

## Bibliometrics and scientometrics in India: An overview of studies during 1995-2014 Part II: Contents of the articles in terms of disciplines and their bibliometric aspects

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This part of the study highlights the contents of the published articles in terms of various disciplines or sub-disciplines and the bibliometric aspects discussed in these articles. The analysis of 902 papers published by Indian scholars during 1995-2014 indicates that the main focus of bibliometrics/scientometrics is on assessment of science and technology in India in different sub-disciplines including contributions by Indian states and other individual countries followed by bibliometric analysis of individual journals. Papers dealing with bibliometric laws received a low priority as compared to other sub-disciplines of bibliometrics/scientometrics. The analysis of data indicates that the share of theoretical studies using mathematical and statistical techniques which were missing in the earlier period (1970-1994) has increased during 1995-2014. The field of medicine as a discipline received the highest attention as compared to other disciplines.

**Keywords:** Scientometrics; Bibliometrics; Content analysis; India

### Introduction

In Part I of the study<sup>1,2</sup> authors discussed about the Indian output in bibliometrics/scientometrics and its impact. It also identified most prolific institutions and authors and examined their impact in terms of citations per paper and relative citation impact. The present study examines the bibliometric aspects of 902 papers published during 1995-2014. The complete list of papers is available at Annexure 1. The bibliometric aspects have been categorized into 10 different sub-disciplines. These are:

1. Cross national assessment in different disciplines;
2. Assessment of science and technology in India in different sub-disciplines including contributions by Indian states and other individual countries;
3. Assessment of institutional output under different sectors like academics and scientific agencies;
4. Scientometric portrait of eminent Indian and foreign scientists;
5. Bibliometric assessment of individual journals and group of journals;
6. Applicability of bibliometric laws;

7. Studies related to collaboration;
8. Studies related to doctoral dissertations;
9. Models of growth; and
10. Theoretical studies

The studies which could not fit into the above 10 categories have been clubbed together under others.

An analysis of data indicates that highest number (23%) of articles dealt with bibliometric assessment of individual countries including India. This was followed by studies on bibliometric studies of individual journals and cross national assessment. The share of each was 18.7% and 14.9% respectively of the total output. Thus, these three categories constituted more than half of the output. Rest of the output was scattered in other seven sub-disciplines including others. The details of contents of all the sub-disciplines with the bibliometric aspects examined in each have been described below.

### Cross national assessment in different disciplines

Several studies have been published that dealt with cross national assessment in different sub-disciplines

of science, technology, medicine and social sciences. The topics of such studies are given in Table 1.

#### Assessment of S&T in India in different sub-disciplines

Several studies have been published that dealt with bibliometric assessment of science and technology in India using different databases and different periods besides studies in different sub-disciplines of science, technology, medicine and social sciences. The topics of such studies are given in Table 2

#### Assessment of institutional output under different sectors like academics and scientific agencies

Several agencies involved in scientific research in India are academic institutions (universities and colleges), institutes of higher learning like engineering colleges including Indian Institutes of Technology (IITs) and national institutes of technology and medical colleges and hospitals. Besides these several government funded laboratories

under the aegis of Council of Scientific and Industrial Research (CSIR), Department of Atomic Energy (DAE), Indian Council of Medical Research (ICMR), Indian Council of Agriculture Research (ICAR), State Agriculture Universities (SAUs), Department of Space (DOS), Department of Science and Technology (DST), Department of Biotechnology (DBT) and Defence Research and Development Organization (DRDO) are also actively engaged in research in different areas of science and technology. The published studies dealt with publication productivity and citation impact of different institutions under different scientific agencies. These have been listed below in Table 3 by different performing sectors.

