian
4	163	Southeast University, Nanjing
5	155	Harbin Institute of Technology, Harbin
6	153	Zhejiang University, Hangzhou
7	151	University of Electronic Science & Technology of China, Chengdu
8	145	City University of Hong Kong, Hong Kong
9	125	Xian Jiaotong University, Xian
10	124	Hong Kong University of Science & Technology, Hong Kong
11	119	Huazhong University of Science & Technology, Wuhan
12	114	Hong Kong Polytechnic University, Hong Kong
13	102	Peking University, Beijing
14	85	Fudan University, Shanghai
15	81	Chinese University of Hong Kong, Hong Kong
16	76	University Hong Kong, Hong Kong
17	74	University of Science & Technololgy of China, Hefei
18	73	Beijing University Posts & Telecommun, Beijing
19	72	Jilin University, Changchun
20	67	Nanjing University, Nanjing

F2: Computers

Rank	N of pub 04-06	Institution Name, City
1	399	Shanghai Jiaotong University, Shanghai
2	336	Tsinghua University, Beijing
3	330	Zhejiang University, Hangzhou
4	254	Harbin Institute of Technology, Harbin
5	228	Xian Jiaotong University, Xian
6	221	Huazhong University of Science & Technology, Wuhan
7	197	Peking University, Beijing
8	187	City University of Hong Kong, Hong Kong
9	186	University of Science & Technology of China, Hefei
10	165	Fudan University, Shanghai
11	161	Southeast University, Nanjing
12	159	Dalian University of Technology, Dalian
13	156	University of Hong Kong, Hong Kong
14	154	Chinese University of Hong Kong, Hong Kong
15	153	Hong Kong Polytechnic University, Hong Kong
16	152	Hong Kong University of Science & Technology, Hong Kong
17	151	Chinese Academy of Sciences, Institute of Computer Technology, Beijing
18	150	Wuhan University, Wuhan
19	149	Zhongshan University, Guangzhou
20	147	Xidian University, Xian

F3: Optics

Rank	N of pub 04-06	Institution Name, City
1	176	Shanghai Jiaotong University, Shanghai
2	159	Zhejiang University, Hangzhou
3	141	Tsinghua University, Beijing
4	139	University of Science & Technology of China, Hefei
5	129	Huazhong University of Science & Technology, Wuhan
6	112	Chinese Academy of Sciences, Shanghai Institute of Optics & Fine Mechanics, Shanghai
7	108	Nankai University, Tianjin
8	90	Harbin Institute of Technology, Harbin
9	89	Tianjin University, Tianjin
10	88	Jilin University, Changchun
11	87	Peking University, Beijing
12	80	Xidian University, Xian
13	79	Fudan University, Shanghai
14	73	Chinese Academy of Sciences, Institute of Physics
14	73	City University of Hong Kong, Hong Kong
14	73	University of Electronic Science & Technology of China, Chengdu
17	71	Shandong University, Jinan
18	64	Hong Kong Polytechnic University, Hong Kong
19	61	Beijing University of Posts & Telecommunication, Beijing
19	61	Southeast University, Nanjing

F4: Measuring, control

Rank	N of pub 04-06	Institution Name, City
1	222	Shanghai Jiaotong University, Shanghai
2	201	Tsinghua University, Beijing
3	191	Peking University, Beijing
4	156	Harbin Institute of Technology, Harbin
5	156	Zhejiang University, Hangzhou
6	148	University of Science & Technology of China, Hefei
7	110	Jilin University, Changchun
8	93	Huazhong University of Science & Technology, Wuhan
9	88	Wuhan University, Wuhan
10	85	Hong Kong Polytechnic University, Hong Kong
11	83	Nanjing University, Nanjing
12	80	Xian Jiaotong University, Xian
13	78	Fudan University, Shanghai
13	78	Shandong University, Jinan
15	71	Xiamen University, Xiamen
16	70	Zhongshan University, Guangzhou
17	69	City University of Hong Kong, Hong Kong
18	66	Tianjin University, Tianjin
19	63	Sichuan University, Chengdu
20	61	Beijing Normal University

F5: Medical engineering

Rank	N of pub 04-06	Institution Name, City
1	217	Chinese University of Hong Kong, Hong Kong
2	186	University of Hong Kong, Hong Kong
3	101	Fudan University, Shanghai
3	101	Peking University, Beijing
5	86	Zhejiang University, Hangzhou
6	85	Shanghai Jiaotong University, Shanghai
7	76	Tsinghua University, Beijing
8	71	Zhongshan University, Guangzhou
9	57	Sichuan University, Chengdu
10	54	Hong Kong Polytechnic University, Hong Kong
10	54	Nanjing University, Nanjing
12	51	Central South University, Changsha
13	49	Peking Union Medical College, Beijing
14	48	Xian Jiaotong University, Xian
15	47	Huazhong University of Science & Technology, Wuhan
16	44	Wuhan University, Wuhan
17	41	Southeast University, Nanjing
18	34	Nankai University, Tianjin
19	26	Chong Qing University, Chongqing
20	23	Tianjin University, Tianjin

