Ranking and performance of Indian Universities, based on publication and citation data

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Abstract

This paper describes the management and role of higher education in India, the type and growth of higher education and its priorities as listed in the current 11th Five-Year Plan of Government of India. The study also stresses the need for ranking Indian universities. The article focuses on new methodology of ranking of top 50 productive Indian universities using publications, citations and international collaborative publication data. The factors affecting productivity and quality of research in Indian universities were identified. The study also indicates the various methods employed for ranking universities.

Keywords: India, higher education, universities, ranking, publications, citation impact, management.

Introduction

Higher education in India has witnessed a phenomenal development– both in quantitative and qualitative terms, since independence. The Government has been steadily increasing the budgetary allocation for education and the country has also made significant strides in higher and technical education. From a brief analysis of the current Five Year Plan, one can infer that the government considers education as a main pillar for sustained economic growth & social welfare. Keeping this in mind, substantial financial resources have been allocated to education sector in the yearly budgets & subsequent 5- year plans.

India's higher education system is the third largest in the world after China and United States. The main government body at the tertiary level is the University Grants Commission (UGC), which enforces its standards, advices the government and help coordinate between the center and states. Accredition for higher education is overseen by 12 autonomous institutions established by UGC, including National Assessment and Accreditation Council (NACC).

The priorities for Higher Education in the XI Plan are: (i) Expansion- stands for increasing the number of higher education institutions and for augmenting the capacity of the existing ones; (ii) Excellence - stands for increasing the quality of higher education, notably by investing in physical infrastructure, quantity and quality of teachers, academic and administrative governance structure, and practices in universities and colleges; (iii) Optimal use of information & communication Technology to promote achievement of these objectives, (iv) Enhancing public spending, encouraging private initiatives and initiating the long overdue major institutional and policy reforms; (v) To increase Gross Enrollment Ratio from 11% in 2006 to 15% by 2011-12 through rapid expansion of higher education system while ensuring quality and inclusion, and also restructure and re-orient higher education system to meet the requirements of a knowledge economy in a globalised world.

The institutions of higher learning in India fall into the following broad categories; (i) central and state universities; (ii) deemed to be Universities (given deemed to be university status by the Central Government on the recommendation of the University Grants Commission); (iii) private Universities (established by various State governments through their own legislation); (iv) Institutes of National Importance (declared as such by the Government of India by an Act of Parliament and are empowered to award degrees); and (v) Premier Institutes of Management (set up by the Central Government and are outside the formal university system. They offer Post-Graduate Diploma Programs equivalent to Master's Degree Programs in management). India has now a system of higher education with 460 plus degree awarding institutions apart from thousands of Diploma awarding establishments.

In addition, there are colleges, which are affiliated to universities and provide undergraduate education. Some colleges also undertake post-graduate teaching and research. The affiliating universities oversee the standards of the affiliated colleges and hold examinations and award degrees to successful candidates. The college sector is managed both by the Government and Private bodies. There are some constituent colleges that are established and managed by a particular university.

The UGC, on the recommendation of an Expert Committee and in consultation with the State Government and the University concerned, confers the autonomous status on colleges. Such institutions have the capability to design their own curriculum, evolve innovative teaching and testing strategies.

Approximately 22% of the enrolment in higher education was attributed to be institutions covered under distance education programs. Indira Gandhi National Open University (IGNOU) established in 1985 is the apex

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body for imparting and monitoring the distance-learning program in India.

A number of developments have taken place regarding private initiatives in higher education: (i). Establishment of private universities by various governments through their own legislation, which vary from State to State, and also within the State. (ii) Establishment of deemed to be universities including de-novo category, involving particularly private institutions imparting technical, medical and other professional education, and (iii) Conceptualization of virtual universities for entry of foreign universities in different kinds of collaboration. Today there are a significant number of private universities & colleges in various states and the numbers are growing very rapidly.

Role of Indian universities

In the developing countries, universities have to play an active role in transforming traditional society into the modern information society or knowledge society. Universities have the social obligation for producing specific, technical and skilled manpower required for the society. Universities have a major role in information generation since a major part of scientific and technical publications are from the universities.

