Science in India – A profile based on India's publications as covered by *Science Citation Index* 1989–1992

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With a view to mapping scientific research in India, we have analysed papers originating in India and indexed in the CD-ROM version of Science Citation Index (SCI) in the four years 1989–1992. With more than 10,000 papers in each year (more than 42,000 papers in about 2,300 journals indexed in SCI in the four years), India is the twelfth largest publishing nation, down from eighth in 1980. Italy, the Netherlands, Australia and Spain have published more papers than India in journals indexed in SCI in 1992. Chemistry and physics account for the bulk of the papers, followed by engineering and clinical medicine. India's contribution to areas such as classical biology and agriculture is not properly reflected in SCI, as many journals in which Indian scientists publish are not covered by SCI. Although most Indian papers appear in low impact journals, the number of papers appearing in leading journals of the world, especially in the areas of physics, chemistry and materials science is increasing, even if only marginally. Also, the number of papers appearing in foreign journals as a whole, as well as the average impact factor of journals in which Indian scientists have published their work, is increasing, reflecting the increasing awareness among Indian scientists for the need to publish in high-impact journals. While the slide from the eighth to the twelfth position – from 2.8% of the world literature to about 2.0% – should be of concern, the increasing use of high impact journals is a welcome trend. In this macrolevel analysis we have looked at India as a whole and have not attempted to analyse the data at lesser levels of aggregation.

THIS study is based on the premise that the literature of science is a reasonably good mirror of a country's level of participation in the worldwide enterprise of scientific research and the belief that an inventory of research publications, besides reflecting the country's endogenous research capacity, can form the basis for science policy making.

India has a large S&T establishment, and a large population of science and engineering graduates who are active in research. The Department of Science and Technology (DST) of the Government of India has estimated that in 1992 there were more than 117,000 scientists and engineers engaged in research and development activity in India. Most of the more than 220 universities and institutes of higher learning have science and engineering faculties and many of these are active in research and contribute research papers to both Indian and foreign journals. Apart from universities, colleges and institutions of higher learning, there is also a whole range of government-funded laboratories under the Department of Atomic Energy, Department of Space, Council of Scientific and Industrial Research, Defence Research and Development Organization, Indian Council of Agricultural Research, Indian Council of Medical Research, etc. Besides, there are many R&D laboratories of private and public sector companies and other non-governmental organizations. Thanks to the incentives given by the Government of India under the scheme of recognition of such R&D laboratories (for tax concessions) operated by the Department of Scientific and Industrial Research (DSIR), there has been a considerable growth in the number of such laboratories. Lists of R&D laboratories and public and private sector industrial R&D units are available from Indian National Scientific Documentation Centre (INSDOC) and DST respectively[1,2]. A comprehensive list of Indian higher educational institutions is available from the Association of Indian Universities (AIU)[3]. AIU has also published handbooks of engineering, medical, agricultural and management edu-

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cation[4-7], each one of which lists relevant institutions.

India invested more than Rs 51,410 million (approx. $1,460 million) or about 0.83% of her GNP on R&D in science and technology in the fiscal year 1992–93. Indeed, the amount invested on scientific research has been increasing from year to year; however, as a per cent of GNP, of late, there has been a decline in investment on R&D. In 1989–90, the figure was 0.93%, and it came down to 0.85% in 1990–91 and 0.84% in 1991–1992 (ref. 8). As expected, bulk of the investment came from the Central Government. The industry's contribution is meagre, but is rising steadily. In 1992–93, private industry accounted for 15% of the total investment on scientific research, as against 11.4% invested by public sector industry[8].

No wonder that with so much being invested on research and so many centres performing research in a wide spectrum of fields ranging from andrology and astronomy to zoology and covering almost all subfields of science, engineering and technology, medicine, and agriculture, India accounts for a very large number of research papers.

It is our purpose to quantify the publication output of India. This is not an easy task as it may appear. In most developing countries authentic statistics of any kind is difficult to come by, and India, even if the situation here is considerably better than in most developing countries, is no exception. We will not be looking at prolific institutions, individuals and cities or states in this study. We will be looking at India as a whole.

Indian researchers publish their work in a wide range of journals, published from many countries. Not all of these journals are indexed in secondary services. Therefore, it will be virtually impossible to identify all the research papers published by Indian researchers. Even annual reports of reputed institutions do not always provide comprehensive lists of publications. For our mapping exercise, we decided to count only those papers which are covered in major international databases. Wherever possible, we downloaded data from CD-ROM databases. In this paper, we provide an analysis of papers from India that were indexed in the CD-ROM version of *Science Citation Index* (*SCI*) in the four years 1989–1992. Arunachalam and co-workers have carried out similar analyses of India's contribution to medicine[9,10], materials science[11], mathematics[12], physics[13], etc. as seen from appropriate international secondary services. Reports on India's contribution to biology and agriculture are under preparation. There have been a few studies looking at India's contribution to the scientific literature based on *SCI*[14–16], but none of them as comprehensive as this study.

