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SCIENTOMETRIC STUDY ON RESEARCH PERFORMANCE IN CHINA

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Abstract—Research performance in China has increased appreciably during the past few years, both in regard to relative output of publications and in their impact on the international research productivity. The purpose of this survey, based on the data recorded in the Science Citation Index (SCI) database between 1987 and 1993, is to study the research performance in the People's Republic of China. The 35,087 papers published in domestic or foreign periodicals were selected for analysis and evaluation of the distribution of publications and citations, for the numerical characterization of research performance in China. The findings indicate that 17,687 papers covered by the Source Indexes of the SCI in the period 1990–1992 had received 7944 citations in the year 1993 and that the mean citation rate is 0.45. The number of cited papers is 4491 and the proportion of cited papers to the total is 0.25. Copyright © 1997 Elsevier Science Ltd

INTRODUCTION

The assessment of scientific research is an extremely delicate and sophisticated venture (Braun *et al.*, 1985). However, the Science Citation Index (SCI), as a tool in quantitative studies of scientific research, is of the utmost importance as an international database with a unique method for its citations, which can provide a system of scientometric indicators based on number of publications, authors, references and citations. To evaluate the numerical characterization of research performance, many studies have used the number of publications produced by authors in the disciplines or in the regions and the number of citations received by those publications as measures of scientific productivity (Schubert & Telcs, 1989; Braun *et al.*, 1990; Narin *et al.*, 1991; Nederhof & Noyons, 1992; Lewison *et al.*, 1993; Zhang, 1993; Yamazaki, 1994; Klaic, 1995). The purpose of this study is to characterize research performance in China through the numbers of papers published in periodicals and the number of citations received by those papers covered by the SCI database from 1987 to 1993. Although the SCI shows a considerable bias in favor of periodicals published in the U.S. and other English-language periodicals, and against periodicals with non-Roman alphabets (Carpenter & Narin, 1981; Irvine *et al.*, 1985; King, 1989), it is still the most comprehensive and frequently used source database of choice for a broad review of national science.

METHOD

Data sources

The research was conducted by searching the SCI database, referenced only nine periodicals published from China and accounted for 0.28% of all the selected periodicals, during the period

1987–1993 for building scientometric indicators datafiles, consisting of the published papers in domestic or foreign periodicals with addresses of institutions from the People's Republic of China.

Science disciplines

Scientific periodicals were classified according to the subfields used in the Journal Citation Reports. When a particular periodical appeared in two different subfields, in this paper it was classified into the larger subfield. The classification of published papers was based on the Classification and Code of Discipline (in Chinese).

Citation period

The number of published papers in domestic or foreign periodicals with addresses of institutions from China in the Source Indexes of the SCI in the period 1987–1992 were considered source items, and the number of citations received by them was counted for the period 1987–1993.

RESULTS AND DISCUSSION

The indicators of papers and citations

In the development of modern science there are many characteristics that are fully reflected by the variations of annual paper output. Scientific performance can be evaluated in a region or a country in terms of output of papers from the view of bibliometrics. In China, output of published papers covered in the SCI has increased steadily for every field since 1980. The share of world papers rose from 0.46 in 1980–1984 to 0.75 in 1985–1989, and to 1.04 in 1989–1993 (Braun *et al.*, 1994a, 1995a). During the 11-year period 1983–1993, the annual numbers of papers with addresses of institutions from China are shown in Fig. 1 The numbers of papers and of paper citations from 1990 to 1992 are shown in Table 1.

Figure 1 shows that the annual numbers of papers published in foreign periodicals is higher than that in domestic periodicals during the study period. Figure 1 also shows that the annual paper output in foreign periodicals has been substantially increasing. The growth rate between 1983 and 1993 is 1.75. However, annual paper output in domestic periodicals has been steadily decreasing.

