WHERE INDIAN SCIENTISTS PUBLISH

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AN analysis of the publication practices of Indian scientists can yield useful indicators of trends in several important areas: scientific productivity, the productivity of particular institutions, the influence of Indian research results abroad, the accessibility of these results in India, and the strength of the national literature.

A number of bibliometric analyses have already been applied to science publications generated in India. For example, Chakraborty[1] studied the extent to which articles characterized as 'Indian geology' are scattered over Indian and non-Indian periodicals. He found that 870 of 918 items (*i.e.*, 95 %) were published in Indian periodicals and only 48 (5 %) in non-Indian. 'Indian geology,' in this case, refers almost exclusively to 'papers on geology written by Indian authors'. Somewhat similar analyses have been applied to other subject fields (*e.g.* Rajagopalan *et al*[2] and Peter and Rajagopalan[3] in mathematics). Studies of wider scope have been reported by Arunachalam[4] and Arunachalam and Markanday[5] but, as far as we are aware, no analysis of where Indians publish, and on what subjects, has previously been undertaken for the whole field of science. The present study is an attempt at a more comprehensive analysis.

The *Science Citation Index* now classifies citing articles by country of the institutional affiliations of authors. This was the source used in the present study. In the period from 1979 to June 1981, some 38,000 publications were recorded in the *Science Citation Index* under India as producing country. From these, a systematic random sample of 3378 was drawn (*i.e.* every 11th citation listed, after a random start). For the subject analysis, a subset of 480 was drawn from the 3378 by the same type of procedure. These 3378 publications were categorized by institution, by journal, by country of publication and by subject. A breakdown by language was not appropriate since the language of Indian science is almost exclusively English.

Table 1 presents the breakdown by institution, with any institution producing less than four papers for the period studied classified under the 'other' category, whether it is a university, government agency or private foundation. In India, institutions of higher education seem to contribute more than half of the papers published and private foundations make a very minor contribution to the research literature. Table 2 shows the most productive institutions of higher

Table 1 *Productivity by Type of Institution*

Institution	Papers #	Papers %
Institutions of Higher Education	2284	67.6
Government Agency	762	22.6
Private Foundations	38	1.1
*Others	294	8.7
Total	3378	100

*This includes all institutions producing less than 4 papers.

Table 2 *Institutions of Higher Education**

Institution	Publications #	Publications %**
1. Indian Institute of Science	146	6.4
2. Banaras Hindu University	106	4.6
3. Delhi University	98	4.3
4. Madras University	89	3.9
5. Calcutta University	84	3.7
6. IIT/Delhi	65	2.8
7. Osmania University	64	2.8
8. Allahabad University	58	2.5
9. Aligarh Muslim University	56	2.5
10. IIT/Kanpur	54	2.4
11. Panjab Agricultural University	52	2.3
12. Panjab University	48	2.1
13. Roorkee University	48	2.1
14. Postgraduate Institute of Medical Education and Research***	48	2.1
15. IIT/Madras	46	2.0
16. Lucknow University	41	1.8
17. IIT/Bombay	37	1.6
18. Sri Venkateswara University	37	1.6
19. Utkal University	37	1.6
20. Meerut University	35	1.5
21. Andhra University	35	1.5
22. Agra University	33	1.4
23. Gorakhpur University	31	1.4
24. Harayana Agricultural University	31	1.4
25. Guru Nanak Dev University	30	1.3

* Affiliated colleges were included with their parent institutions.
** % of the total of 2284 publications contributed by institutions of higher education. Institutions accounting for less than 1.3 % of total are omitted.
*** This institute could equally well appear in Table 3.

education and the number of papers each produces. The results reveal that the research is widely scattered over many Indian institutions, with no heavy concentration in a single one. This is quite unlike the situation in, say, Brazil[6], where a single institution contributes about 27% of the science literature. Table 3 gives a similar analysis for government sources.

Table 4 shows that the sample drawn is—quite as expected—predominantly journal articles. Table 5 presents a breakdown by country of publication. Almost half of Indian papers are published in national journals. This proportion agrees closely with data quoted by Arunachalam and Markanday[5]. However, the proportion published in Indian journals may be greater than indicated since the *Science Citation Index* coverage of non-Indian journals can be expected to be more complete than its coverage of the Indian journals. Unlike the situation for some other developing countries, such as Brazil[6], the results of much of Indian research are readily accessible to Indian investigators in domestic journals. Outside of India itself, the United States and the United Kingdom publish most Indian research papers. The gap between India and the other contributing countries is very great. Almost half of 3345 papers examined appear in 35 journals published in India and only 634 papers appear in 139 journals published in the United States.