SCI covers approximately 3,300 journals, covering a wide range of subjects. It is the only truly multidisciplinary science database in English. Journals for coverage are chosen largely based on their significance as seen from citations received by papers published in them. Other criteria used in selection of journals are peer judgement, timely publication, good editorial practice, etc.

Unlike most other databases, *SCI* provides the complete postal addresses of all the authors of papers it indexes. Through multiple access points, it is possible to access and retrieve effectively and efficiently the world's significant literature of science. Thanks to the excellent software used, the CD-ROM version has become even more attractive than the print version. No wonder then more scientometric studies are carried out using *SCI* than any other database. *SCI* is also available on magnetic tape and online and these cover a larger number of journals and articles than the CD-ROM version does.

Analysis

India's position, in terms of number of papers published as seen from the CD-ROM version of *SCI*, varied between eleventh and twelfth during the four-year period 1989–1992 (Table 1). To see India's share in the world literature of science and technology in perspective, we looked at the numbers of papers published by twenty other leading publishing countries. Throughout this period, the US retained the top position with the UK being a distant second. As is to be expected, the G-7 countries and the Soviet Union were the prolific publishing nations. India's rank was eighth in 1980. Surely, there has been a decline in the number of papers published by Indian researchers as seen from *SCI*. As pointed out by Tibor Braun and colleagues, India had 47,372 papers (2.1% of the world's papers) in *SCI* in the second half of the 1980s (1985–1989), as against 57,655 papers (2.8% of the world's papers) in the first half (1980–1984). In the early nineties, India's share has declined to about 2% as seen from Table 2. One reason for this decline is the fall in the number of Indian journals indexed in *SCI*. There were times when *SCI* indexed 40 Indian journals (in 1979), but now it indexes less than a dozen[16–18]. Several Indian journals have failed to retain their place in *SCI*, largely because they do not meet the criteria for inclusion in *SCI*.

In each one of the four years 1989–1992, India had published only about 2% of the world's output of papers, but has used nearly half the number of the more than 3,300 journals indexed in *SCI* (Table 2). *SCI* indexes different categories of papers. India's contributions are mostly in the form of articles, followed by notes. The proportion of articles has increased from 75.4% in 1989 to 80.5% in 1992, but there has been a fall in the proportion of notes (from 17.8% to 11.9%) and letters (4.2% to 3.7%). About 1% of India's papers are reviews.

Table 1. The relative position of India in terms of number of papers published as seen from *SCI* 1989–1992 (Numbers in parantheses denote rank)

Country	1989	1990	1991	1992	Total
USA	203,106 (1)	226,023 (1)	224,955 (1)	241,146 (1)	895,230
UK	53,169 (2)	54,855 (2)	54,536 (2)	59,420 (2)	221,980
Japan	40,914 (3)	44,048 (3)	44,521 (3)	50,066 (3)	179,549
Germany	33,879 (5)	34,960 (4)	40,378 (4)	44,512 (4)	153,729
Soviet Union	34,223 (4)	34,081 (5)	32,838 (5)	34,842 (5)	135,984
France	28,732 (6)	29,293 (6)	30,102 (6)	34,158 (6)	122,285
Canada	24,892 (7)	26,776 (7)	27,181 (7)	29,213 (7)	108,062
Italy	15,865 (8)	16,777 (8)	17,803 (8)	20,312 (8)	70,757
The Netherlands	11,986 (10)	12,829 (9)	12,699 (9)	14,004 (9)	51,518
Australia	12,039 (9)	12,298 (10)	12,592 (10)	13,547 (10)	50,476
India	10,426 (11)	10,103 (12)	10,468 (11)	11,160 (12)	42,157
Sweden	9965 (12)	10,152 (11)	10,125 (12)	10,766 (13)	41,008
Spain	7638 (13)	8560 (13)	9369 (13)	12,122 (11)	37,689
Switzerland	7596 (14)	8337 (14)	8624 (14)	9777 (14)	34,334
P R China	5491 (16)	6509 (15)	6630 (15)	7630 (15)	26,260
Israel	6262 (15)	6211 (16)	6206 (16)	6755 (16)	25,434
Belgium	5207 (17)	5517 (17)	5643 (17)	6259 (17)	22,626
Denmark	4930 (19)	5055 (18)	5102 (18)	5796 (18)	20,883
Poland	5149 (18)	5002 (19)	4972 (19)	5400 (19)	20,523
Czeckhoslovakia	3322 (20)	3424 (20)	3328 (20)	3852 (20)	13,926
Hungary	2385 (21)	2349 (21)	2504 (21)	2671 (21)	9909