#### Scientometric portraits of scientists

Bio-bibliometrics is a term that was first coined by Sen and Gan<sup>4</sup> to mean the quantitative and analytical method for discovering and establishing functional relationships between bio-data and bibliometric data

Table 1—Cross national assessment in science, technology, medicine and social sciences

Sl. no.	Subject	Topics
1.	Medicine	Osteoarthritis, cardiology, conjunctivitis, dengue, glaucoma, Japanese encephalitis, limbic encephalitis, malaria and malaria vaccine, mental disorder in children, measles, mouth cancer, pharmacology, retina, swine flu, vitiligo, microRNA, shrimp disease, robotic medicine, oncology, polycystic ovary syndrome, schizophrenia, genetic engineering, genetics research and use of apocynin, artemisia and podophyllotoxin.
2.	Physics	Bhabha scattering, dark energy, fibre optics, astronomy and astrophysics, institutional productivity in laser science and technology, monsoon, nuclear waste, pulsed laser, radio isotopes, Tsunami, geophysics, laser science and technology using patent and publication data, polymer solar cells, thorium research and physics research as a whole discipline.
3.	Agricultural sciences	Animal cell culture technology, fish culture, food preservation, food science and technology, forest fungal research, plant genetics and breeding, spice research, tobacco, spice research in Asian countries, date palm and agricultural sciences as a whole.
4.	Engineering and technology	Cloud computing, semantic web, cryptography, fuel cell research, nanoscience and nanotechnology based on publications and patents output, nanobiotechnology, nanotubes, mobile technology and studies related to ocean science and technology, assessment of patents for marine bio-prospecting and knowledge management.
5.	Biological sciences and biotechnology	Bioinformatics, patents in biotechnology, biosensors using patent data, enzyme engineering research, stem cell research and population genetics.
6.	Chemical sciences	Electrochemical research, fullerenes using patent data, material science, plastic literature, bio-fuels and synthetic organic chemistry
7.	Environmental sciences	Study of CO <sub>2</sub> reduction trends
8.	Social sciences	Library and information science research, library and information science research as reflected in open access journals, personal attitude and job satisfaction among LIS professionals, social science, social psychology, sociology, bibliometrics and review article on national and cross national assessment, distance education, social science research in India, China and Brazil, social science research in four South Asian countries (Nepal, Bangladesh, Pakistan, and Sri Lanka), LIS research in ASEAN, SAARC and other Asian countries

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Table 1—Cross national assessment in science, technology, medicine and social sciences

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Sl. no.	Subject	Topics
9.	Other comparative studies in S&T	S&T research in India, China and South Korea, S&T research in four South Asian countries (Nepal, Bangladesh, Pakistan, and Sri Lanka), S&T research in India and Brazil, assessment of S&T output of developed versus developing countries, assessment of S&T output of BRIC countries, assessment of S&T output of South Asian countries, assessment of S&T output of SAARC countries based on patents, assessment of output of India versus Germany and patenting activity in Asian countries
10.	Assessment of output of China versus India	Patenting activity in China and India, laser S&T in India and China, physics research in India and China, plant based medicine research in India and China, Tuberculosis and diabetes research in India and China, computer science research in India and China, Fish research in India and China, Nanotechnology research India and China, assessment of research of academic institutions of India and China and assessment of research of Indian and Chinese institutions in chemical sciences, characteristics of highly cited papers from India and China, science and technology infrastructure in India and China, assessment of science and technology literature generated by India and China
11.	Others	Ranking of world universities, academic institutions and engineering institutions.

Table 2—Bibliometric assessment of Indian science, Technology and its sub-disciplines