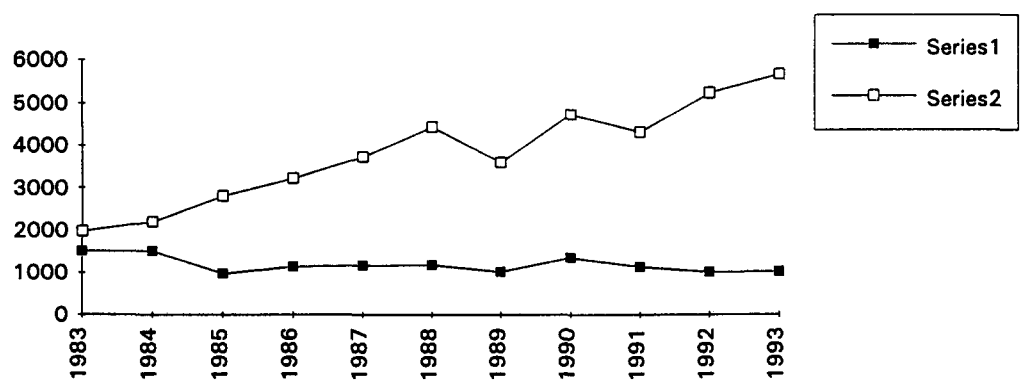

Fig. 1. Distribution of Publications from 1983 to 1993.

Table 1. Percentage distribution of the number of papers and paper citations

Years	Number of papers		Cited papers		Number of citations		
	Domestic(A)	Foreign(A)	(B)	(B/A)	(C)	(C/B)	(C/A)
1990	1344	4711	1565	0.26	2878	1.84	0.48
1991	1118	4290	1570	0.29	2943	1.87	0.54
1992	1003	5221	1356	0.22	2122	1.57	0.34
Total	3465	14,222	4491	0.25	7944	1.77	0.45

Table 1 shows that the 17,687 papers issued in 1990–1992 received 7944 citations in both domestic and foreign periodicals in the 1993 Citation Index volume of the SCI database and the mean citation rate is 0.45. The number of uncited papers is 13,196 and the proportion of uncited papers to the total is 0.75.

Distribution of cited disciplines

The bibliometric approach towards science studies implies the quantification of documentary flows of information, since these studies lean primarily on quantitative indicators reflecting the

Table 2. Number of publications and citations involving the disciplines

Disciplines	Number of publications (A) 1990–92	Cited publications (B) 1993	Number of citations (C) 1993	(B/A)	(C/A)	(C/B)
Basic sciences	11,079	3050	5532	0.28	0.50	1.81
Mathematics	1122	203	299	0.18	0.27	1.47
Mechanics	463	61	84	0.13	0.18	1.38
Physics	4919	1449	2726	0.29	0.55	1.89
Chemistry	2941	999	1839	0.34	0.63	1.84
Astronomy	175	39	59	0.22	0.34	1.51
Physiography	677	88	140	0.13	0.21	1.59
Biology	782	214	385	0.31	0.55	1.80
Health sciences	2771	557	1018	0.20	0.37	1.83
Agriculture*	220	50	76	0.23	0.35	1.52
Industrial technology	3575	827	1308	0.23	0.37	1.58
Others	42	7	10	0.21	0.24	1.11
Total	17,687	4491	7944	0.25	0.45	1.77

* Includes forestry, livestock husbandry and fisheries.

Table 3. Number of citations from universities (1990–1992)

University	Number of publications (A)	Cited publications (B)	Number of citations (C)	(B/A)	(C/A)	(C/B)
Beijing	559	154	316	0.28	0.57	2.05
Nanjing	532	145	262	0.27	0.49	1.81
Lanzhou	351	107	177	0.30	0.50	1.65
China University of Science & Technology	503	104	193	0.21	0.38	1.86
Qinghua	394	94	148	0.24	0.38	1.57
Fudan	417	92	143	0.22	0.34	1.55
Nankai	281	88	152	0.31	0.54	1.73
Wuhan	199	78	137	0.39	0.69	1.76
Jilin	277	75	114	0.27	0.41	1.52
Shandong	233	73	118	0.31	0.51	1.62
Total	3746	1010	1760	0.27	0.47	1.74

Table 4. Number of citations from institutes (1990–1992)