Contribution to different fields

SCI categorizes the journals it covers into many subfields and these have been clubbed into eight major subjects by Francis Narin of CHI Research Inc. Indian researchers had used 2,316 journals to publish more than 42,000 papers in the four years 1989–1992 (Table 3). Nearly one-fourth of India's papers are in the field of chemistry, about 18% in physics and 13% each in engineering and clinical medicine. Biology (including agriculture) accounts for just about 12%. Because of Institute for Scientific Information's (ISI) selection policy, which aims at covering only the significant journals and not a comprehensive coverage of journals, a very large number of Indian biology and agriculture journals are not indexed in *SCI*. *BIOSIS* covers more than 100 Indian journals and *CAB Abstracts* about 280. Unlike in physics and chemistry, where Indian researchers used a relatively smaller number of journals, in medicine they have used a larger number of journals. The average number of papers published (per journal used) is four times larger in physics and chemistry than in medicine. This could, at least in part, be explained by the fact that there are too many specialities in medicine, each having its own set of journals. The number of papers published and number of journals used in each one of the subfields of the eight subject categories are provided in a report submitted to the DST, New Delhi. The number of papers in all these subfields add up to far more than the actual number of papers published by Indian researchers. This is because some journals are included in more than one subfield. For example, *Acta Tropica* published from Switzerland is classified under biology, parasitology and tropical medicine; *Alcohol*, a UK journal, is classified under pharmacology, substance abuse and toxicology; and *International Journal of Hydrogen Energy* (UK) is classified under energy, environmental science and atomic physics.

In Table 4, we list the 20 journals in which Indian researchers have published most often and give both the number of papers published in each of the four years and the rank. Also given are the impact factors of journals as seen from *Journal Citation Reports* 1992 and the journal country. The first four journals are from India, and there are five Indian journals in the top ten. Among the foreign journals, *Journal of Materials Science Letters* and *Physical Review B* are the ones most often used, followed by *Astrophysics and Space Science*, *Physical Reveiw A* and *Journal of Applied Polymer Science*. Indeed, in a way, this set of journals reflects areas of strength of Indian science. Materials science, astronomy and astrophysics and polymer science are among the fields perceived to be strong in India by a team of American experts[19]. Apart from *Indian Journal of Medical Research Sections A and B*, the list of most often used 61 journals (each one of which has carried 100 or more papers from India in the four-year period) contains only three medical journals, viz. *International Journal of Cardiology*, *Lancet* and *International Journal of Leprosy*. Also conspicuous is the absence of mainstream engineering journals. Apart from materials science journals, there are only two journals that can be considered engineering journals – *Microelectronics and Reliability* and *Fuzzy Sets and Systems*. While there are many chemistry journals in this list, there is hardly any devoted to chemical engineering. Again, there are many physics journals but none devoted to mainstream electrical engineering or mechanical engineering where Indian

scientists have published at least 100 papers in four years. Perhaps, Indian medical and engineering researchers publish their work in many journals, contributing fewer articles (than the threshold we have chosen) in each of them. Or probably, unlike their Chinese counterparts, Indian researchers, with a few exceptions, while being comfortable with routine problems in basic science, fight shy of working in areas which lie in the interface of basic research and development. This is also reflected in the rather low number of patents, especially commercially exploitable patents, filed by Indian researchers. Leaders of science like R. A. Mashelkar, Secretary to the Government of India in the DSIR, are now taking steps to bring in a culture of patenting.

Use of high-impact journals

To have an idea of what proportion of Indian papers in different fields appears in journals of different impact factor ranges, we analysed all Indian papers covered in just one year of *SCI* , viz. 1992. This is essential as the impact factor depends on several factors and varies from field to field. The results are presented in Table 5. The impact factors of journals are increased in steps of 0.5, and under each subject category both the number of journals falling under the given impact factor range and the number of papers published in these journals are listed. Journals classified under more than one field are included in more than one field. Overall, a little over 60% of Indian papers indexed in *SCI* 1992 have appeared in journals whose impact factor is less than 1.0 and about 6% of papers in journals of impact factor greater than 3.0.