Sl. no.	Subject	Topics
1	Science and technology	Bibliometric assessment of S&T in India using Web of Science, Scopus, and Indian Science Abstracts for different periods, bibliometric assessment of Indian S&T based on review articles, social science research in India, assessment of patents filed by India.
2	Medicine	Diabetes, asthma, cancer, dementia, cholera research, pulmonary obstructive diseases, dental science, Embelia ribes, endocrinology research, glaucoma, health science, hepatitis, HIV/AIDS, immunology and microbiology, lymphoma, malaria, life sciences, medical historiography, mental retardation, neuroscience, occupational health, osteoporosis, periodontology, pharmacology and toxicology, psoriasis, tuberculosis research, robotic medicine, yoga research, genetics and heredity, genetics and molecular biology, neurological sciences, dental science, antioxidant and medical science as a whole.
3	Chemical sciences	Alkaloid chemistry and green chemistry research, biochemistry, material science, organic chemistry, polymer science, chemistry research as a whole.
4	Agriculture sciences	Crop science research, fish research, food preservation research, food technology research, neem research, agriculture patents, potato research, spice research, turmeric research, wild life, genetic engineering research, role of nano-technology research in agriculture, and agriculture science research as a whole.
5	Engineering and technology	Computer science, human computer interaction, nano-science and technology, innovation management, spacecrafts and propulsion, studies related to ocean science and technology, patents in information technology, engineering research as a whole.
6	Physical sciences	Condensed matter physics, laser research, neutron research, nuclear science and technology, solar cell, solar energy, solar photovoltaic, thorium research, thin films, wind energy and physics as a whole.
7	Biological sciences and biotechnology	Biotechnology research, patenting in biotechnology pheromone biology.
8	Social sciences	Information literacy, LIS research, LIS management, sociology, bibliometrics of bibliometrics, webometrics, review article on bibliometric studies in India.
9	Others	Environmental science research, mathematics, general articles on Indian Citation Index.
10	Indian States	Library and information science research in Maharashtra and Madhya Pradesh, S&T output of Chandigarh, Orissa and Kerala, agricultural research in Himachal Pradesh and West Bengal, health science research in Orissa, engineering research in Karnataka, research contributions and the citation impact of LIS teachers from South India, agriculture science research in West Bengal.

Table 3—Bibliometric assessment of institutional output under different sectors

Sl. no.	Agency	Topics
1	Academic institutions	Bhagalpur University; chemistry, mathematics and zoology department of the Burdwan University; central universities of India; State universities of Karnataka; chemistry research at Guru Nanak Dev University; Indian universities; Kerala University and its department of Physics; Mysore university; chemistry department of the Pune University, web impact factor of Indian universities, assessment of Indian universities in terms of output and impact and Tata Institute of Social Sciences.
2	ICAR including State Agriculture Universities	Ranking of Indian agriculture and allied science institutions; animal science division of Indian Council of Agricultural Research (ICAR); Bidhan Chandra Krishi Vishvidyalaya (BCKV); Central Institute of Cotton Research; Central Tuber Crops Research Institute; agriculture colleges of India; Central Potato Research Institute; National Research Centre for Soya bean; state agriculture universities.
3	Department of Atomic Energy	Chemistry division, analytical chemistry division, radio chemistry division, nuclear physics division, bio-organic chemistry division, technical physics and prototype engineering division of the Bhabha Atomic Research Centre (BARC); technical reports generated by BARC; Centre for Advanced Technology; Institute of Plasma Research, Nuclear Science Centre and Tata Institute of Fundamental Research and UGC-DAE consortium.
4	CSIR	Central Electro Chemical Research Institute; Central Leather Research Institute; National Institute of Interdisciplinary Sciences and Technology; National Metallurgical Laboratory; Structural Engineering Research Centre; INSDOC's contributions to bibliometrics; all institutions under the Council of Scientific and Industrial Research, patents filed by CSIR, use of references in US patent documents by R&D scientists from CSIR in India.
5	Engineering colleges and IITs	Individual Indian Institutes of Technology (IITs) and all IITs; National Institutes of Technology and engineering institutions located in different parts of India.
6	Medical colleges and Indian Council of Medical Research	Government medical college and hospital Chandigarh, medical research institutes of India, All India Institute of Medical Sciences and Post Graduate Institute of Medical Education and Research, National Institute of Occupational Health, University College of medical sciences.
7	State Government Institutes	Rajiv Gandhi Centre for Biotechnology, Rubber Research Institute, Jawaharlal Nehru Tropic Botanical Garden and Research Institute (JNTBGRI), foreign R&D institutions in India, and Botanical Survey of India.