India has witnessed a vast expansion in higher education. The number of universities had increased from 20 to 431 during the period 1950-2008; the number of colleges had multiplied from 500 to 20,677; the strength of teachers had increased from 15,000 to 5.05 lakh and the enrollment of students went up from I lakh to 116.12 lakh; the gross enrollment index was only 13 % compared to a world average of 22 per cent. At present, enrollment was 13 %, which would go up to 15 % by 11th Plan while a target to achieve 22 % enrollment had been fixed for the 12th Plan period. The state universities accounted for 90 % of the enrollment of students in higher education. Around 75,000 students are enrolled in research and nearly 11,000 are awarded Ph. D. every year, of which 50 % are from Science & Technology disciplines. The higher education sector in India is vast, diverse and fragmented.

For research and development activities, major funding to academic institutions comes from University Grants Commission (UGC) and Ministry of Human Resources Development (MHRD). In addition, these academic institutions get extramural funding from Central Government research departments, agencies and All India Council of Technical Education (AICTE). The state universities get funding for research from State Governments.

Research and scholarship ought to become a priority in universities in India so that creation of knowledge becomes the fundamental objective of higher education. India is undergoing dramatic transformation. It is important to take steps towards establishing universities that will bring together the best of academic scholarship, teaching excellence and research aptitude for promoting knowledge based initiatives all across the country.

Measuring Institutional Productivity, Ranking and Quality

Measuring institutional quality is gaining prominence in higher education due to the interplay between many factors. Some of the factors that trigger the interest among the stakeholders are: (i) shrinking resource allocation for higher education from public funds, (ii) increasing competition among higher education institutions and (iii) the growing awareness about the value of money among the public. The stakeholders pay attention to institutional quality with one or more interests: (i) governments for accountability and policy-making, (ii) funding agencies for funding decisions; (iii) society for value of tax payers' money, (iv) industry for institutional-industry partnership, (v) prospective students for admission and career prospects, etc.

Research performance is a multi-dimensional concept, which cannot be encapsulated in a single universal indicator. A number of indicators have been proposed in literature to cope with the variety of institutional locale of research, in the objectives of research, in the nature of output, and in the purpose of measuring research performance. The evaluation is one of the key components of any R&D activity. One well-known productivity indicator of the R&D is the number of publications produced by the scientists, institutions and the country and the citations these publications receive. In addition, other scholars include average citation per paper, share of international collaborative papers, share and number of share of high cited papers, etc. The analysis of publications provide some insight in to complex dynamics of research activity and enables policy makers and science administrators in framing policies and directions in which R&D has to be conducted.

National and international rankings are gaining popularity over the years worldwide. In higher education, college and Univ. rankings are listing of universities is an order determined by any combination of factors. Rankings can be based on subjectively perceived "quality," on some combination of empirical statistics, or on surveys of educators, scholars, students, prospective students, or others.

In India, there is no formal system of rankings for colleges and universities. In India, too, all the major newsweeklies (*India Today*, *Outlook*, *The Week*) rank our colleges, B-schools, engineering and medical colleges – with poor (and poorly spelt out) methodologies, each pointing to a different conclusion. The National Assessment and Accreditation Council (NAAC) may soon rank Indian Universities and the ranking system would be in global perspective. NAAC, an autonomous body to assess and credit institutions of higher education in the country is discussing the possibilities with concerned departments and a committee has been formed to devise a framework. For developing its own grading scales, NAAC is studying various university ranking models like Shanghai Jiao Tong Univ.'s (SJTU) Academic Ranking of

World Universities (ARWU), the ranking considered in UK and Australia.

The Academic Ranking of World Universities compiled by the Shanghai Jiao Tong Univ., which was a large-scale Chinese project to provide independent rankings of universities around the world primarily to measure the gap between Chinese and "world class" universities. The Shanghai ranking includes institutes of higher education ranked according to a formula that took into account alumni winning Nobel Prizes and Fields Medals (10 percent), staff winning Nobel Prizes and Fields Medals (20 percent), "highly-cited researchers in 21 broad subject categories" (20 percent), articles published in Nature and Science (20 percent), the Science Citation Index, Social Sciences Citation Index, and Arts and Humanities Citation Index (20 percent) and the size of the institution (10 percent) (Ranking from the Institute of Higher Education Shanghai Jiao Tong University of the World's Research Universities; http:///www.arwu.org).