Some significant facts revealed by this table are: 267 papers in physics (10.9%), 85 papers in chemistry (3.1%), and 147 papers in clinical medicine (8.6%), 46 papers in biology (3.2%), and 150 papers in biomedical research (12.8%) were published in journals whose impact factors are greater than 3.0. In the area of engineering and technology, 46 papers (2.3%) were published in six journals with an impact factor higher than 2.0. In all, 187 papers had appeared in journals with impact factor greater than 5.0. Most of these papers in high impact journals have come from clinical medicine (67 papers), biomedical research (42), and physics (39).

It is significant that although the overall performance in medical research in India is perceived to be poor[20,21], it is clinical medicine and biomedical research which account for the bulk of the papers in high impact journals. In the four years studied, Indian researchers have published just ten papers in journals of impact factors higher than 10.00 in the areas of physics and chemistry: seven in *Chemical Reviews*, and one each in *Advances in Chemical Physics*, *Reviews of Modern Physics* and *Surface Science Reports*. In contrast, India has

Table 2. Total number of papers from India and the world indexed in *SCI* 1989–92

		1989	1990	1991	1992
Papers	World*	559,399	590,841	590,306	639,198
	India*	10,426	10,103	10,468	11,160
	Rank	11	12	11	12
Journals used	World	3,170	3,192	3,213	3,241
	India	1,531	1,525	1,579	1,612

*These numbers are taken from the printed version of the *SCI* guide.
*These numbers are obtained from the CD-ROM version of *SCI*, which covers considerably lesser number of journals and papers than the magnetic tape/online edition of *SCI*.

Table 3. Distribution of Indian papers by major subjects as seen from *SCI* 1989–92

	Journals		Papers	
Subject[a]	No.[b]	%	No.	%
Chemistry (8)	243	10.5	10,181	24.2
Physics (12)	161	6.9	7525	17.9
Engineering & technology (21)	321	13.9	5646	13.4
Clinical medicine (34)	582	25.1	5533	13.1
Biology (21)	393	17.0	5118	12.1
Biomedical research (13)	353	15.2	3979	9.4
Earth & space (9)	122	5.3	1713	4.1
Mathematics (5)	102	4.4	551	1.3
Others (5)	39	1.7	1911	4.5
Total	2316	100.0	42,157	100.0

[a]The numbers given in parantheses are the number of subfields under which the subject is classified in *SCI* guide. For example, Chemistry is classified under 8 subfields.
[b]Number of unique journal titles which published an article from India in at least one of the four years 1989–1992. Also, if the same title is classified by *SCI* under more than one major subject category, it is included under only one category, viz. the one which appears first alphabetically.
Journals with changed titles are counted as two different journals, e.g. *Journal of Physics C – Solid State Physics* is now known as *Journal of Physics – Condensed Matter*.

Table 4. Number of papers published by Indian researchers in journals most often used by them*

Journal	IF92	Journal country	1989	1990	1991	1992	1989–92 Total
Current Science	0.253	IND	572	334	277	309	1492
Indian Journal of Chemistry Section B – Organic Chemistry including *Medicinal Chemistry*	0.275	IND	355	268	270	219	1112
Indian Journal of Chemistry Section A – Inorganic Bio-Inorganic Physical Theoretical & Analytical Chemistry	0.357	IND	328	309	238	219	1094
Pramana–Journal of Physics	0.390	IND	131	109	100	102	442
Journal of Materials Science Letters	0.511	UKD	98	87	80	109	374
Physical Review B – Condensed Matter	3.259	USA	81	76	93	109	359
Astrophysics and Space Science	0.325	NLD	84	84	113	60	341
Indian Journal of Medical Research Section A – Infectious Diseases	0.227	IND	79	96	65	80	320
Physical Review A	2.157	USA	62	72	85	99	318
Journal of Applied Polymer Science	0.969	USA	56	86	79	88	309
Phytochemistry	1.133	UKD	91	71	70	72	304
Biochemistry International	0.697	AUS	66	73	86	71	296
Solid State Communications	1.369	USA	62	70	82	82	296
Journal of Materials Science	0.798	UKD	55	68	71	77	271
Tetrahedron Letters	2.321	UKD	57	70	67	72	266
Synthetic Communications	0.716	USA	77	76	56	47	256
Proceedings of the Indian Academy of Sciences – Chemical Sciences	0.387	IND	57	83	51	62	253
Journal of Applied Physics	1.532	USA	53	63	67	59	242
Physica Status Solidi B – Basic Research	0.568	DEU	64	48	64	57	233
Indian Journal of Medical Research Section B – Biomedical Research other than *Infectious Diseases*	0.172	IND	0	73	90	68	231

*Indian researchers have published 100 or more articles in 61 journals in the four years considered.

contributed 146 papers to clinical medicine journals of impact factor greater than 10.00, including 122 in *Lancet* (UK), and nine each in *New England Journal of Medicine* and *Clinical Research* (USA). However, one should not be misled by numbers. The ten papers in the physical sciences are all substantial reviews, whereas the bulk of the papers in the clinical medicine journals are letters to the editor. Also, clinical medicine and biomedical research have many journals with high impact factors, whereas such journals are very few indeed in physics and chemistry.