Tables 6 and 7 show the most productive Indian and foreign journals respectively. When arranged by productivity the top thirteen journals are all produced in India. These thirteen journals could be considered as constituting the core of Indian science research for a library concerned with building a collection on the subject. They correspond closely to the 'highest impact' Indian journals (most cited in relation to amount published) as reported by Arunachalam and Markanday[5].

Table 8 shows how the 3345 papers are scattered over 1069 different journals. The table represents the data in the form of a ranked list by declining frequency of contributions. The most productive journal yielded 162 papers from India during 1979 to June 1981, the second most productive journal yielded 159 papers, and so forth. At the bottom of the table one may notice

Table 3 *Government Agencies**

Agency	Publications #	Publications %**
1. Council of Scientific and Industrial Research	201	26.4
2. Department of Atomic Energy	164	21.5
3. Indian Council of Agricultural Research	116	15.2
4. Indian Council of Medical Research	91	11.9
5. Indian Association for the Cultivation of Science	34	4.5
6. Ministry of Defence	27	3.5
7. Physical Research Laboratory	20	2.6
8. Indian Statistical Institute	18	2.4
9. Indian Institute of Astrophysics	10	1.3
10. Oil and Natural Gas Commission	10	1.3
11. Geological Survey of India	8	1.0
12. Other	63	8.3

* Affiliated institutes are grouped with parent agency wherever several units have contributed substantially to the output of the agency (*e.g.* the National Physical Laboratory is subordinate to CSIR). Where a single unit was predominant, however, it is listed in its own right (*e.g.* Geological Survey of India rather than Department of Mines). The authority used was the Department of Science and Technology's *Research & Development Statistics*.

** % of the 762 publications contributed by government agencies.

Table 4 *Breakdown by Type of Publication*

Journal articles	3345	99.0%
Books	33	1.0%
Total	3378	100.0%

Table 5 *Breakdown of Journal Articles by Country of Publication* (N = 3345)

Country	Journals #	Journals %	Papers #	Papers %
1. India	35	3	1406	42
2. U.S.A.	139	13	634	19
3. United Kingdom	193	18	500	15
4. Netherlands	82	8	106	3
5. Germany	74	7	98	3
6. Canada	74	7	83	2
7. Hungary	58	5	62	2
8. Switzerland	54	5	62	2
9. Denmark	56	5	58	2
10. Poland	51	5	55	2
11. Japan	50	5	51	2
12. Belgium	41	4	44	1
13. Austria	36	3	38	1
14. Czechoslovakia	31	3	34	1
15. Italy	24	2	26	.7
16. France	20	2	22	.6
17. Yugoslavia	17	2	20	.5
18. Ireland	16	1	17	.5
19. Finland	12	1	13	.3
20. China	6	1	6	.1
Total	1069	100%	3345	99.7%

Table 6 *The Most Productive Indian Journals*

Journal	Number of papers
1. Current Science	162
2. *Indian Journal of Experimental Biology*	159
3. Indian Journal of Medical Research	123
4. Journal of Indian Chemical Society	119
5. Indian Journal of Biochemistry and Biophysics	109
6. Indian Journal of Chemistry – Section A	103
7. Indian Journal of Chemistry – Section B	103
8. *Indian Journal of Animal Sciences*	71
9. Indian Journal of Pure and Applied Physics	62
10. National Academy of Sciences – Letters	36
11. Indian Veterinary Journal	33
12. Pramana	28
13. Indian Journal of Pure and Applied Mathematics	27
14. Acta Botanica Indica	23
15. Cheiron	20

Table 7 *The Most Productive Non-Indian Journals*

Journal	Number of papers
1. Experientia	26
2. Physica Status Solidi A	20
3. Physics Letters A	18
4. *Journal of Inorganic and Nuclear* Chemistry	16
5. Acta Physica Polonica	15
6. Acta Physica Academiae Scientiarum	15
7. Journal of Applied Physics	15
8. *Phytochemistry*	14
9. Thermochimica Acta	14
10. Hydrobiologia	13
11. Journal of Materials Science	13
12. Tetrahedron Letters	13
13. Physics Letters B	12
14. Physica Status Solidi B	12
15. Journal of Polymer Science	12
16. Chemical Physics Letters	12

that 101 journals published only 2 papers each during the period studied and a single paper only was contributed by each of 793 journals. The literature is widely scattered and, in fact, the scatter approximates the geometric dispersion phenomenon first observed by Bradford[7]. According to 'Bradford's Law,' when the ranked list of contributing journals is divided into zones, such that each zone contains approximately the same number of articles, the relationship between the number of journals in each zone is a roughly geometric series.