F6: Nuclear technology

Rank	N of pub 04-06	Institution Name, City
1	59	Chinese Academy of Sciences, Institute of High Energy Physics
2	58	Tsinghua University, Beijing
3	54	Peking University, Beijing
4	50	China Institute of Atomic Energy, Beijing
5	37	University of Science & Technology of China, Hefei
6	27	Shandong University, Jinan
7	26	Harbin Institute of Technology, Harbin
8	25	Chinese Academy of Sciences, Institute of Plasma Physics
9	24	Shanghai Jiaotong University, Shanghai
10	22	Beijing Normal University
10	22	Fudan University, Shanghai
12	21	Chinese Academy of Sciences, Shanghai Institute of Applied Physics
13	19	Shanghai University, Shanghai
13	19	Sichuan University, Chengdu
15	17	Lanzhou University, Lanzhou
15	17	Xian Jiaotong University, Xian
17	15	Chinese Academy of Engineering Physics, Mianyang
17	15	East China University of Science & Technology, Shanghai
17	15	Southwest Jiaotong University, Chengdu
20	13	Dalian University of Technology, Dalian

F7: Organic chemistry

Rank	N of pub 04-06	Institution Name, City
1	196	Chinese Academy of Sciences, Shanghai Institute of Organic Chemistry
2	167	Peking University, Beijing
3	113	Chinese Academy of Sciences, Shanghai Institute of Material Medica
4	101	Zhejiang University, Hangzhou
5	98	Nankai University, Tianjin
6	88	Sichuan University, Chengdu
7	85	East China University of Science & Technology, Shanghai
8	71	Tsinghua University, Beijing
9	70	Chinese Academy of Sciences, Shanghai Institute of Chemistry
10	69	Lanzhou University, Lanzhou
11	67	Suzhou University, Suzhou
12	62	Fudan University, Shanghai
12	62	Nanjing University, Nanjing
14	57	Xiamen University, Xiamen
15	56	Wuhan University, Wuhan
16	56	Zhongshan University, Guangzhou
17	50	South China University of Technology, Guangzhou
17	50	Shandong University, Jinan
19	44	Ocean University of China, Qingdao
19	44	University of Hong Kong, Hong Kong

F8: Polymers

Rank	N of pub 04-06	Institution Name, City
1	184	Zhejiang University, Hangzhou
2	165	Fudan University, Shanghai
3	164	University of Science & Technology of China, Hefei
4	154	Sichuan University, Chengdu
5	149	South China University of Technology, Guangzhou
6	132	Donghua University, Shanghai
7	129	Shanghai Jiaotong University, Shanghai
8	122	Chinese Academy of Sciences, Shanghai Institute of Chemistry
9	114	Beijing University of Chemical Technology, Beijing
10	114	Jilin University, Changchun
11	108	Tsinghua University, Beijing
12	105	East China University of Science & Technology, Shanghai
13	104	Nanjing University, Nanjing
14	98	Zhongshan University, Guangzhou
15	89	Nankai University, Tianjin
16	88	Wuhan University, Wuhan
17	71	Peking University, Beijing
18	70	Tianjin University, Tianjin
19	68	Chinese Academy of Sciences, Changchun Institute of Applied Chemistry
20	58	Suzhou University, Suzhou

F9: Pharmacy

Rank	N of pub 04-06	Institution Name, City
1	369	Peking University, Beijing
2	331	Zhejiang University, Hangzhou
3	253	Chinese Academy of Sciences, Shanghai Institute of Material Medica
4	244	ShenYang Pharmaceutical University, Shenyang
5	230	Fudan University, Shanghai
6	215	Chinese University of Hong Kong, Hong Kong
7	197	University of Hong Kong, Hong Kong
8	159	Zhongshan University, Guangzhou
9	123	Huazhong University of Science & Technology, Wuhan
10	112	Nanjing University, Nanjing
11	109	Wuhan University, Wuhan
12	108	Sichuan University, Chengdu
13	102	Shanghai Jiaotong University, Shanghai
14	98	Second Military Medical University
14	98	Shandong University, Jinan
16	86	Lanzhou University, Lanzhou
17	79	Central South University, Changsha
17	79	Xian Jiaotong University, Xian
19	74	Peking Union Medical College, Beijing
20	60	Tsinghua University, Beijing

F10: Biotechnology

Rank	N of pub 04-06	Institution Name, City
1	730	Peking University, Beijing
2	658	Zhejiang University, Hangzhou
3	578	Fudan University, Shanghai
4	421	Zhongshan University, Guangzhou
5	420	University of Hong Kong, Hong Kong
6	385	Shanghai Jiaotong University, Shanghai
7	301	Tsinghua University, Beijing
8	273	Huazhong University of Science & Technology, Wuhan
9	261	China Agricultural University, Beijing
10	260	Chinese University of Hong Kong, Hong Kong
11	250	Nanjing University, Nanjing
12	239	Wuhan University, Wuhan
13	210	Sichuan University, Chengdu
14	193	Chinese Academy of Sciences, Institute of Zoology
15	190	Shandong University, Jinan
16	189	Central South University, Changsha
17	157	Chinese Academy of Sciences, Institute of Biophysics
18	156	Chinese Academy of Sciences, Shanghai Institute of Organic Chemistry
19	154	University of Science & Technology of China, Hefei
20	150	Second Military Medical University

F11: Food, nutrition

Rank	N of pub 04-06	Institution Name, City
1	130	Zhejiang University, Hangzhou
2	101	South Yangtze University, Wuxi
3	90	Chinese University of Hong Kong, Hong Kong
4	78	China Agricultural University, Beijing
5	52	Shanghai Jiaotong University, Shanghai
6	38	University of Hong Kong, Hong Kong
6	38	Zhongshan University, Guangzhou
8	36	Peking University, Beijing
9	31	Nanjing Agricultural University, Nanjing
10	26	East China University of Science & Technology, Shanghai
11	26	South China University of Technology, Guangzhou
12	22	Nanjing University, Nanjing
13	20	Ocean University of China, Qingdao
14	17	Chinese Academy of Sciences, Research Center for Eco-Environmental Sciences
14	17	Sichuan University, Chengdu
14	17	Xiamen University, Xiamen
17	14	Fudan University, Shanghai
17	14	Huazhong Agricultural University, Wuhan
17	14	Huazhong University of Science & Technology, Wuhan
17	14	Tianjin University, Tianjin