The Performance Ranking of Scientific Papers for World Universities is a bibliometric based ranking produced by the Higher Education Evaluation and Accreditation Council of Taiwan. The performance measures are composed of eight indicators (11 years articles, Current articles, 11 years citations, Current citations, Average citations, H-index, Highly cited papers, High Impact journal articles) representing three different criteria of scientific papers performance: research productivity, research impact, and research excellence. This project employs bibliometric methods to analyze and rank the scientific papers performances of the top 500 worlds' universities and the top 300 worlds' universities among six fields (http://ranking.heeact.edu.tw/).

The Webometrics Ranking of World Universities is produced by the Cybermetrics Lab (CCHS), a unit of the National Research Council (CSIC), the main public research body in Spain. The Webometrics Ranking is built from a database of over 11, 000 universities and more than 5,000 research centers. The ranking started in 2004 and is based on a combined indicator that takes into account both the volume of the Web contents and the visibility and impact of these web publications according to the number of external inlinks they received. The ranking is updated every January and July, providing Web indicators for universities and research centres worldwide. This approach takes into account the wide range of scientific activities represented in the academic websites, frequently overlooked by the bibliometric indicators. Webometric indicators (Webometrics Ranking of World Universities by Cybermetrics Laboratory) are provided to show the commitment of the institutions to Web publication. Thus, universities of high academic quality may be ranked lower than expected due to a restrained web publication policy.

The Webometrics approach is the G-Factor methodology, which counts the number of links only from other Univ. websites. The G-Factor is an indicator of the popularity or importance of each Univ.'s website from the combined perspectives of the creators of many other Univ. websites. It is, therefore, a kind of extensive and objective peer review of a Univ. through its website - in social network theory terminology, the G-Factor measures the 'nodality' of each Univ.'s website in the 'network' of Univ. websites (Webometrics Ranking of World Universities by Cybermetrics Laboratory).

The European Commission also weighed in on the issue, when it compiled a list of the 22 European universities, which have the highest scientific impact (measured in terms of the impact factor of their scientific output). This ranking was compiled as part of the Third European Report on Science & Technology Indicators, prepared by the Directorate General for Science and Research of the European Commission in 2003 (updated 2004). The report first identifies the top Univ. in each country, in terms of three criteria: number of publications, citations, and impact factor. Second, a ranking is provided of the top 22 European universities in terms of citation impact factor of their scientific publications.

Slovenian ranking - Another study conducted by the Jozef Stefan Institute in Slovenia, also provides a ranking for all world universities (CSIC, Spain (http://www.webometrics.info) and can be accessed at: Univ. Ranking by Institute Jozef Stefan, Slovenia. Unlike the Shanghai Jiao Tong study, the main criteria used include the ratio between SCI and Scopus listed publication per ratio of staff. The report provides, however, downloadable Excel files, through which the user can select different criteria (such as the total number of publications, number of SCI publications only or the corresponding performance ratios).

Among other ranking includes a survey of United States *Newsweak* magazine on ranking of top 100 global universities for 2006. They evaluated universities on some of the measures used by Shanghai Jiaotong Univ. and the Times Higher Education Survey. Fifty percent of the score came from equal parts of three measures used by Shanghai Jiatong: the number of highly-cited researchers in various academic fields, the number of articles published in Nature and Science, and the number of articles listed in the ISI Social Sciences and Arts & Humanities indices. Another 40 percent of the score came from equal parts of four measures used by the Times: the percentage of international faculty, the percentage of international students, citations per faculty member (using ISI data), and the ratio of faculty to students. The final 10 percent came from library holdings (number of volumes) (Taken from MSNBC's website).

Methodology and database used

A total of 50 Indian universities with comparatively high output of publications during a ten year period from 1999-08 were identified, based on their publications data downloaded from the *Scopus* international multidisciplinary bibliographical database covering

Table 1. Ranking of Top 50 Indian Universities based on Publication Output, Average Citation per Paper, Share of International Collaborative Papers and H-Index