Table 8 *Distribution of 3345 Articles over 1069 Journal Titles*

A Number of Journals	B Number of Papers	A × B
1	162	162
1	159	159
1	123	123
1	119	119
1	109	109
2	103	206
1	71	71
1	62	62
1	36	36
1	33	33
1	28	28
1	27	27
1	26	26
1	23	23
2	20	40
2	18	36
5	17	85
1	16	16
4	15	60
2	14	28
6	13	78
6	12	72
5	11	55
8	10	80
6	9	54
12	8	96
9	7	63
18	6	108
18	5	90
37	4	148
19	3	57
101	2	202
793	1	793
1069		3345

In a perfect Bradford series, 900 articles might be distributed over 285 journals as follows:

	Papers	*Journals*
Zone 1 (the nucleus)	300	5
Zone 2	300	35
Zone 3	300	245

This is a perfect geometric series, namely $5:5 \times 7:5 \times 7^2$, with a 'multiplier' between zones of exactly 7. A Bradford-type distribution applies to the data of table 8. If arranged into the "zones" described by Bradford, the data look like:

Zone 1	1108 papers in 12 journals
Zone 2	1037 papers in 107 journals
Zone 3	1200 papers in 950 journals

In this case, the multiplier between Zone 1 and Zone 2 is 8.9; and between Zone 2 and Zone 3 is 8.8 (*i.e.* the series is $12:(12 \times 8.9):(12 \times 8.8^2)$). Because Zone 3 contains almost 20% more papers than Zone 2, the Indian literature is less highly dispersed than would be predicted by a perfect Bradford distribution. This is hardly surprising since the source from which the data derive may miss a large number of journals that occasionally carry papers by Indian authors.

In table 9 a breakdown by subject matter is presented, based upon a random sample of 480 citations drawn from the 3378. The breakdown into different subject categories is somewhat subjective and different investigators might use a rather different categorization scheme. The scheme adopted was the one used by Lancaster and Carvalho[6], allowing a comparison of the output of Brazilian and Indian authors.

CONCLUSIONS

The data reported here, of course, are only as good as the source from which they are derived. The *Science Citation Index* does not cover *all* the literature of science, but it is certainly one of the most comprehensive of data bases. Its use is likely to lead to an underestimate of the proportion of the literature published in Indian journals since (1) many Indian journals, including some important ones, are not covered, and (2) the Indian scientists who publish abroad are likely to seek out the most prestigious journals (of the United States and the United Kingdom, for example) and these will all be covered in the data base used.

The least that can be said of the data is that they represent the publication patterns of Indian scientists as reflected in the most comprehensive English language data base devoted to the complete range of the sciences.

The data indicate that publications reporting the results of science research emanate overwhelmingly from the academic community. Many institutions contribute this literature; no single institution dominates.

Journals published in India itself, in the United States and the United Kingdom appear to account for about 75% of the papers published by Indian scientists. The Indian literature published domestically is quite compact. The ten most productive journals accounted for over 1000 papers among the sample of 3345. In contrast, the ten most productive foreign journals contributed less than 200 papers by Indian scientists. Looked at another way, while 10 Indian journals contribute 1000 papers, it would take the top 150 foreign journals to yield 1000 papers by Indian scientists. A further 1000 papers or so are distributed over almost 1000 further journal titles. The literature contributed by Indian scientists to foreign journals is widely scattered.

The list of most productive foreign journals (table 7) is dominated by titles in the physical sciences, whereas table 9 indicates that about 30% of all the papers published by Indian scientists fall in the life sciences. This is partly explained by the fact that the journal literature of the hard sciences seems more compact than that of the life sciences (*i.e.* a much higher proportion of the hard science literature is concentrated in a small nucleus of journals). Another factor relates to the universality of research in the hard sciences in contrast to the life sciences, where much of the research may be of more local interest (related to local flora, fauna, climatic conditions, and so on) and thus less likely to be published in foriegn journals.