Institutes	Number of publications (A)	Cited publications (B)	Number of citations (C)	(B/A)	(C/A)	(C/B)
Institute of Physics, Academia Sinica	476	152	270	0.33	0.57	1.78
Shanghai Institute of Organic Chemistry	266	137	286	0.52	1.08	2.09
Institute of Metals, Academia Sinica	240	104	213	0.43	0.89	2.05
Changchun Applied Chemistry Institute	271	95	179	0.35	0.66	1.88
Fujian Inst. of Res. on Structure of Matter	140	65	138	0.46	0.99	2.12
Institute of Chemistry, Academia Sinica	140	54	121	0.39	0.86	2.24
Dalian Institute of Chemical Physics	119	53	117	0.45	0.98	2.21
Shanghai Institute of Metallurgy	141	44	89	0.31	0.63	2.02
Shanghai Institute of Optical Precision Machinery	192	38	53	0.20	0.28	1.39
Institute of Biophysics, Academia Sinica	85	34	57	0.40	0.67	1.68
Total	2070	776	1523	0.38	0.74	1.95

state of science as a whole or its separate fields (Marshakova-Shaikevich, 1993). The figures for disciplines and national scientific performance measured by paper counts provide information in almost all countries. The numbers of papers published in 1990–1992 recorded in the 1993 Citation Index were identified for different disciplines. Table 2 presents the citation rates of papers from all science fields.

Table 2 shows that the most heavily cited papers were in chemistry in 1993, and papers in biology and physics also received more citations than the average. However, the overall mean citation rate for Chinese papers is not above 0.65 for any discipline in 1993. A further contribution to this lack of citation is language: papers in languages other than English are significantly less frequently cited than English-language papers (Narin & Frame, 1989; Liu, 1993).

Ranking of research institutes

There are 804 colleges and universities in China according to the 1993 China Statistical Yearbook on Science and Technology. The number of citations recorded in the 1993 Citation Index to the relevant papers published from 1987 to 1992 was counted for each university; 3955 papers produced by the universities were cited, 56.02% of all the cited papers, and they received 6828 citations by these papers. The key universities, directly under the guidance of the Ministry of Education, have a higher paper output and higher citations. The ranking results are shown in Table 3.

The figures in Table 3 show that Beijing University takes the first rank with 559 papers and 316 citations and a mean citation rate of 0.57. The number of cited papers is 154 and the percentage of cited papers is 0.28. Nanjing University is the second with 532 papers and 262

Table 5. Number of citations from citing authors and periodicals

Authors	Institutions	Number of citations				
		Self-citation	Citations	Total	Citing authors	Citing periodicals
Huang Meng-Er	Shanghai Second Medical University	0	94	94	89	60
Han Qi-De	Beijing Medical University	0	39	39	38	26
Jiang He	Third Military Medical University	0	34	34	32	15
Sun Chang-Pu	Northeast Normal University	2	30	32	23	11
Huang Kun	Institute of Semiconductor, Academia Sinica	0	32	32	25	12
Chen Chuang-Tian	Fujian Institute of Res. on Structure of Matter	0	30	30	29	14
Tu Lian-Ying	Shanghai Medical University	0	28	28	23	19
Chen Zi-Xing	Suzhou Medical College	0	23	23	27	20
Zhang Ming-Yuan	Shanghai Institute of Mental Health	0	23	23	23	15

citations. The mean citation rate is 0.49.

The number of citations recorded in the 1993 Citation Index to the relevant papers published from 1987 to 1992 was counted for each research institute, and 329 papers from institutes were cited in the same period; 2967 papers produced by the institutes were cited, 42.03% of all the

Table 6. Field distribution and citation frequency of periodicals (1987–1993)