Classification of journals countrywise

It is interesting that *Lancet*, the high impact medical journal from Britain, has published 30 papers from India in 1992, and its US counterpart, the *New England Journal of Medicine*, has not published a single paper from India as seen from *SCI* 1992. The British–American divide, as far as Indian scientists are concerned, is not restricted to medical journals alone. It seems to extend to the two most well-known multidisciplinary journals, viz. *Nature* and *Science*. In the four years, there were 68 papers from India in *Nature* (of which 28 are articles and 37 are letters to the editor), and only five in *Science*! There could be many reasons for this phenomenon, such as page charges levied by American journals, editors' attitude and India's long-term links with the UK[9,10].

Indian researchers use American and British journals to a very large extent. In the four years 1989–1992, nearly 28% of India's papers had appeared in 854 US journals and 25% in 549 British journals. They had also used 248 journals published in the Netherlands to publish 5868 papers. Twelve Indian journals were used to publish 5,504 papers. In all they have used journals from 38 countries.

Classification of journals by countries of origin is not all that straightforward. While *Indian Journal of Chemistry* and *Current Science* are 100% Indian journals, journals published by many commercial publishers in the West cannot be said, with the same level of certainty, to belong to a single country. For instance, *Nature*, probably the most visible scientific journal, published by Macmillan Magazines Ltd, has its main office in London. That is where its editor functions from. But *Nature* has also editorial offices in Washington DC, Munich, Paris and Tokyo which are far more than mere outposts. They also receive manuscripts and carry out

editorial functions. The Elsevier Group, one of the largest publishers of scientific and technical journals, brings out journals under different imprints and from different countries. They have publishing operations in Amsterdam, Lausanne, New York, Oxford and Paris. Most journals published by such companies have university professors and other laboratory scientists drawn from different countries as editors. For instance, *Journal of Electroanalytical Chemistry and Interfacial Electrochemistry* is currently edited by Roger Parsons of the University of Southampton, with T. J. VanderNoot of the University of London as the Assistant Editor and W. R. Fawcett of the University of California at Davis as the North American Editor. In this paper we have assigned countries to journals from the *SCI* Guide.

C. N. R. Rao, one of India's visible scientists, suggests that it is becoming increasingly difficult for Indian scientists to get their papers published in important journals of the world, especially in the experimental sciences. However, our data indicate that there has not been any noticeable decline, during the four years studied, in the number of papers published by Indian researchers in important foreign journals, such as *Astrophysical Journal*, *Physical Review C*, *Physical Review Letters*, *Journal of Chemical Physics*, *Journal of Materials Science*, *Journal of Physical Chemistry*, *Journal of Organic Chemistry* and *Tetrahedron Letters*. Of the 61 journals in which Indian scientists have published 100 or more papers in the four years, eleven have an impact factor of greater than 2.0: *Physical Review B* (3.259; 359 papers), *Physical Review A* (2.157; 318), *Tetrahedron Letters* (2.321; 266), *Chemical Physics Letters* (2.686; 175); *Physical Review D* (2.587, 171), *Physics Letters B* (3.438; 171), *Physica C* (2.044; 166), *Journal of the Chemical Society–Chemical Communications* (2.511; 153), *Lancet* (15.940; 122), *Journal of Physics A* (2.189, 112), and *Journal of Physics B* (2.268, 102). In all these journals, Indian papers have appeared above a threshold level throughout the four-year period studied (Figure 1). Indeed, in the four years studied, there has been a considerable increase in the number of papers published by Indian scientists in foreign journals as a whole, which rose from 8,751 in 1989 to 9,958 in 1992, and in many high-impact journals, especially in the areas of physics and chemistry. In contrast, there was a 27% decline in the number of papers published in the 12 Indian journals indexed in *SCI* – from 1,675 in 1989 to 1,202 in 1992.