elements. Kademani and Kalyane<sup>5,6</sup> were the first to use the phrase “Scientometric portrait” to carry out bio-bibliometric studies on scientists. Several authors have carried out studies dealing with the scientometric portraits of different eminent scientists and social scientists. These are A.H. Zewail (Nobel laureate in chemistry), A.H. Chokshi (material scientist), T.M. Aminabhavi (polymer scientist), Anthony J Leggett (Nobel laureate in physics), H.J. Bhabha (Nuclear scientist), B.N. Koley (Physiologist), S.R. Ranganathan (father of Indian library science), C.R. Bhatia (Indian geneticist), Eugene Garfield (Chairman Emeritus of Institute of Scientific Information and pioneer of citation analysis), G.N. Ramachandran (Biotechnologist), C.V. Raman (Nobel laureate in physics), J.S. Yadav (organic chemist), H.W. Kroto (Nobel laureate in chemistry), Lalji Singh (molecular biologist), M.N. Srinivas (social scientist), Harald zur Hausen (Nobel laureate in medicine), Pierre-Gilles de Gennes (Nobel laureate in physics), N.N. Borthakur (Biometeorologist), Dorothy Crowfoot Hodgkin (Nobel laureate in chemistry), P.N. Kaula (Professor

in library and information science), Peter John Wyllie (Geophysicist), R. Chidambaram (Nuclear scientist), Ranjit Kumar Mitra (molecular biologist), R.C. Sinha (Plant Pathologist), R.S. Rastogi (Earth and planetary sciences), N. Rudraiah (Applied mathematician), S. Chandrasekhar (Nobel laureate in physics), Vikram Sarabhai (Space scientist), S. Ramaseshan (Crystallographer), S.N. De ( Discoverer of Cholera toxin), Tibor Braun (analytical chemist and scientometrician), R.G. Rastogi (earth and planetary scientist) and T S West (analytical chemist), Wolfgang Ketterle (Nobel laureate in physics). Two studies each were published for A.H. Zewail and Eugene Garfield.

#### Bibliometric assessment of journals

Bibliometric assessment of journals can be categorized into two- assessment of individual journals and assessment of a group of journals. Studies on individual journals mainly dealt with number of articles published in the concerned journal during a particular period, their subject contents,

geographical distribution and productivity of authors, their gender and institutional affiliation, co-authorship pattern and degree of collaboration among authors. Some studies have also undertaken citation analysis of the references attached to articles which analyzed the number and distribution of citations referenced per article over number of years; authorship pattern of citations; most referenced authors; types of cited documents; the age of cited documents; cited documents half-life; and ranked list of cited journals. During the period under review, Indian researchers published more than 100 papers which dealt with the bibliometric assessment of individual journals, mainly published from India, in different disciplines of science and technology, social sciences and humanities. Individual journals that have been subjected to bibliometric and reference analysis are listed in Table 4.

Of the above listed journals four studies were

related to *DESIDOC Journal of Library and Information Technology*, three to *Journal of Oil Seed Research and Indian Journal of Pure and Applied Mathematics and Current Science*, two each for *Annals of Library and Information Studies*, *DESIDOC Bulletin of Information Technology*, *IETE Journal of Research*, *Library Herald and Studies in Conservation*, *ACM Transactions on Information Systems*, *Defence Science Journal*, *IASLIC Bulletin* and *ILA Bulletin*. One study each dealt with the study of the impact factor of *Journal of Occupational Health* and acknowledgement pattern in *DESIDOC Journal of Library and Information Technology*.

Several studies dealing with different bibliometric aspects of two or more journals have been reported in literature. These studies dealt with evaluation of Library and Information Science journals, Indian Science & Technology journals and authorship pattern in journals. These have been described below:

Table 4—List of journals subjected to bibliometric analysis

Sl. no.	Journal
1.	<i>ACM Transactions on Information Systems</i>
2.	<i>Annals of Library and Information Studies</i>
3.	<i>Allelopathy Journal</i>
4.	<i>American Journal of Ophthalmology</i>
5.	<i>Applied Engineering in Agriculture</i>
6.	<i>Baltic Astronomy</i>
7.	<i>Bulletin Botanical Survey of India</i>
8.	<i>Current Science</i>
9.	<i>DESIDOC Bulletin of Information Technology</i>
10.	<i>DESIDOC Journal of Library and Information Technology</i>
11.	<i>Defence Science Journal</i>
12.	<i>D-Lib Magazine</i>
13.	<i>Demography India</i>
14.	<i>Ethno Botany Journal</i>
15.	<i>Herald of Library Science</i>
16.	<i>IASLIC Bulletin</i>
17.	<i>IEEE Transactions on Image Processing</i>
18.	<i>IETE Journal of Research</i>
19.	<i>IETE Technical Review</i>
20.	<i>Indian Forester</i>
21.	<i>Indian Journal of Animal Research</i>
22.	<i>Indian Journal of Chemistry Section A and B</i>
23.	<i>Indian Journal of Cancer</i>
24.	<i>Indian Journal of Fibre and Textile Research</i>
25.	<i>Indian Journal of Medical Research</i>
26.	<i>Indian Journal of Pure and Applied Mathematics</i>

Table 4—List of journals subjected to bibliometric analysis

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Sl. no.	Journal
27.	<i>Indian Journal of Pure and Applied Physics</i>
28.	<i>Indian Economic Review</i>
29.	<i>Indian Journal of Chest Diseases and Allied Sciences</i>
30.	<i>Indian Journal of Economics</i>
31.	<i>Indian Journal of Agricultural Sciences</i>
32.	<i>Indian Journal of Environmental Protection</i>
33.	<i>Indian Journal of International Law</i>
34.	<i>Indian Journal of Pharmaceutical Education and Research</i>
35.	<i>Indian Journal of Plant Genetics and Breeding</i>
36.	<i>Indian Journal of Law</i>
37.	<i>Indian Journal of Fisheries</i>
38.	<i>Indian Journal of Marketing</i>
39.	<i>Indian Journal of Plant Physiology</i>
40.	<i>Indian Journal of Physiology and Allied Sciences</i>
41.	<i>Industry and Trade</i>
42.	<i>International Journal of Tropical Agriculture</i>
43.	<i>International Social Science Journal</i>
44.	<i>Journal of Biosciences</i>
45.	<i>Journal of Economic Botany</i>
46.	<i>Journal of Family Welfare</i>
47.	<i>Journal of Food Science and Technology</i>
48.	<i>Journal of Forensic Dental Sciences</i>
49.	<i>Journal of Indian Coffee</i>
50.	<i>Journal of Entrepreneurs</i>
51.	<i>Journal of Indian Library Association and ILA Bulletin</i>
52.	<i>Journal of Genetics</i>
53.	<i>Journal of The Indian Society for Cotton Improvement</i>
54.	<i>Journal of Informetrics</i>
55.	<i>Journal of Oil Seed Research</i>
56.	<i>Journal of Rock Mechanics and Tunneling Technology</i>
57.	<i>Journal of Soil Sciences</i>
58.	<i>Journal of Spices and Aromatic Crops</i>
59.	<i>Journal of Plant Cell Physiology</i>
60.	<i>Journal of Plantation Crops</i>
61.	<i>Journal of Propulsion and Power</i>
62.	<i>Journal of Spacecraft and Rockets</i>
63.	<i>Journal of Structural Engineering</i>
64.	<i>Journal of Tobacco Research</i>
65.	<i>Journal of Intellectual Property Rights</i>
66.	<i>Journal of Scientific and Industrial Research</i>
67.	<i>Library Herald</i>
68.	<i>Library Hi-Tech Journal</i>
69.	<i>Library Science With A Slant To Documentation and Information Studies</i>
70.	<i>Mausam</i>
71.	<i>The Nucleus</i>
72.	<i>Oryza: The International Rice Journal</i>
73.	<i>Planters Chronicle</i>
74.	<i>Pramana: Journal of Physics</i>

Contd—

Table 4—List of journals subjected to bibliometric analysis

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Sl. no.	Journal
75.	<i>Proceedings of Mathematical Sciences</i>
76.	<i>Research and Industry</i>
77.	<i>Review of Ecological Systems A</i>
78.	<i>Sankhya</i>
79.	<i>Scientometrics</i>
80.	<i>SRELS Journal of Information Measurement</i>
81.	<i>Studies in Conservation</i>
82.	<i>University News</i>

### Evaluation of Library and Information Science journals

Genesis, growth and visibility of Indian and global library and information science journals, identification of core journals in library and information science and their citation analysis, evaluation of open access and electronic journals in LIS, Web of Science based ranking of Indian library and information science journals, evaluation of LIS journals published from SAARC countries, co-citation analysis of journals in the area of information retrieval and comparative analysis of citations of *Annals of Library and Information Studies* and *DESIDOC Journal of Library and Information Technology*.