Disciplines	Number of periodicals	%	Number of citations	%
Mathematics	76	4.00	553	4.29
Mechanics	20	1.05	131	1.02
Physics	229	12.06	3953	30.65
Chemistry	230	12.11	2560	19.85
Astronomy	15	0.79	76	0.59
Physiography	18	4.11	242	1.88
Biology	282	14.85	813	6.30
Public health	30	1.58	108	0.84
Basic medicine	348	18.33	1134	8.79
Pharmacology & pharmacy	58	3.05	364	2.82
Clinical medicine	130	6.85	330	2.56
Military medicine	5	0.26	16	0.12
Agriculture	22	1.16	45	0.35
Forestry	3	0.16	4	0.03
Livestock husbandry	15	0.79	19	0.15
Fisheries	2	0.11	5	0.04
Surveying & mapping sciences	1	0.05	4	0.03
Materials science	44	2.32	488	3.78
Engineering technology	4	0.21	7	0.05
Mining science	9	0.47	18	0.14
Energy science	5	0.26	9	0.07
Metallurgy	22	1.16	169	1.31
Mechanics and instruments	18	0.84	94	0.74
Dynamics & electricity	28	1.47	80	0.62
Nuclear science	23	1.21	211	1.64
Telecommunications	60	3.16	536	4.16
Computer applications	18	0.95	119	0.92
Chemical industry	31	1.63	306	2.37
Light industry	6	0.32	12	0.09
Food science	10	0.53	15	0.12
Architecture	2	0.11	41	0.32
Hydraulic engineering	3	0.16	3	0.02
Transportations	1	0.05	1	0.01
Aerospace	2	0.11	10	0.08
Environmental science	26	1.37	138	1.07
Safety technology	1	0.05	1	0.01
Management science	1	0.05	1	0.01
Other sciences	41	2.16	270	2.09
Total	1899	100.00	12,896	100.00

Table 7. Impact factor and immediacy index of nine periodicals

	Impact factor					Immediacy index				
Periodicals	1989	1990	1991	1992	Mean	1989	1990	1991	1992	Mean
Acta Pharmacologica Sinica	0.331	0.425	0.356	0.297	0.352	0.049	0.077	0.063	0.086	0.068
Communications in Theoretical Physics	0.200	0.309	0.337	0.304	0.288	0.078	0.230	0.125	0.033	0.117
Science in China (Ser. B)	0.149	0.189	0.211	0.288	0.209	0.060	0.031	0.034	0.025	0.038
Chinese Physical Letters	—	—	0.232	0.137	0.203	—	—	0.070	—	0.070
Science in China (Ser. A)	0.144	0.138	0.189	0.206	0.169	0.039	0.088	0.045	0.027	0.050
Chinese Medical Journal	0.075	0.105	0.071	0.132	0.096	—	0.043	0.015	0.073	0.044
Acta Geologica Sinica	0.042	0.188	0.047	0.108	0.096	—	—	—	0.045	0.045
Chinese Annals of Mathematics	0.091	0.046	0.090	0.050	0.069	0.056	—	—	0.019	0.038
Chinese Physics	0.046	0.038	0.010	0.049	0.036	—	0.007	—	—	0.007

Table 8. Japan, India and China ranked by their publication count all science fields combined (1989–1993)