In Table 6, we provide some citation based indicators. The ISI, publisher of *SCI*, provides for each journal it indexes in *SCI* an impact factor which is a measure of how often articles published in a journal are cited, on average, in subsequent literature. Not all articles published in a journal will be cited the same number of times. Some will be cited more often than the others. Also, the larger the number of articles a journal published the greater the possibility of the journal being cited. To neutralize this advantage accruing to journals publishing a large number of articles, the impact factor is calculated on a per article basis. ISI calculates impact factors of journals every year, and the values vary from year to year. In this paper, we have used the impact factor values given in *Journal Citation Reports 1992*. In general, the higher the impact factor of a journal, the greater will be the difficulty of publishing a paper in that journal. For example, Indian researchers had not published a single paper in *Cell* (impact factor 33.617) or *Annual Review of Biochemistry* (35.500) in the four

Table 5. Number of journals used and number of papers published as indexed in *SCI*-1992 categorized under subjects and impact factors of journals

Impact factor range	Chemistry		Physics		Eng. & Tech.		Clin. Med.		Biology		Bio Med.		Earth & Spac		Maths		Others		Total papers	Papers %
	Jrl	Pap	Jrl	Pap	Jrl	Pap	Jrl	Pap	Jrl	Pap	Jrl	Pap	Jrl	Pap	Jrl	Pap	Jrl	Pap		
0.00	3	93	6	34	5	10	13	23	7	12	7	23	3	15	1	1	2	2	199	1.78
≥ 0.0 < 0.5	42	881	31	496	129	688	82	460	89	385	33	186	26	201	40	128	11	381	3431	30.74
≥ 0.5 < 1.0	56	663	41	506	100	944	110	440	116	628	70	334	28	113	22	89	4	15	3129	28.03
≥ 1.0 < 1.5	49	473	42	485	28	256	89	348	47	270	49	214	25	100	3	10	3	11	1801	16.14
≥ 1.5 < 2.0	27	293	23	283	17	78	53	156	19	69	38	141	13	59	1	2	2	5	966	8.66
≥ 2.0 < 2.5	10	122	12	245	4	35	31	81	11	24	25	91	3	7	0	0	1	1	533	4.78
≥ 2.5 < 3.0	9	115	9	137	1	8	18	54	4	8	10	33	4	47	0	0	0	0	394	3.53
≥ 3.0 < 3.5	2	62	7	207	0	0	8	24	4	26	8	30	2	8	0	0	0	0	355	3.18
≥ 3.5 < 4.0	3	5	1	21	1	1	7	20	1	2	6	71	1	1	0	0	0	0	118	1.06
≥ 4.0 < 4.5	1	4	0	0	0	0	11	33	2	3	4	5	0	0	0	0	0	0	42	
≥ 4.5 < 5.0	0	0	0	0	0	0	3	3	0	0	2	2	0	0	0	0	0	0	5	
≥ 5.0 < 7.5	3	14	4	37	1	2	9	26	0	0	6	32	0	0	0	0	0	0	109	2.1
≥ 7.5 < 10	0	0	1	1	0	0	2	7	0	0	2	7	0	0	0	0	0	0	9	
≥ 10.0	0	0	1	1	0	0	3	34	2	15	3	3	0	0	0	0	2	17	69	
																			11160	100.0
Total	205	2725	178	2453	286	2040	439	1709	302	1442	263	1172	105	551	67	230	25	432	1870	12754
% →	11.0	21.4	9.5	19.2	15.3	16.0	23.5	13.4	16.1	11.3	14.1	9.2	5.6	4.3	3.6	1.8	1.3	3.4		

years 1989–1992 as seen from *SCI*. There was only one paper each from India during 1989–1992 in *Advances in Chemical Physics* (10.529) and *Microbiological Reviews* (16.121), and two papers in *Trends in Biochemical Sciences* (15.788). The average impact factor, calculated taking the impact factor of journals in which at least one of India's papers had appeared, is given in rows 3–5 for all papers, papers in Indian journals, and papers in foreign journals respectively. Between 1989 and 1992, as seen from rows 3 and 5, there has been a perceptible increase in the impact index (calculated on the basis of impact factors of journals in which Indian researchers have published their papers) of papers published in all journals and in non-Indian journals.