### Indian Science and Technology Journals

Assessment of journals indexed by Journal Citation Reports, journal performance metrics, quality of Indian science journals, citation analysis of Indian science journals indexed by SCIE, Indian S&T journals in international indexing and abstracting databases and in SCI, citation analysis of Indian medical science journals and their ranking; evaluation of open access journals in nursing medical journals and evaluation of life science journals, citation pattern of NISCAIR journals.

### Authorship pattern in journals

Authorship pattern in *Journal of the American Society for Information Science and Technology* and *Scientometrics*, authorship pattern in aquaculture journals, citations and authors in *Annals of Mathematics* and *Econometrica*.

### Others

Evaluation of scientific journals using aggregated citations, evaluation of journals using iCE approach

and h index, gate keeping in science journals, development of a new indicator based on journal self citations, co-author pair frequency distribution in journals of gender studies, impact factor of open access versus subscribed journals, ranking of journals in oceanography and computer science, citation analysis and bibliographic coupling of toxicology journals, bibliometrics of open access journals in computer science, Bengali S&T periodicals, growth of Hindi, English and Urdu periodicals in India.

### Applicability bibliometric laws

One of the important areas in bibliometric research concerns with the application of bibliometric laws. The three most commonly used laws in bibliometrics are: Bradford's law of scattering, Lotka's law of author productivity and word frequency count given by Zipf. These laws have well-established formulas and the concepts embedded in them are less likely to change with time. Their validity has been verified several times by several authors. These have been described below.

#### *Bradford's law*

Several studies were published in different journals which dealt with the validation of Bradford's law to different disciplines. These disciplines were animal cell culture, bio-energy, mathematics and statistics, human computer interaction, library and information science, toxicology, psoriasis. Other studies on Bradford's law analyzed citations appended to doctoral dissertations submitted to the department of library and information science to different universities, horticulture science, social sciences and psychology, physics, methodology for estimating Bradford groups, analysis of Bradford's multipliers and model to explain law of scattering, applicability

of Bradford's law and growth of literature with time, correlation analysis for identification of core journals in immunology and book collection in Bhabha Atomic Research Centre library.

#### *Lotka's law and author productivity*

Applicability of Lotka's law was examined for library and information science literature, institutional productivity, output in physics of an institution, productivity of CSIR scientists, human computer interaction, computer science and toxicology literature. The validity of Lotka's law and negative binomial distribution has also been examined for theoretical population genetics in different time periods. Some studies also dealt with rationale for Lotka's law, method for calculation of Lotka's constants, comparison of counting techniques for productivity studies and fractional frequency distribution for Lotka's law.

#### *Zipf's law*

Only a few studies have been reported on the applicability of Zipf's law. These studies dealt with applicability of Zipf's distribution to word length and average hits on a search engine and its application to the literature of library and information science.

#### **Studies related to collaborations**

Collaboration studies dealt with different aspects of collaboration. These dealt with collaboration of India with different countries (Australia, China, South East Asian nations, South Asian nations, Latin American countries, Germany, middle East nations, Russia, international collaboration of India and Asian nations, international collaboration and its impact on institutional performance, collaboration pattern of IISc and other elite institutions, collaboration pattern of Nobel laureates, pattern of collaboration of Israel in new biology, etc.