	Mathematics	Material science	Electronic engineering	Nuclear sciences	Mechanical civil & other engineering	Inorganic chemistry & engineering	Analytical chemistry	Physical chemistry	Organic chemistry	Applied physics	Solid-state physics	Geosciences	Other physics	Life sciences
Japan														
Publication														
Count	2196	10,263	7013	5715	3512	14,709	5164	7793	11,687	17,775	10,232	2752	14,422	123,249
Share (%)	3.57	13.26	7.65	8.92	7.70	10.24	10.95	9.58	12.89	16.76	7.45	3.18	7.27	7.09
Citation														
Count	2132	13,997	13,290	10,395	2372	37,456	11,961	20,210	36,795	50,296	34,915	5284	51,730	415,281
Share (%)	3.97	12.58	9.97	6.78	6.07	10.69	10.05	8.93	14.73	18.72	7.26	2.30	6.19	5.68
Mean citation rate														
Observed	0.97	1.36	1.90	1.82	0.68	2.55	2.32	2.59	3.15	2.87	3.41	1.92	3.59	3.17
Expected	0.95	1.42	1.93	1.99	0.73	2.57	2.37	3.01	2.97	3.01	3.52	2.70	3.70	3.40
Relative	1.02	0.96	0.98	0.92	0.93	0.99	0.98	0.86	1.06	0.95	0.97	0.71	0.97	0.92
AI	0.48	1.68	0.97	1.13	0.98	1.30	1.39	1.21	1.63	2.12	0.94	0.40	0.92	0.90
India														
Publication														
Count	901	3075	1299	1987	876	5410	1511	1906	4379	1698	4561	1505	4925	19,937
Share (%)	1.54	3.97	1.42	3.10	1.92	3.77	3.21	2.34	4.83	1.60	3.32	1.74	2.48	1.22
Citation														
Count	579	2703	819	2024	452	6163	1383	3404	5383	1870	7077	1398	6447	19,865
Share(%)	1.03	2.43	0.61	1.32	1.16	1.76	1.16	1.50	2.15	0.69	1.47	0.61	0.77	0.37
Mean citation rate														
Observed	0.64	0.88	0.63	1.02	0.52	1.14	0.92	1.79	1.23	1.10	1.55	0.93	1.31	1.03
Expected	0.88	1.45	1.27	2.01	0.95	1.54	1.74	2.54	1.77	2.48	2.83	1.95	2.43	2.13
Relative	0.73	0.61	0.50	0.51	0.54	0.74	0.53	0.70	0.69	0.44	0.55	0.48	0.54	0.49
AI	0.82	2.12	0.76	1.66	1.03	2.01	1.71	1.25	2.58	0.86	1.78	0.93	1.33	0.65
China														
Publication														
Count	1508	2177	1524	1190	815	1319	1177	1338	1265	2386	3488	802	4942	5478
Share (%)	2.52	2.81	1.66	1.86	1.79	0.92	2.50	1.65	1.40	2.25	2.54	0.93	2.49	0.34
Citation														
Count	767	1752	1289	1155	466	1383	1580	1593	1652	2257	5368	410	4564	5010
Share (%)	1.36	1.57	0.97	0.75	1.19	0.39	1.33	0.70	0.66	0.83	1.12	0.18	0.55	0.09
Mean citation rate														
Observed	0.51	0.80	0.85	0.97	0.57	1.05	1.34	1.19	1.31	0.95	1.54	0.51	0.92	1.12
Expected	0.66	1.52	1.73	2.08	0.81	1.85	2.12	2.27	2.09	2.21	3.03	1.53	1.62	2.17
Relative	0.77	0.53	0.49	0.47	0.70	0.57	0.63	0.52	0.63	0.43	0.51	0.33	0.57	0.52
AI	2.47	2.69	1.59	1.78	1.71	0.88	2.39	1.06	1.34	2.15	2.43	0.89	2.39	0.33

cited papers, and they received 5740 citations by these papers. The ranking of research institutes by the number of papers is shown in Table 4.

The results presented in Table 4 demonstrate that Institute of Physics attached to the Academia Sinica is in first place, with 476 papers and 270 citations, and the mean citation rate is 0.57. The number of cited papers is 152 and the percentage of cited papers is 0.33. Shanghai Institute of Organic Chemistry is second with 266 papers and 316 citations, and the mean citation rate is 1.08. The mean citation rate in Table 4 (research institutes) is much higher than that in Table 3 (universities). The assumption is that highly cited papers have a major impact on research performance; numerous studies suggest that is a valid assumption (Martin *et al.*, 1987; Nederhof & Noyons, 1992; Diodato, 1994).

Distribution of cited authors

A more complex way to calculate the author impact factor is to use the impact factors of the periodicals in which the author has published (Diodato, 1994). The highest cited papers have been published in *Blood*, *Nature*, *Chest* and the *Journal of Clinical Pathology*, which could indicate the contribution to a field of cited authors. Table 5 records the highly cited authors who published a paper in 1987–1992 which received 23 or more citations covered in the 1993 Citation Index.

The figures presented in Table 5 indicate that five authors were engaged in basic medicine and one author in clinical medicine. "Use of all-trans retinoic acid in the treatment of acute promyelocytic leukemia", published in *Blood* in 1988 by Huang Meng-Er *et al.*, had garnered a total of 237 citations from 1990 to 1993 in the Citation Index volumes of the SCI database. "Alfpha-1-adrenoceptor subtypes linked to different mechanism for increasing intra-cellular Ca+2 in smooth-muscle", issued in *Nature* in 1987, had garnered a total of 172 citations.