Rank	Publication Output (P)	Average Citation per Paper (C/P)	% Share of Int. Collab. Papers	H-Index
1	Banaras Hindu Univ. (4870)	Univ. of Hyderabad (4.63)	Mangalore Univ. (49.02)	Univ. of Hyderabad (49)
2	Jadavpur Univ. (4807)	Panjab Univ. (3.68)	Bharthidasan Univ. (34.30)	Univ. of Delhi (45)
3	Univ. of Delhi (4784)	Jammu Univ. (3.12)	Alagappa Univ. (31.07)	Panjab Univ. (44)
4	Anna Univ. (3687)	Univ. of Pune (3.09)	Panjab Univ. (30.02)	Jadavpur Univ. (43)
5	Madras Univ. (3060)	Jamia Millia Islamia (3.06)	Sri Venkateshwar Univ.(26.15)	Banaras Hindu Univ. (42)
6	Panjab Univ. (2575)	Burdwan Univ. (3.01)	North East Univ. (25.69)	Univ. of Pune (37)
7	Aligarh Muslim Univ. (2522)	Alagappa Univ. (2.85)	Univ. of Hyderabad (24.93)	Univ. of Mumbai (36)
8	Univ. of Mumbai (2501)	Guru Nanak Dev Univ. (2.77)	Bharathiar Univ. (24.44)	Jawaharlal Nehru Univ. (35)
9	Univ. of Calcutta (2408)	Univ. of Delhi (2.71)	Pondicherry Univ. (24.03)	Anna Univ. (35)
10	Annamalai Univ. (2388)	Jawaharlal Nehru Univ. (2.67)	Univ. of Delhi (22.62)	Madras Univ. (34)
11	Univ. of Hyderabad (2371)	Karnatak Univ. (2.62)	Univ. of Pune (22.42)	Annamalai Univ. (33)
12	Jawaharlal Nehru Univ. (2084)	Kalyani Univ. (2.59)	Univ. of Mysore (22.35)	Univ. of Calcutta (32)
13	Univ. of Rajasthan (1937)	Bharthidasan Univ. (2.58)	Madras Univ. (19.74)	Aligarh Muslim Univ. (32)
14	Univ. of Mysore (1928)	Jamia Hamdard (2.57)	Jawaharlal Nehru Univ. (19.72)	Karnatak Univ. (31)
15	Univ. of Pune (1766)	Univ. of Rajasthan (2.56)	M.G.Univ. (19.36)	Burdwan Univ. (30)
16	Andhra Univ. (1662)	M.G.Univ. (2.56)	Guru Nanak Dev Univ. (19.26)	Bharathiar Univ. (29)
17	Cochin Univ. of Science & Technology (1640)	Madras Univ. (2.55)	Univ. of Lucknow (19.08)	Guru Nanak Dev Univ. (29)
18	Guru Nanak Dev Univ. (1578)	Annamalai Univ. (2.49)	Jammu Univ. (18.91)	Visva Bharti (29)
19	Osmania Univ. (1572)	Bharathiar Univ. (2.49)	Anna Univ. (18.74)	M.G.Univ. (28)
20	Sri Venkateshwar Univ. (1476)	Shivaji Univ. (2.48)	Jadavpur Univ. (18.14)	Bharthidasan Univ. (27)
21	M.S.Univ. of Baroda (1343)	North East Univ. (2.46)	Madurai Kamraj Univ. (18.05)	Sri Venkateshwar Univ. (27)
22	Karnatak Univ. (1317)	Jadavpur Univ. (2.41)	Jamia Millia Islamia (16.84)	Jamia Millia Islamia (27)
23	Madurai Kamraj Univ. (1263)	Pondicherry Univ. (2.38)	Burdwan Univ. (16.58)	Univ. of Rajasthan (27)
24	Mangalore Univ. (1177)	Madurai Kamraj Univ. (2.38)	Univ. of Rajasthan (15.85)	Madurai Kamraj Univ. (26)
25	Univ. of Lucknow (1169)	Devi Ahila Visvidyalaya (2.31)	Univ. of Calcutta (15.78)	Shivaji Univ. (26)