#### *Collaboration in different fields*

Collaboration of India has been examined for different field like material sciences, Indian medicine, cotton science, chemical sciences, Japanese Encephalitis, LIS research, social science research, population genetics, zoology, epidemiology of neoplasm, laser science and technology, solar cells, computer science, statistics and Indian physics during 1800-1950 and Indian science. Impact of collaboration has been examined for growth of

geology literature and ethnobotany. Other aspects of collaboration studied difference between technical and scholarly collaboration, collaboration in Indian patents and linkage between industry and academic institutions. Other studies dealt with MCC, a new measure of collaboration; analysis of collaboration pattern of India using correspondence analysis and forecasting of international collaboration.

#### **Studies related to doctoral dissertations**

These studies have been divided into three categories. These are (i) dissertations submitted in different disciplines, (ii) citation analysis of references appended to doctoral dissertations in different disciplines and (iii) doctoral dissertations submitted by an academic or research institution over a period of time.

#### *Dissertations submitted in different disciplines*

Various disciplines in which doctoral dissertations were submitted were chemistry, LIS, mathematics, neurology, physics, English, horticulture science, oil seeds, botany, plant pathology, psychology, alcoholism and economics, social sciences and library and information science. The highest number of papers was on those that dealt with doctoral dissertations submitted in the discipline of LIS.

#### *Analysis of references appended to doctoral dissertations*

Analysis of references appended to doctoral dissertations in the discipline of engineering and technology, veterinary science, English, sociology, agriculture, zoology, mathematics, geography and physics have been carried out in various studies.

#### *Doctoral dissertations submitted by scholars of an academic or research institution over a period of time*

These studies examined theses submitted at CSIR-National Institute of Interdisciplinary Science and Technology (Thiruvananthapuram), Burdwan university (Burdwan), Kuvempu university (Shimoga), RTM Nagpur university (Nagpur), CSIR-Institute of Microbial Technology (Chandigarh), Kerala University in physics (Thiruvananthapuram), Indian Institute of Science in physics (Bangalore), CSIR- Regional Research Laboratory (Jorhat) in organic chemistry, Karnataka university (Dharwad), Nagpur University, and Annamalai university.



### Models of growth

Growth models have been applied for several fields like chemical sciences, ferrous metals, human computer interaction, liquid crystals, physics, social sciences, theoretical population genetics, electrical and electronic engineering, physical science literature, graph theory, marine engineering literature and highly qualified S&T manpower in India during 1990-1998.

### Theoretical studies

A large number of papers were published on different theoretical aspects of scientometrics.

Theoretical studies dealt with weighted indices for evaluating the quality of research with multiple authors, R&D efficiency in terms of papers and patents and its relation with R&D expenditure and manpower, interaction between science and technology in thin-films, analytical model for investigation of keyword characteristics in Fermi liquid, Bose-Einstein statistics and scattering of articles in journals, technique for calculating normalized impact factor, theory and practical applications of aggregated citations of cited articles, applicability of different theoretical functions in cited references in theoretical population genetics, probability distributions to co-authorship patterns and relation between growth and obsolescence rate of literature in population genetics, use of data envelopment analysis in cross national assessment. Some studies dealt with h-index and related aspects like mock h-index-a complement to h index, identification of 100 prolific authors using p-index, fractional and harmonic p-indices for multiple authorship, tapered h-index, studies on different h-index, broadness and h-index and thermodynamic model for h-index and z-index.

**Others studies:** These studies dealt with impact-citation-exergy assessment of Indian institutions, theory of performance based on energy analogy, energy, exergy and entropy sequence for a bibliometric assessment and its application to percentile ranking, quantity-quality-quasity and energy-exergy-entropy exegesis of expected value calculation of citation performance, impact-citations-energy approach to measure scientific performance of countries, new journal performance indicator, second order indicators for evaluating international collaboration, impact assessment using impact-citation and exergy analysis, relations between

references and citations, and impact factors and citations, distribution of IF in software journals, concentration measures in hierarchical random distributions, dynamic model of the growth of scientific knowledge, bivariate distribution of circulation data and information diffusion models, percentile ranking normalization, proof of conjecture of Moed and Garfield on authoritative references and extension to non-authoritative references and theory and experimentation on the most recent reference distribution and associated key word formation in physics.