Analysis of citing periodicals

In his law of scattering, Bradford (1950) described the way in which the literature on a particular subject was distributed in the periodicals. Bradford's law is one of several statistical expressions that try to describe the workings of science by mathematical means. Each law applies to a different specific phenomenon (Garfield, 1980). The law, in this paper, can also show a relationship between the number of papers of a given period of time and the number of periodicals that cite the papers. During the 6-year period 1987–1992, 1899 periodicals cited papers with addresses of the institutions from China a total of 12,896 times. Periodicals from which only one paper was cited made up 47.19% of all the citing periodicals, and 3.58% of the periodicals cited 24.28% of all the papers. The statistics in Table 6 show that substantial differences emerge in the different disciplines.

In terms of citing periodicals from Table 6, it shows that the four disciplines ranking at the top are basic medicine (348), biology (282), chemistry (230) and physics (229). However, total number of citations show that physics holds first place with 3953 citations; chemistry ranks second with 2560 citations, followed by basic medicine with 1134 citations and biology with 813 citations.

Impact factor and immediacy index

Impact factor and immediacy index are defined as parameters of more sophisticated mathematical models in evaluation for characterizing publication output. The former is a measure of the frequency with which the average cited article in a journal has been cited in a particular year, and the latter is a measure of how quickly the average cited article in a particular journal is cited (Garfield, 1975). Table 7 shows the impact factor and immediacy index of nine periodicals of China from the Journal Citation Reports.

Table 7 shows that the mean impact factor of *Acta Pharmacologica Sinica* was 0.352 from

1989 to 1992, which was much lower than the average (0.945) of the periodicals of the world. The immediacy index of *Communication in Theoretical Physics* was 0.117 in 1989–1992, which was lower than the average (0.159) of the periodicals of the world.

Top fields of study with Japan and India

During the past few years, research performance in China has increased appreciably, both in regard to relative output of publications and in their impact on the international research productivity. Ranking of countries by their percentage share in the world publication output, China's percentage change was 61.5% from 1980–1984 to 1985–1989 and 72.1% from 1985–1989 to 1989–1993, while Japan's was 12.3 and 4.9% and India's was −25.1 and −10.9%, respectively (Braun *et al.*, 1994b). Table 8 shows China's output and impact scores relative to the world share in 14 fields, along with two Asian giant countries—Japan and India (Braun *et al.*, 1995b). In mathematics, mechanical, civil and other engineering, analytical chemistry, life sciences and other physics over the past 5 years, the relative impact of China's papers was higher than those of India but lower than those of Japan. In the category of life sciences, the fields showing the greatest output of papers were general medicine, pharmacology and pharmacy. The former shared 1.00 in the world publication output and was 0.73 in the relative impact; the latter shared 0.85 in output and was 0.79 in impact.

CONCLUSIONS

From this study as well as other studies published in recent times (Mervis, 1995; Maddox & Swinbanks, 1995), it is believed that China has a much greater chance to forge ahead quickly. Not only has China recorded the fastest growth rate in scientific performance, but also made important and high-quality contributions in selected areas of science. In terms of paper output, China's annual paper output has been substantially increasing, especially the publications in foreign periodicals, and ranked 15th in the world in 1993 (Japan ranked 3rd and India ranked 11th). For the year 1993, 1899 periodicals out of the corresponding world total (3291) cited 12,869 references from papers with addresses of the institutions from China. The number of citations varied in the different disciplines. The mean citation rate from 1990 to 1992 was 0.45.

What are the chances that China will succeed? The country spent about $7.5 billion in 1993 on science and technology, one-third of which is classified as research and development (about 7% of those R&D funds are used for basic research, with 30% going to applied research and the rest classified as development), and had 640,000 full-time R&D personnel in 1993, including 418,000 scientists and engineers. Almost half work at state-run R&D institutions, with one-third at universities and the rest at companies (Mervis, 1995). For the future, Chinese science and technology faces two major challenges. The first is how to improve the country's scientific and technological infrastructure and the standard of research, especially for creative work and high-quality papers. The lack of investment in science and technology seriously impedes the development of Chinese science and technology. The second is how to eradicate the ingrained prejudice in the minds of some referees in the West about authors from Third World countries—many researchers in the developing world feel trapped in a vicious circle of neglect and, some say, prejudice by publishing barriers that, they claim, doom good science to oblivion (Wayt Gibbs, 1995).

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