26	Bharathiar Univ. (1080)	Mangalore Univ. (2.15)	Banaras Hindu Univ. (14.74)	Kalyani Univ. (25)
27	Allahabad Univ. (1057)	Sri Venkateshwar Univ. (2.15)	Aligarh Muslim Univ. (14.67)	M.S.Univ. of Baroda (25)
28	Bangalore Univ. (1051)	Himachal Pradesh Univ. (2.12)	Jamia Hamdard (14.00)	Univ. of Kerala (25)
29	Bharthidasan Univ. (1032)	Banaras Hindu Univ. (2.07)	Andhra Univ. (13.90)	Mangalore Univ. (24)
30	Kalyani Univ. (1006)	Sardar Patel Univ. (2.03)	Cochin Univ. of Science & Technology (13.29)	Jammu Univ. (24)
31	Shivaji Univ. (986)	Visva Bharti (2.03)	Maharishi Dayanand Univ. (12.25)	Andhra Univ. (24)
32	Burdwan Univ. (983)	M.S.Univ. of Baroda (2.02)	Kalyani Univ. (12.03)	Cochin Univ. of Science & Technology (24)
33	Jammu Univ. (973)	Cochin Univ. of Science & Technology (2.01)	Osmania Univ. (11.96)	Osmania Univ. (24)
34	Jamia Millia Islamia (962)	Univ. of Kerala (2.01)	Karnatak Univ. (11.39)	Bangalore Univ. (24)
35	Punjabi Univ. (871)	Anna Univ. (2.00)	Bangalore Univ. (11.23)	Pondicherry Univ. (23)
36	Univ. of Kerala (832)	Bangalore Univ. (1.93)	Shivaji Univ. (9.74)	Univ. of Mysore (23)
37	North East Univ. (798)	Univ. of Calcutta (1.92)	Annamalai Univ. (9.71)	Univ. of Lucknow (23)
38	Kurukshetra Univ. (778)	Kakatiya Univ. (1.90)	Visva Bharti (9.65)	Jamia Hamdard (23)
39	Sardar Patel Univ. (776)	Univ. of Lucknow (1.87)	Gulbarga Univ. (9.51)	Alagappa Univ. (22)
40	Jawaharlal Nehru Technological Univ. (738)	Aligarh Muslim Univ. (1.86)	Kurukshetra Univ. (8.87)	North East Univ. (21)
41	Visva Bharti (725)	Univ. of Mysore (1.81)	Univ. of Mumbai (8.76)	Kakatiya Univ. (21)
42	Pondicherry Univ. (724)	Gulbarga Univ. (1.67)	Allahabad Univ. (8.61)	Allahabad Univ. (20)
43	M.G.Univ. (687)	Punjabi Univ. (1.65)	Sardar Patel Univ. (7.99)	Sardar Patel Univ. (20)
44	Kakatiya Univ. (687)	Univ. of Mumbai (1.59)	Kakatiya Univ. (7.57)	Punjabi Univ. (20)
45	Jamia Hamdard (643)	Kurukshetra Univ. (1.56)	M.S.Univ. of Baroda (7.52)	Himachal Pradesh Univ. (20)
46	Alagappa Univ. (618)	Osmania Univ. (1.52)	Punjabi Univ. (7.46)	Kurukshetra Univ. (17)
47	Gulbarga Univ. (610)	Andhra Univ. (1.50)	Univ. of Kerala (6.85)	Jawaharlal Nehru Technological Univ. (16)
48	Devi Ahila Visvidyalaya (599)	Maharishi Dayanand Univ. (1.48)	Jawaharlal Nehru Technological Univ. (5.01)	Maharishi Dayanand Univ. (15)
49	Maharishi Dayanand Univ. (596)	Allahabad Univ. (1.41)	Himachal Pradesh Univ. (4.97)	Gulbarga Univ. (15)
50	Himachal Pradesh Univ. (543)	Jawaharlal Nehru Technological Univ. (1.20)	Devi Ahila Visvidyalaya (3.51)	Devi Ahila Visvidyalaya (11)