F12: Basic chemistry

Rank	N of pub 04-06	Institution Name, City
1	708	Peking University, Beijing
2	652	Zhejiang University, Hangzhou
3	582	Nanjing University, Nanjing
4	471	Tsinghua University, Beijing
5	441	Fudan University, Shanghai
6	405	University of Science & Technology of China, Hefei
7	386	Zhongshan University, Guangzhou
8	356	Chinese Academy of Sciences, Dalian Institute of Chemistry Physics
9	345	Chinese Academy of Sciences, Shanghai Institute of Chemistry
10	344	Shanghai Jiaotong University, Shanghai
11	341	Nankai University, Tianjin
12	325	Xiamen University, Xiamen
13	313	Dalian University of Technology, Dalian
14	302	Sichuan University, Chengdu
15	282	Jilin University, Changchun
16	267	Tianjin University, Tianjin
17	218	Huazhong University of Science & Technology, Wuhan
18	217	East China University of Science & Technology, Shanghai
19	208	Beijing University of Chemical Technology, Beijing
20	204	Hunan University, Changsha

F13: Chemical engineering

Rank	N of pub 04-06	Institution Name, City
1	203	Zhejiang University, Hangzhou
2	173	Dalian University of Technology, Dalian
3	162	Tianjin University, Tianjin
4	150	Tsinghua University, Beijing
5	132	East China University of Science & Technology, Shanghai
6	116	Shanghai Jiaotong University, Shanghai
7	97	Beijing University of Chemical Technology, Beijing
8	87	University of Science & Technology of China, Hefei
9	81	Chinese Academy of Sciences, Dalian Institute of Chemistry Physics
10	79	South Yangtze University, Wuxi
11	70	China University of Petroleum, Beijing
12	67	Nanjing University, Nanjing
13	65	Chinese Academy of Sciences, Institute of Process Engineering
13	65	Sichuan University, Chengdu
15	63	South China University of Technology, Guangzhou
16	60	China University of Petroleum
17	54	Zhejiang Sci-Tech University
18	50	Jilin University, Changchun
19	48	Chinese Academy of Sciences, Institute of Coal Chemistry
19	48	Harbin Institute of Technology, Harbin

F14: Materials research

Rank	N of pub 04-06	Institution Name, City
1	600	Shanghai Jiaotong University, Shanghai
2	497	Tsinghua University, Beijing
3	442	Harbin Institute of Technology, Harbin
4	411	Zhejiang University, Hangzhou
5	388	University of Science & Technology of China, Hefei
6	370	Dalian University of Technology, Dalian
7	333	Nanjing University, Nanjing
8	284	Tianjin University, Tianjin
9	277	Peking University, Beijing
10	275	Xian Jiaotong University, Xian
11	259	Jilin University, Changchun
12	258	University of Science & Technology of Beijing, Beijing
13	257	Chinese Academy of Sciences, Institute of Metal Research
13	257	Huazhong University of Science & Technology, Wuhan
15	253	South China University of Technology, Guangzhou
16	243	Sichuan University, Chengdu
17	228	Shanghai University, Shanghai
18	225	Northwestern Polytechnical University, Xian
19	207	Zhongshan University, Guangzhou
20	205	Fudan University, Shanghai

F15: Environmental engineering

Rank	N of pub 04-06	Institution Name, City
1	59	Tsinghua University, Beijing
2	57	Chinese Academy of Sciences, Research Center for Eco-Environmental Sciences
3	45	Hong Kong University of Science & Technology, Hong Kong
4	40	Zhejiang University, Hangzhou
5	39	Peking University, Beijing
6	37	Hong Kong Polytechnic University, Hong Kong
7	37	University of Hong Kong, Hong Kong
8	33	Harbin Institute of Technology, Harbin
9	33	Nanjing University, Nanjing
10	31	Chinese Academy of Sciences, Cold and Arid Regions Environmental and Engineering Research Institute
11	31	City University of Hong Kong, Hong Kong
12	30	Tongji University, Shanghai
13	25	Shanghai Jiaotong University, Shanghai
14	23	University of Science & Technology of China, Hefei
15	21	Beijing University of Technology, Beijing
15	21	Chinese Academy of Sciences, Guangzhou Institute of Geochemistry
15	21	Wuhan University, Wuhan
18	20	Chinese Academy of Sciences, Guangzhou Institute of Soil Science
19	16	Dalian University of Technology, Dalian
19	16	Shandong University, Jinan

F16: Mechanical engineering

Rank	N of pub 04-06	Institution Name, City
1	597	Shanghai Jiaotong University, Shanghai
2	388	Tsinghua University, Beijing
3	333	Harbin Institute of Technology, Harbin
4	289	Xian Jiaotong University, Xian
5	265	Zhejiang University, Hangzhou
6	222	Dalian University of Technology, Dalian
7	202	Northwestern Polytechnical University, Xian
8	198	University of Science & Technology of China, Hefei
9	189	Huazhong University of Science & Technology, Wuhan
10	180	City University of Hong Kong, Hong Kong
11	177	Tianjin University, Tianjin
12	172	University of Science & Technology of Beijing, Beijing
13	171	Chinese Academy of Sciences, Institute of Metal Research
13	171	Hong Kong Polytechnic University, Hong Kong
15	159	Beijing University of Aeronaut & Astronaut, Beijing
16	148	Peking University, Beijing
17	138	Tongji University, Shanghai
18	128	Jilin University, Changchun
19	120	Southeast University, Nanjing
20	117	Northeastern University, Shenyang