### Other studies

#### *Authorship pattern*

There have been a few studies on authorship pattern in different sub-disciplines like aquaculture research, *Azadirachtaindica*, international monetary fund literature, laser science and technology, psychology literature, veterinary literature, Indian chemistry, physics, physics dissertations, library and information science literature and relation between co-authorship and productivity, mega authorship in library and information science, authorship pattern of cited references in horticulture science and immunology.

#### *Citation analysis*

Distribution of letters and their citation analysis published in journals indexed by SCIE, citation analysis of theoretical population genetics literature, laser science and technology, identification of highly cited researchers, highly web citations in LIS literature, citation generation potential of an article and synchronous references in physics Nobel lectures, comparison of citations between Scopus, WoS and Google scholar. This does not list studies for citation analysis that were part of cross national and assessment of Indian science as these have been included under that sub-heading.

#### *Gender differences and publication productivity*

Only few studies have been published on gender differences and productivity. These were in the discipline of psychology research, life sciences and productivity of CSIR male and female scientists.

#### *Obsolescence studies*

These studies examined obsolescence of chemical literature, LIS literature, psychology literature,

zoology literature, physics literature cited in PhD dissertations and half-life of URL citations.

#### **Webometrics**

Webometrics dealt with an analysis of websites of the central universities of India, LIS association in India, visibility of web sites of Indian state universities on the web, and webometrics of institutes of national importance. Web citations of Indian LIS literature were also examined and indicators of the visibility of web sites.

#### **General studies on bibliometrics**

These studies can be divided into the following:

- (i) Impact of SERC funding on chemical sciences, factors affecting research productivity, measurement of innovation, impact of funding on research productivity and educational development, organizational environment and performance of research groups, project sponsoring patterns and their outcomes.
- (ii) General articles on different topics like impact factor, Science Citation Index, informetrics, products of the Institute of Scientific Information, Indian Citation Index, Altmetrics and COLLNET.
- (iii) Decline in science education, S&T issues discussed in Indian parliament, quantitative assessment of S&T issues in leading Indian dailies, biomedical research and environmental issues in leading Indian dailies,
- (iv) Cognitive mobility and mapping of networks in mathematics, scientific activity of Indian Diaspora, scientific productivity and its relation with number of journals indexed by a database and journal packing density, assessment of Bhatnagar awardees and INSA fellow, emergence of physics research in India as reflected by historical sociology and bibliometrics, study on types of dedicatees and pattern of dedication, migration pattern of Indian scientists, data on Indian patent output, growth and decay of URLs, delay in publishing of manuscripts in online and print journals, Symbols and formulas for a few bibliometric concepts, role of bibliometrics in

studying the dynamics of S&T, analysis of references attached to reports published by National Institute of Hydrology,

- (v) Analysis of book reviews published in *The Hindu*, *Journal of Scientific and Industrial Research* and *Current Science*.

#### **Other individual countries**

S&T research in Bangladesh, Brazil, Nepal, Pakistan, South Korea and Sri Lanka, nano-science and nano-technology research in China have also been studied.

#### **Conclusion**

The content analyses of 902 papers published during 1995-2014 indicate that the nature of studies in terms of bibliometric aspects has changed considerably. In an earlier study by Basu and Garg<sup>2</sup>, the emphasis was on bibliometric laws particularly Bradford's law of scattering, but in the present study the quantum of these studies has decreased significantly. The emphasis now appears more on evaluative aspects of bibliometrics particularly on assessment of different disciplines of Indian science and technology and cross national assessment in different fields. These two together constituted about one-third of the total output. Several studies have appeared on assessment of output and impact of Indian institutes and collaboration. Earlier these areas of investigation got a low priority. Several theoretical studies using mathematical and statistical techniques have been published which were missing in the earlier period. The analysis also indicates that among the disciplines of science, the sub-disciplines related to medicine received the highest priority, while in social sciences, the subject of library and information science received the maximum emphasis. However, much of the work particularly studies related to bibliometric aspects of journals whose quantum is quite high in terms of the number of papers appears to an academic exercise by individual professionals of library and information science without fulfilling any useful purpose.

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