more than 16, 000 international pear reviewed journals of the world. The citations received by these Univ. papers are considered for first three years (three year citation window) from the date of their publication. This allows the average number of citations per paper (C/P) to be computed for each of these universities for the three years citation window. H-Index for these universities for the same period (i.e. 1999-2008) was determined from the Scopus database. Similarly, the number of papers, which resulted from international collaboration (TICP)

Table 2. Ranking of Top 50 Indian Universities based on p-Index

S.No.	Affiliation	P	C	C/P	TICP	% TICP	h-Index	p-Index
1	Univ of Hyderabad	2371	10968	4.6	591	24.9	49	37.02
2	Delhi Univ.	4784	12962	2.7	1082	22.6	45	32.75
3	Panjab Univ.	2575	9471	3.7	773	30.0	44	32.66
4	Jadavpur Univ.	4807	11565	2.4	872	18.1	43	30.30
5	Banaras Hindu Univ.	4870	10097	2.1	718	14.7	42	27.56
6	Univ of Madras	3060	7813	2.6	604	19.7	34	27.12
7	Pune Univ.	1766	5449	3.1	396	22.4	37	25.62
8	Annamalai Univ.	2388	5953	2.5	232	9.7	33	24.57
9	Jawaharlal Nehru Univ.	2084	5554	2.7	411	19.7	35	24.55
10	Anna Univ.	3687	7381	2.0	691	18.7	35	24.54
11	Univ of Rajasthan	1937	4952	2.6	307	15.9	27	23.31
12	Guru Nanak Dev Univ.	1578	4370	2.8	304	19.3	29	22.96
13	Jammu Univ.	973	3033	3.12	184	18.91	24	21.15
14	Karnatak Univ., Dharwad	1317	3451	2.62	150	11.39	31	20.83
15	Jamia Millia Islamia, Delhi	962	2942	3.06	162	16.84	27	20.80
16	Univ of Calcutta	2408	4633	1.9	380	15.8	32	20.73
17	Burdwan Univ.	983	2956	3.01	163	16.58	30	20.72
18	Aligarh Muslim Univ.	2522	4693	1.9	370	14.7	32	20.59
19	Madurai Kamaraj Univ.	1263	3002	2.4	228	18.1	26	19.25
20	Bharathidasan Univ., Tiruchirapalli	1032	2666	2.58	354	34.3	27	19.03
21	Shri Venkateswara Univ.	1476	3180	2.2	386	26.2	27	18.99
22	Kalyani Univ.	1006	2603	2.59	121	12.03	25	18.88
23	Bharathiar Univ., Coimbatore	1080	2694	2.49	264	24.44	29	18.87
24	Cochin Univ of S & T	1640	3299	2.0	218	13.3	24	18.79
25	Univ of Mumbai	2501	3974	1.6	219	8.8	36	18.48
26	Univ of Mysore	1928	3483	1.8	431	22.4	23	18.46
27	Mangalore Univ.	1177	2669	2.27	577	49.02	24	18.22
28	Shivaji Univ., Kolhapur	986	2442	2.48	96	9.736	26	18.22
29	M.S.Univ. of Baroda	1343	2708	2.02	101	7.52	25	17.61
30	Alagappa Univ.	618	1760	2.85	192	31.07	22	17.11
31	North East Univ., Shillong	798	1960	2.46	205	25.69	21	16.89
32	Mahatma Gandhi Univ., Kottayam	687	1758	2.56	133	19.36	28	16.51
33	Jamia Hamdard, Delhi	643	1655	2.57	90	14	23	16.21
34	Pondicherry Univ.	724	1734	2.4	174	24.03	23	16.07
35	Univ. of Lucknow	1169	2189	1.87	223	19.08	23	16.00
36	Bangalore Univ.	1051	2030	1.93	118	11.23	24	15.77
37	Andhra Univ.	1662	2486	1.5	231	13.9	24	15.49
38	Osmania Univ.	1572	2397	1.5	188	12.0	24	15.40
39	Univ. of Kerala	832	1670	2.01	57	6.851	25	14.97
41	Sardar Patel Univ., Vidyanagar	776	1577	2.03	62	7.99	20	14.74
40	Devi Ahila Visvidyalaya, Indore	599	1385	2.31	21	3.506	11	14.74
42	Visva Bharti, Santiniketan	725	1469	2.03	70	9.655	29	14.38
43	Kakatiya Univ.	687	1308	1.9	52	7.569	21	13.55
44	Himachal Pradesh Univ., Shimla	543	1150	2.12	27	4.972	20	13.45
45	Punjabi Univ., Patiala	871	1434	1.65	65	7.463	20	13.32
46	Allahabad Univ.	1057	1496	1.41	91	8.61	20	12.84
47	Kurukshetra Univ.	778	1210	1.56	69	8.869	17	12.35
48	Gulbarga Univ.	610	1018	1.67	58	9.508	15	11.93
49	Guwahati Univ.	540	950	1.76	42	7.778	19	11.87
50	Maharishi Dayanand Univ., Rohtak	596	883	1.48	73	12.25	15	10.94

was determined and from this the percentage share of papers from international collaboration to the total number of papers published (% TICP) was determined.