F17: Thermal processes

Rank	N of pub 04-06	Institution Name, City
1	153	Shanghai Jiaotong University, Shanghai
2	119	Tsinghua University, Beijing
3	85	Zhejiang University, Hangzhou
4	79	Dalian University of Technology, Dalian
5	77	Xian Jiaotong University, Xian
6	62	Tianjin University, Tianjin
7	55	Chinese Academy of Sciences, Dalian Institute of Chemistry Physics
8	53	University of Science & Technology of China, Hefei
9	49	Harbin Institute of Technology, Harbin
10	48	East China University of Science & Technology, Shanghai
11	46	Huazhong University of Science & Technology, Wuhan
12	39	Beijing University of Technology, Beijing
13	36	Taiyuan University ofTechnology, Taiyuanl
14	35	Hong Kong Polytechnic University, Hong Kong
15	34	China University of Petroleum, Shandong
16	32	China University of Mining & Technology
17	31	Chinese Academy of Sciences, Institute of Coal Chemistry
18	28	South China University of Technology, Guangzhou
18	28	China University of Petroleum, Beijing
20	26	Chinese Academy of Sciences, Guangzhou Institute of Energy Conversion

F18: Civil engineering

Rank	N of pub 04-06	Institution Name, City
1	93	Tsinghua University, Beijing
2	87	Tongji University, Shanghai
3	74	Shanghai Jiaotong University, Shanghai
4	73	Hong Kong Polytechnic University, Hong Kong
5	59	University of Science & Technology of Beijing, Beijing
6	57	Dalian University of Technology, Dalian
7	55	University of Hong Kong, Hong Kong
8	51	City University of Hong Kong, Hong Kong
9	50	Zhejiang University, Hangzhou
10	46	Wuhan University, Wuhan
11	38	Harbin Institute of Technology, Harbin
11	38	Hohai University, Nanjing
13	32	Southeast University, Nanjing
14	31	Hong Kong University of Science & Technology, Hong Kong
14	31	Hunan University, Changsha
14	31	Northeastern University, Shenyang
17	30	Central South University, Changsha
17	30	China University of Mining & Technology
17	30	Chinese Academy of Sciences, Cold and Arid Regions Environmental and Engineering Research Institute
20	28	Nanjing University, Nanjing

F19: Physics

Rank	N of pub 04-06	Institution Name, City
1	684	University of Science & Technology of China, Hefei
2	552	Shanghai Jiaotong University, Shanghai
3	529	Tsinghua University, Beijing
4	488	Peking University, Beijing
5	437	Nanjing University, Nanjing
6	426	Jilin University, Changchun
7	363	Zhejiang University, Hangzhou
8	356	Chinese Academy of Sciences, Institute of Physics
9	356	Fudan University, Shanghai
10	315	Shandong University, Jinan
11	291	Dalian University of Technology, Dalian
12	288	Tianjin University, Tianjin
13	284	Harbin Institute of Technology, Harbin
14	272	Xian Jiaotong University, Xian
15	266	Zhongshan University, Guangzhou
16	248	Huazhong University of Science & Technology, Wuhan
17	228	Chinese Academy of Sciences, Institute of High Energy Physics
18	225	Nankai University, Tianjin
19	194	Shanghai University, Shanghai
20	188	City University of Hong Kong, Hong Kong

F20: Medicine

Rank	N of pub 04-06	Institution Name, City
1	1796	University of Hong Kong, Hong Kong
2	1382	Chinese University of Hong Kong, Hong Kong
3	1315	Peking University, Beijing
4	1205	Zhejiang University, Hangzhou
5	985	Fudan University, Shanghai
6	928	Zhongshan University, Guangzhou
7	696	Huazhong University of Science & Technology, Wuhan
8	625	Sichuan University, Chengdu
9	593	Wuhan University, Wuhan
10	558	Shanghai Jiaotong University, Shanghai
11	486	Fourth Military Medical University, Xian
12	437	Peking Union Medical College, Beijing
13	420	Shanghai Medical University, Shanghai
14	406	Xian Jiaotong University, Xian
15	403	Capital University of Medical Sciences, Beijing
16	372	Nanjing University, Nanjing
17	355	Shandong University, Jinan
18	327	Central South University, Changsha
19	316	China Medical University, Shenyang
20	292	Third Military Medical University, Chongqing

F21: Biology

Rank	N of pub 04-06	Institution Name, City
1	880	Zhejiang University, Hangzhou
2	774	Peking University, Beijing
3	637	Fudan University, Shanghai
4	574	Chinese Academy of Sciences, Shanghai Institute of Biological Sciences
5	514	University of Hong Kong, Hong Kong
6	444	Zhongshan University, Guangzhou
7	431	Shanghai Jiaotong University, Shanghai
8	411	China Agricultural University, Beijing
9	326	Tsinghua University, Beijing
10	320	Chinese University of Hong Kong, Hong Kong
11	296	Chinese Academy of Sciences, Institute of Zoology
12	259	Huazhong University of Science & Technology, Wuhan
13	253	Ocean University of China, Qingdao
14	250	Sichuan University, Chengdu
15	241	Fourth Military Medical University, Xian
16	238	Wuhan University, Wuhan
17	233	Nanjing University, Nanjing
18	211	Nanjing Agricultural University, Nanjing
19	172	Central South University, Changsha
20	170	Huazhong Agricultural University, Wuhan