The fact that so much of Indian research appears in Indian journals suggests that these journals are strong compared with the national journals of other developing countries. In contrast[6], Brazilian scientists tend to

Table 9 *Subject Distribution of a Sample of Papers*

Subject	Papers #	Papers %
1. Engineering; applied mechanics; aerodynamics	25	5.2
2. Agriculture; forestry; fisheries	34	7.1
3. Plant sciences; Phytochemistry	34	7.1
4. Food science; nutrition	3	0.6
5. Astronomy, astrophysics; atmospheric sciences	9	1.9
6. Earth sciences; geophysics	15	3.1
7. Physics; electronics (excluding biophysics, astrophysics, geophysics)	69	14.4
8. Chemistry; crystallography; chemical engineering (excluding biochemistry, plant chemistry)	122	25.4
9. Materials science (including metals, ceramics, plastics, polymers)	16	3.3
10. Biomedical sciences (including biochemistry, biophysics and all of the preclinical sciences)	94	19.6
11. Zoology; entomology; marine biology	35	7.3
12. Control engineering; cybernetics	4	0.8
13. Mathematics	16	3.3
14. Other technical areas like manufacturing, energy environmental concerns, etc.	4	0.8
	480	99.9%

publish overwhelmingly in English and not in Portuguese in their own national journals.

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1. Chakraborty, A. R., *Ann. Lib. Sci. Doc.*, 1970, 17 March, p. 47.
2. Rajagopalan, T. S., (et al) *Ann. Lib. Sci. Doc.*, 1965, 12 September, p. 137.
3. Peter, K. M. and Rajagopalan, T. S., *Ann. Lib. Sci. Doc.*, 1966, 13 September, p. 142.
4. Arunachalam. S., *Sci. Today*, 1979, 13 March, p. 45.
5. Arunachalam, S. and Markanday, S., *J. Infor. Sci.*, 1981, 3 February, p. 13.
6. Lancaster, F. W. and Carvalho, M. B., Pontes de, *Ciência e Cultura*, 1982, **34**, 627.
7. Bradford, S. C., *Documentation*, Crosby Lockwood, London, 1948.

ANNOUNCEMENTS

GOLDEN JUBILEE YEAR OF THE INDIAN ACADEMY OF SCIENCES, BANGALORE

1984 is the Golden Jubilee Year of the Academy. To commemorate this important event, several programmes have been planned. These essentially consist of scientific activities, which are outlined below:

The 50th Annual Meeting of the Academy has been designated the Golden Jubilee Meeting of the Academy and will be held at Bangalore from Wednesday, 7th November to Sunday, 11th November 1984. The inaugural function will be held at the Chowdiah Memorial Hall at 4p.m. on 7 November, the 96th birth anniversary of the founder President Professor C. V. Raman. The scientific meetings will be held at the Indian Institute of Science/Raman Research Institute. Three cultural programmes are planned for the Golden Jubilee week.

Each of the journals of the Academy will publish a special Golden Jubilee Number during the year. These issues will include invited contributions from distinguished scientists, both in India and abroad, consisting of original articles and state-of-the-art reports on topics of current interest. While some issues have already appeared during April–May 1984, the others will be published before November 1984.

Four international symposia are planned during the Golden Jubilee Meeting on Supernovae and their Remnants, Computers, Atmospheric Sciences and Animal Communication. A Workshop on Supernovae and their Remnants is also planned, just before the symposium.

It is proposed to prepare a small illustrated book, containing a historical account of the Academy, for distribution to Fellows, as a memento on the occasion of the Golden Jubilee of the Academy.

Further particulars may be had from the Secretary, Indian Academy of Sciences, Post Box No. 8005, Sadashivanagar P.O. Bangalore 560 080.

RELIABILITY ASPECTS: FROM DEVICES TO SYSTEMS

The Institute of Physics, London is arranging a two-day conference on "Reliability Aspects: from Devices to Systems" on 11–12 September 1984 at Brunel University, Shoreditch Campus, Egham, Surrey.

Topics covered at the Conference are as follows: (1) Status of reliability, (2) Devices and measurement, (3) Mechanical Systems and Software, (4) Testing and diagnostic methods, (5) Spares, economic and decision analysis, (6) Decision analysis and reliability.

Further information and registration forms are available from the Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.