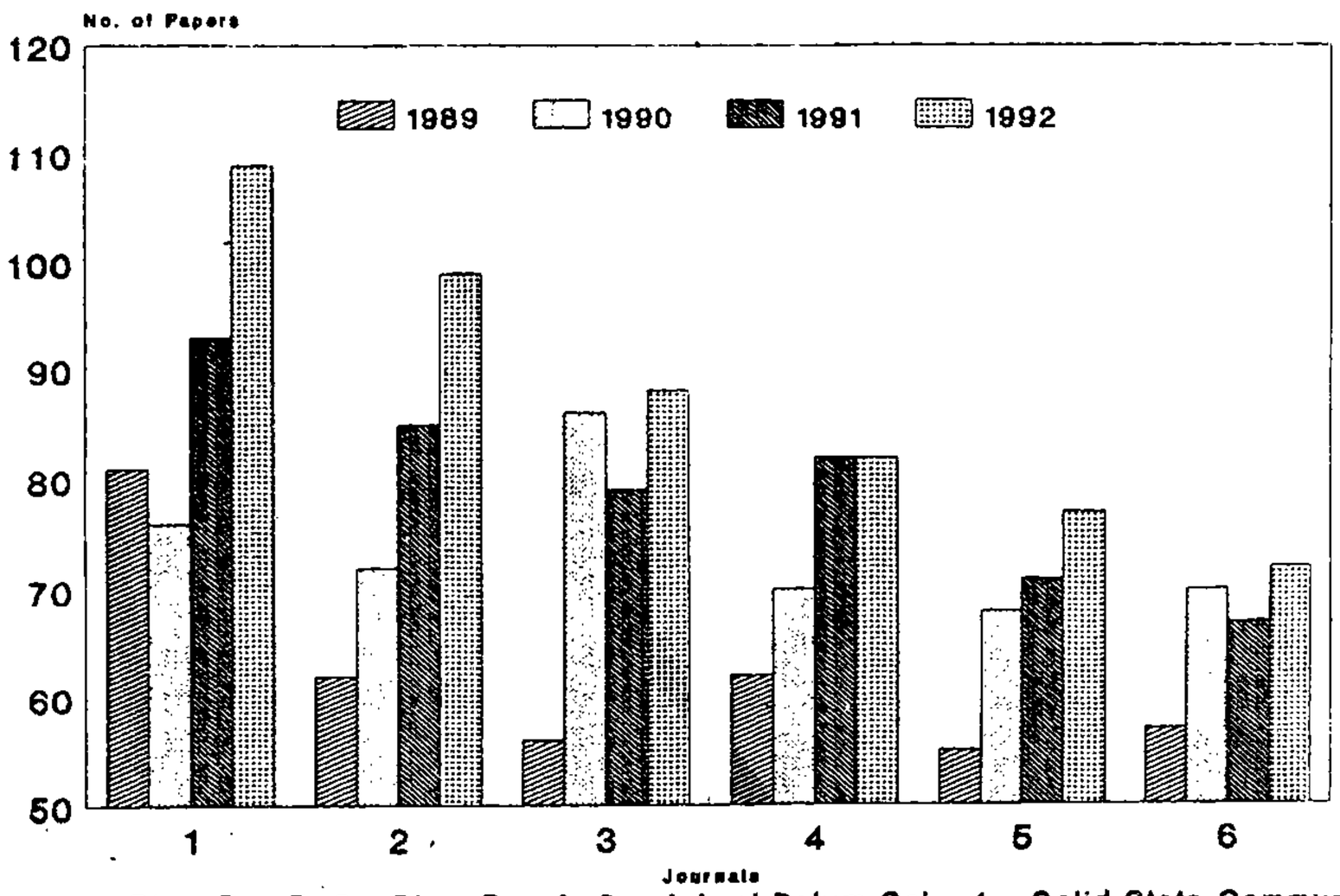

Figure 1. Six selected journals with at least 50 Indian papers in each of the four years (Source: *SCI* 1989–1992).

Table 6. Some impact indicators for Indian papers indexed in *SCI* 1989–1992

		Years			
		1989	1990	1991	1992
1	Total papers	10,426	10,103	10,468	11,160
2	Total journal titles	1531	1525	1579	1612
3	Average impact factor/paper	1.072	1.103	1.191	1.200
4	Average impact factor/paper (Indian journals)	0.251 (1675)	0.248 (1413)	0.249 (1214)	0.287 (1202)
5	Average impact factor/paper (non-Indian journals)	1.229 (8751)	1.242 (8690)	1.315 (9254)	1.311 (9958)
6	Average impact factor*/paper	1.101	1.134	1.213	1.221
7	Average impact factor/Jrl	1.181	1.201	1.260	1.262
8	Average impact factor*/Jrl	1.216	1.235	1.297	1.295
9	Papers with IF = 0	277	275	189	199
10	Journals with IF = 0	43	42	46	41

3 Average impact factor/paper includes journals with impact factor = 0 journal impact factor = 0 may be
  i. as seen from *SCI*
  ii. new journal (not yet calculated)
  iii. change of journal name and no impact factor assigned.
4 Restricted to Indian journals, based on criteria in (3).
5 Restricted to non-Indian journals, based on criteria in (3).
6 Average impact factor/paper excludes journals with impact factor = 0.
7 Irrespective of the number of papers published in a journal, it is counted only once.
8 Same as 7 but not taking into account the journals with impact factor = 0.