F22: Ecology, climate

Rank	N of pub 04-06	Institution Name, City
1	281	Zhejiang University, Hangzhou
2	220	Peking University, Beijing
3	219	Ocean University of China, Qingdao
4	155	Chinese Academy of Sciences, Research Center for Eco-Environmental Sciences
5	148	Nanjing University, Nanjing
6	131	Tsinghua University, Beijing
7	128	Beijing Normal University
8	124	Hong Kong University of Science & Technology, Hong Kong
9	110	Lanzhou University, Lanzhou
10	96	Wuhan University, Wuhan
11	95	Xiamen University, Xiamen
12	89	Fudan University, Shanghai
13	88	Chinese Academy of Sciences, Institute of Atmospheric Physics
13	88	University of Hong Kong, Hong Kong
15	84	China Agricultural University, Beijing
15	84	Shanghai Jiaotong University, Shanghai
17	81	Dalian University of Technology, Dalian
18	76	Chinese Academy of Sciences, Institute of Geographic Sciences and Natural Resources Research
18	76	City University of Hong Kong, Hong Kong
20	72	Tongji University, Shanghai

F23: Mathematics

Rank	N of pub 04-06	Institution Name, City
1	153	Peking University, Beijing
2	144	Shanghai Jiaotong University, Shanghai
3	138	Xian Jiaotong University, Xian
4	132	Zhejiang University, Hangzhou
5	122	Tsinghua University, Beijing
6	121	Zhongshan University, Guangzhou
7	119	Dalian University of Technology, Dalian
8	109	Fudan University, Shanghai
9	108	Shanghai University, Shanghai
10	102	Harbin Institute of Technology, Harbin
11	92	South China University of Technology, Guangzhou
12	91	Shandong University, Jinan
13	87	South Yangtze University, Wuxi
14	85	City University of Hong Kong, Hong Kong
15	82	Chinese Academy of Sciences, Institute of Computational Mathematics and Scientific/Engineering Computing
16	79	Chong Qing University, Chongqing
17	78	University of Science & Technology of China, Hefei
18	77	Nankai University, Tianjin
19	76	University of Hong Kong, Hong Kong
20	73	Chinese University of Hong Kong, Hong Kong

F24: Geosciences

Rank	N of pub 04-06	Institution Name, City
1	178	Peking University, Beijing
2	159	Chinese Academy of Sciences, Institute of Geoglogy & Geophysics, Lanzhou
3	132	Nanjing University, Nanjing
4	122	China University of Geosciences, Beijing
5	101	Chinese Academy of Sciences, Guangzhou Institute of Geochemistry
6	88	China univ geosci wuhan
7	88	Wuhan University, Wuhan
8	85	Lanzhou University, Lanzhou
8	85	Ocean University of China, Qingdao
10	70	Jilin University, Changchun
11	69	Tongji University, Shanghai
12	62	Sinopec
13	61	University of Science & Technology of China, Hefei
14	55	Chinese Academy of Sciences, Institute of Atmospheric Physics
15	52	China University of Mining & Technology
16	49	Beijing Normal University
16	49	Chinese Academy of Sciences, South China Sea Institute of Oceanology
16	49	Tsinghua University, Beijing
19	45	University of Hong Kong, Hong Kong
20	43	Chinese Academy of Sciences, Institute of Geographic Sciences and Natural Resources Research

F25: Multidisciplinary

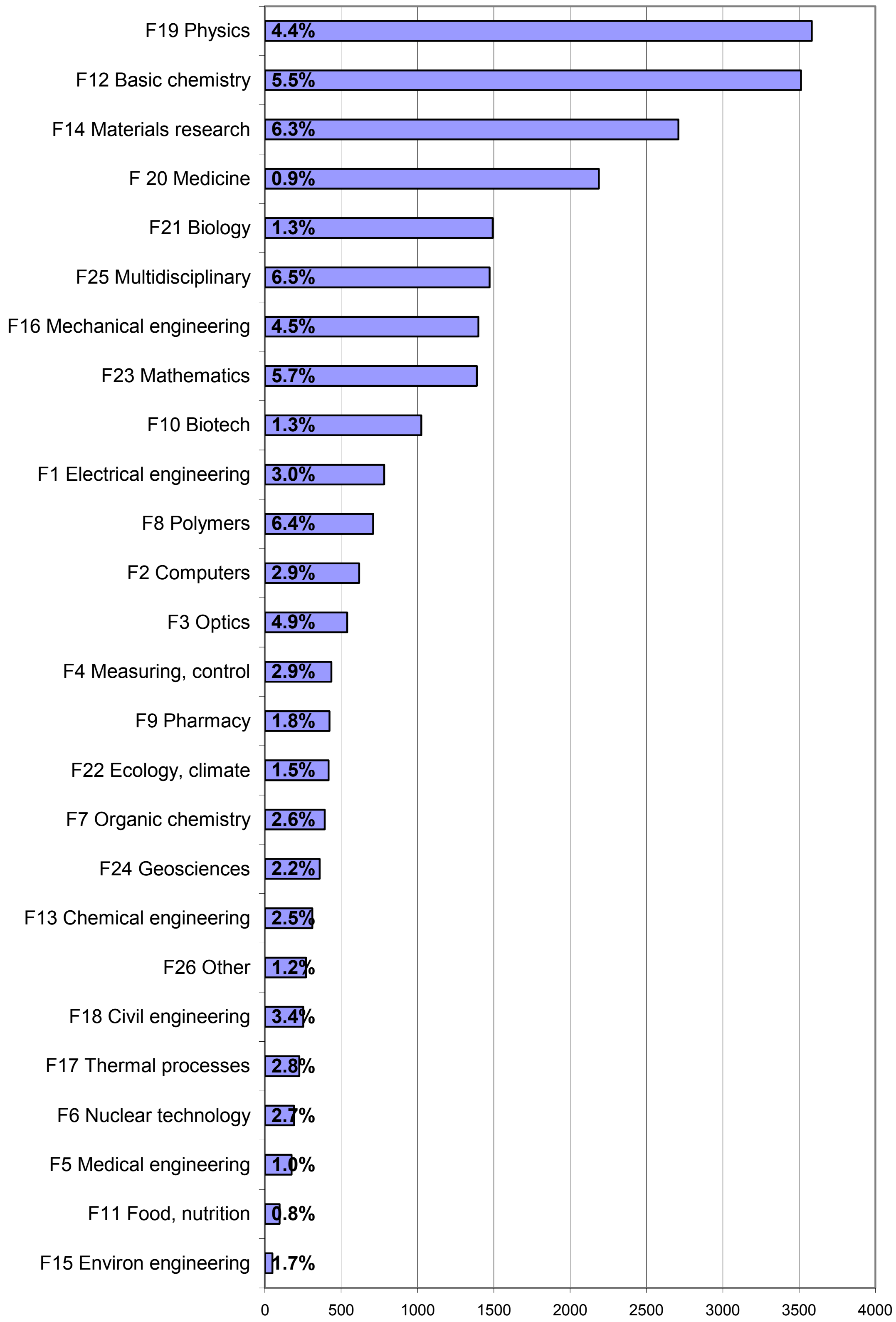
Rank	N of pub 04-06	Institution Name, City
1	625	Peking University, Beijing
2	575	Jilin University, Changchun
3	487	Zhejiang University, Hangzhou
4	396	Tsinghua University, Beijing
5	385	Nanjing University, Nanjing
6	354	Shanghai Jiaotong University, Shanghai
7	312	Fudan University, Shanghai
8	309	University of Science & Technology of China, Hefei
9	257	Zhongshan University, Guangzhou
10	232	Dalian University of Technology, Dalian
11	222	Lanzhou University, Lanzhou
12	214	Sichuan University, Chengdu
13	203	Chinese Academy of Sciences, Shanghai Institute of Chemistry
14	203	Nankai University, Tianjin
15	201	Huazhong University of Science & Technology, Wuhan
16	199	Harbin Institute of Technology, Harbin
17	195	Xiamen University, Xiamen
18	177	South China University of Technology, Guangzhou
19	171	University of Hong Kong, Hong Kong
20	167	Wuhan University, Wuhan

F26: Other

Rank	N of pub 04-06	Institution Name, City
1	298	China Agricultural University, Beijing
2	291	Zhejiang University, Hangzhou
3	137	Nanjing Agricultural University, Nanjing
4	136	Huazhong Agricultural University, Wuhan
5	109	Ocean University of China, Qingdao
6	77	Zhongshan University, Guangzhou
7	76	Lanzhou University, Lanzhou
8	56	Chinese Academy of Sciences, Institute of Geographic Sciences and Natural Resources Research
9	52	Beijing Normal University
10	46	Chinese Academy of Sciences, Research Center for Eco-Environmental Sciences
11	45	Yangzhou University, Yangzhou
12	44	Shanghai Jiaotong University, Shanghai
13	43	Chinese Academy of Sciences, Guangzhou Institute of Soil Science
14	43	Nanjing University, Nanjing
15	40	Chinese Academy of Sciences, Institute of Hydrobiology
16	40	Peking University, Beijing
17	30	Chinese Academy of Sciences, Nanjing Institute of Geology and Palaeontology
18	29	University of Hong Kong, Hong Kong
19	28	Chinese Academy of Sciences, Institute of Applied Ecology
20	28	Xiamen University, Xiamen