Table 7. Indian journals included in *SCI* 1989–1992 along with the number of papers from Indian addresses

Journal	Number of papers (1989–1992)	World papers	%
Current Science	1492	1719	87.0
Indian Journal of Chemistry Section B – Organic Chemistry including *Medicinal Chemistry*	1112	1241	90.0
Indian Journal of Chemistry Section A – Inorganic, Physical, Theoretical & Analytical	1094	1213	90.0
Pramana – Journal of Physics	442	496	89.1
Indian Journal of Medical Research Section A – Infectious Diseases	320	331	97.0
Proceedings of the Indian Academy of Sciences – Chemical Sciences	253	338	75.0
Indian Journal of Medical Research Section B – Biomedical Research other than *Infectious Diseases*	231	241	96.0
Journal of Scientific & Industrial Research	184	381	48.2
Journal of Biosciences	142	160	89.0
Proceedings of the Indian Academy of Sciences – Earth and Planetary Sciences	112	141	79.4
Journal of Astrophysics and Astronomy	75	112	67.0
Journal of Genetics	33	59	56.0
Indian Journal of Medical Research[a]	14	16	87.5
Total	5504	6280	88.0

[a] *Indian Journal of Medical Research* was split into two parts in 1989. In 1989, ISI did not cover *Indian Journal of Medical Research Section B* in *SCI*, and probably covered 14 articles published in the last issue(s) of the undivided journal published in 1988.

Indian journals used

A list of Indian journals covered by *SCI* during 1989–1992 is provided in Table 7. The number of papers published by these journals and the number contributed by Indian authors, as seen from *SCI* are also given. In the 12 Indian journals covered by *SCI*, an average of 88% of papers were from Indian laboratories. About 33% of papers in *Journal of Astrophysics and Astronomy*, an original research journal published by the Indian Academy of Sciences, were from authors residing outside India. *Journal of Genetics*, published by the same Academy, also carries a large number of papers from outside India. The review journal *Journal of Scientific and Industrial Research*, published by the Council of Scientific and Industrial Research, also had published a large number of papers from outside India (greater than 50%!).

The complete list of journals used by Indian scientists to publish their work, along with the number of papers published in each one of the four years, country of publication and subject category as well as their impact factors as seen from *JCR* 1992 is given in the report submitted to DST, New Delhi.

Conclusion

This is a macroscopic view of science in India as reflected by the literature covered by *SCI*. We took the whole country as a single aggregate and we looked at all of science, engineering and medicine paying only limited attention to individual fields and subfields. Such a study has its own value. It gives an overall perception of scientific research in India. However, it will have to be supplemented by studies carried out at lesser levels of aggregation – at the levels of institutions and major fields and subfields.

To sum up, with about 2 per cent of the world's significant journal literature, India occupies the twelfth position among nations of the world in number of scientific papers published. There has been a slide from the eighth position held some years ago. Could this drop be exclusively attributed to the decrease in the number of Indian journals covered by *SCI* in recent years? The data we have indicate that even if *SCI* were to have covered the same number of Indian journals as before, India's rank would still be twelfth. While we observe a trend of marginal decrease in India's per cent share of world's journal articles, the number of foreign journals used has been increasing steadily. This is probably because of the greater awareness among Indian researchers of the better rewards and higher visibility brought to them by these journals and the greater weightage given by funding agencies and science administrators to publications in high-impact journals. This is also reflected in the increase in the average

impact factor of journals used in later years. Notes and review articles constitute a very small fraction of Indian publications. This is a reflection of Indian researchers' inability to seek quick publication of novel results and to consolidate knowledge in emerging areas.

Chemistry and physics appear to be areas of high activity, and medicine and biology neglected areas. Indeed a higher percentage of physics papers appear in high-impact journals than papers in other fields. One also sees a large number of medical papers in well-known journals like *Lancet*, but these are found to be mostly letters to the editor. Medicine is not an area of prolific research in India for several reasons, the most obvious being low level of funding. But, there are a large number of biology departments and students in India. Indeed, the number of Ph Ds awarded in different branches of biology, is comparable to that awarded in chemistry and physics. But most classical biologists of India – botanists, zoologists, etc. – publish their work in Indian or foreign journals not indexed in *SCI*. According to the classification followed here, borrowed from Francis Narin of CHI Research Inc., biology includes agriculture also. And India has a very large population of agricultural researchers and their work is not fully reflected in *SCI*, because they usually and for good reasons publish in Indian journals not indexed in *SCI*. In any case, *SCI*'s coverage of agricultural literature is far from satisfactory.

Overall, only a small proportion of papers have been published in high-impact journals. This is often pointed out by leaders of Indian science such as C. N. R. Rao. However, India has been consistently publishing above a threshold number of papers in some of the leading journals, especially in the areas of physics, chemistry and materials science.

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