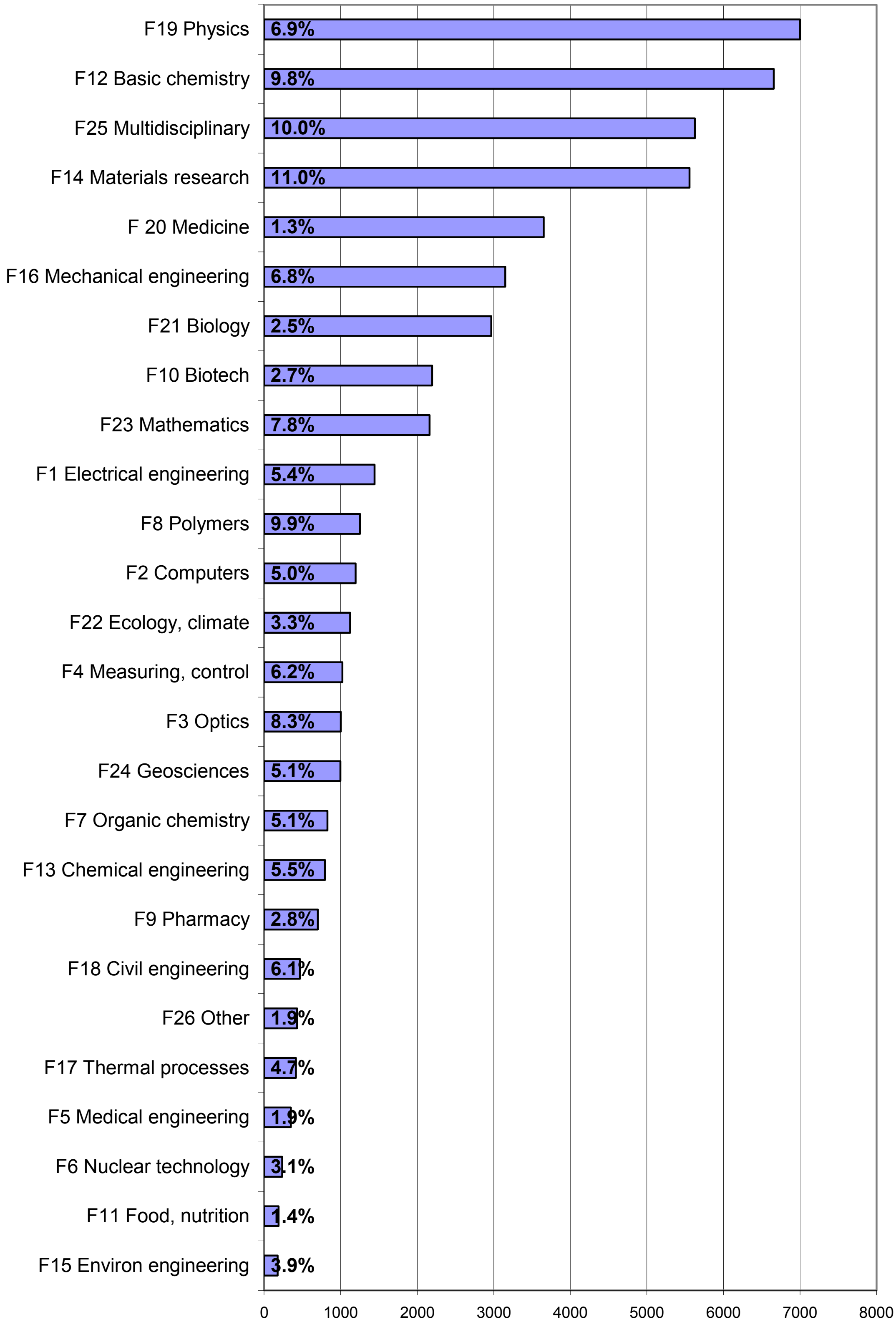
Appendix 4: *Absolute number and shares of Chinese publications*

Figure A2-1: Absolute number and worldwide shares of Chinese publications, 1997



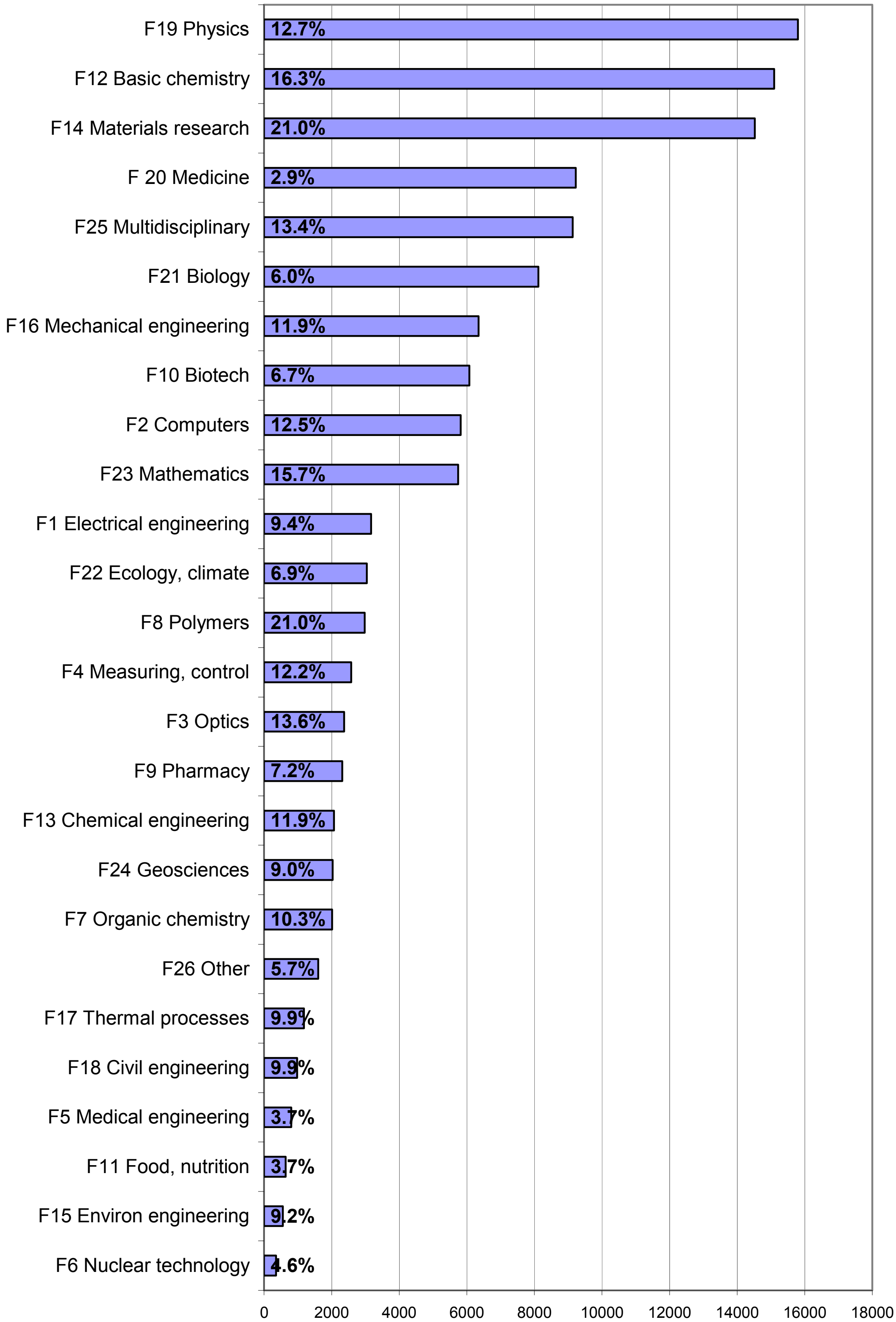
STN: SCISEARCH; Fraunhofer ISI calculations.

Figure A2-2: *Absolute number and worldwide shares of Chinese publications, 2001*



STN: SCISEARCH; Fraunhofer ISI calculations.

Figure A2-3: Absolute number and worldwide shares of Chinese publications, 2006



STN: SCISEARCH; Fraunhofer ISI calculations.

References

Auriol, L. (2006). A role for China in the global work on HRST. OECD-Most Workshop on Indicators for Assessing National Innovation Systems, Chongqing, China. The electronic version is available at http://www.oecd.org/dataoecd/19/26/37740929.pdf.

British Embassy and Consulates-General, China (2007): Emerging trends in China's international co-authorship - lessons for future collaboration, Beijing.

Calero, C. , R. Bulter, C. C. Valdes, & E.D. Noyons. (2006) How to identify research groups using publication analysis: an example in the field of nanotechnology. Scientometrics. 66(2), 365-376.

Edler, J.; Bührer, S.; Ebersberger, B.; Frietsch, R.; Gröhl, S.; Ruhland, S.; Wang, J.; Baier, E.; Jappe, A.; Lo, V.; von Oertzen, J.; Grimpe, C.; Licht, G.; Löhlein, H.; Boekholt, P. (2007): Internationalisierung der deutschen Forschungs- und Wissenschaftslandschaft, 111-90030-4, Karlsruhe: Fraunhofer ISI.

European Commission (2007): COMMISSION STAFF WORKING DOCUMENT Accompanying the Green Paper 'The European Research Area: New Perspectives', SEC(2007) 412/2, Brussels: Commission of the European Communities.

Frietsch, R. (2004): Entwicklung der internationalen Wissenschaftskooperationen, Bundesministerium fuer Bildung und Forschung (BMBF) (Ed.), Studien zum deutschen Innovationssystem Nr. 11-2004, Berlin.

Frietsch, R.; Wang, J. (2007): Intellectual Property Rights and Innovation Activities in China: Evidence from Patents and Publications, Discussion Paper "Innovation System and Policy Analysis" No. 13/2007, Karlsruhe: Fraunhofer ISI.

Hinze, S.; Tang, L.; Gauch, S. (2008): Leistungsfähigkeit und Strukturen der Wissenschaft im internationalen Vergleich, Expertenkommission Forschung und Innovation (Ed.) Studien zum deutschen Innovationssystem, Karlsruhe.

Hu, A. (2005): China´s Context and Development, Beijing: Tsinghua University Press.

Jin, B.; Rosseau, R. (2004): Evaluation of Research Performance and Scientometric Indicators in China In: Moed, H.F.; Glänzel, W.; Schmoch, U. (Hrsg.): Handbook of Qualitative Science and Technology Research. The Use of Publication and Patent Statistics in Studies of S&T Systems. Dordrecht: Kluwer Academic Publishers, S. 497-514.

Ministry of Science and Technology (China) (Hrsg.) (2006): China science and technology indicators 2004. Beijing: Scientific and Technical Documents Publ. House.

Moed, H.F.; Glänzel, W.; Schmoch, U. (Hrsg.) (2004): Handbook of Quantitative Science and Technology Research. The Use of Publications and Patent Statistics in Studies of S&T Systems. Dordrecht: Kluwer Academic Publisher.

OECD (2005): Measuring Globalisation OECD Handbook on Economic Globalisation Indicators, Paris: OECD Publishing.

OECD (2005): OECD economic surveys: China 2005, Paris: OECD Publ. Service.

Schmoch, U. (2004): Leistungsfähigkeit und Strukturen der Wissenschaft im internationalen Vergleich, Bundesministerium fuer Bildung und Forschung (BMBF) (Eds.), Studien zum deutschen Innovationssystem Nr. 13-2004, Bonn.

Schmoch, U. (2006): Scientific Performance in an International Comparison In: Schmoch, U.; Rammer, C.; Legler, H. (Eds.): National Systems of Innovation in Comparison. Structure and Performance Indicators for Knowledge Societies. Dordrecht: Springer, S. 69-88.

Schmoch, U. (2007): Leistungsfähigkeit und Strukturen der Wissenschaft im internationalen Vergleich, Bundesministerium fuer Bildung und Forschung (BMBF) (Eds.), Studien zum deutschen Innovationssystem Nr. 11-2007, Berlin.

Statistisches Bundesamt (2004): Länderprofil China, Wiesbaden.

van Raan, A. (Eds.) (1988): Handbook of quantitative studies of science and technology. Amsterdam.

Wallin, J., A. (2005). Bibilometric Methods Pitfall and Possibilities. Pharmacology & Toxicology(97), 261-275.