There are several ways of ranking the performance of universities, e.g. by quantity of output (papers or citations or share of international collaborative papers) or by quality (mean citation rate = C/P), or combining quantity and quality, e.g. the h-index. In this paper, we view the problem of ranking research performance of universities as one belonging to the domain of random multiplicative processes as is usually the case in most non-linear problems, perhaps the best single indicator to be used for ranking using quality and quantity is a geometric mean of C and C/P. however, by dimensional analysis, one can show that this has the dimensions of $h^{3/2}$. Some recent studies have indicated that a mock h-index defined as h_m

$= (C^2P)^{(1/3)}$ is the best indicator for performance., having the correct dimensionality, that of h. We call here as p-index (Prathap, Gangan & Gupta, 2009a,b).

Analysis of data of Indian Universities

Table 1 shows one way of ranking these 50 universities, based on combined publication output during 1999-08. But in ranking, a number of factors can be taken in account indicating the multi-dimensionality of the problem. It means several ways of ranking performance, e.g. by quantity of output (papers or citations) as indicated in Table 2, or by quality (mean citation rate=C/P), or by another performance index combining qualtity and quality, e.g. the h-index (as shown in Table 2).

A total of top Indian 50 universities, with publication output more than 540 papers during the last ten years (1999-2008) were identified. These 50 universities had published papers in the range from 543 to 4870, and together have contributed 78240 papers, constituting 23.39% of the total cumulative output of India (334476 papers) during 1999-2008.   The publication share of these 50 universities to the total output of India showed increase from 22.15% (28111 papers) during 1999-2003 to 24.11% (50011 papers) during 2004-08. Of the 50 universities, 12 universities have published papers in the publication range 2001 to 4870, 17 universities in the publication range of 1001-2000, and the remaining 21 in publication range of 540 to 1000.

The combined publication output of these 50 universities as reflected in Table 1 is 78240 papers. The average output of these 50 universities is 1565 papers. Of the total universities, 19 universities have published above the average output of these universities during 1999-2008. Among these 19 universities, the largest number of papers (4870) is published by Banaras Hindu Univ., followed by Jadavpur Univ. (4807), Univ. of Delhi (4784), Anna Univ. (3687), Madras Univ. (3060), Panjab Univ. (2575), Aligarh Muslim Univ. (2522), Univ. of Mumbai (2501), Univ. of Calcutta (2408), Annamalai Univ. (2388), Univ. of Hyderabad (2371), Jawaharlal Nehru Univ. (2084), Univ. of Rajasthan (1937), Univ. of Mysore (1928), Univ. of Pune (1766), Andhra Univ. (1662), Cochin Univ. of Science & Technology (1640), Guru Nanak Dev Univ. (1578), Guru Nanak Dev Univ. (1578) and Osmania Univ. (1572).

The 78240 papers contributed by these 50 universities have received 184417 citations during 1999-08, with the average citation per paper as 2.36. Of the 50 universities, 24 universities have scored above the average citations per paper during 1999-2008. Among these 24 universities, the largest impact (4.63) among 50 universities is scored by Univ. of Hyderabad, followed by Panjab Univ. (3.68), Jammu Univ. (3.12), Univ. of Pune (3.09), Jamia Millia Islamia (3.06), Burdwan Universit

Table 3. Correlations matrix between different parameters of productivity and quality

Parameters	h-Index	p-Index
P	0.80	0.78
C	0.90	0.94
C/P	0.56	0.72
TICP	0.80	0.84
h-index		0.92

(3.01`), Alagappa Univ. (2.85), Guru Nanak Dev Univ. (2.77), Univ. of Delhi (2.71), Jawaharlal Nehru Univ. (2.67), Karnatak Univ. (2.62), Kalyani Univ. (2.59), Bharthidasan Univ. (2.58), Jamia Hamdard (2.57), Univ. of Rajasthan (2.56), M.G.Univ. (2.56), Madras Univ. (2.55), Annamalai Univ. (2.49), Bharathiar Univ. (2.49), Shivaji Univ. (2.48), North East Univ. (2.46), Jadavpur Univ. (2.41), Pondicherry Univ. (2.38) and Madurai Kamraj Univ. (2.38).

These 50 universities have together contributed 13621 international collaborative papers, accounting for 17.41% share in total cumulative publications output of 50 universities. Of these total universities, 21 have international collaborative papers share above the average international collaborative share of 50 universities. Among these 21 universities, the largest share (49.02%) of international collaborative publications in total publications output during 1999-08 is recorded by Mangalore Univ., followed by Bharthidasan Univ. (34.30), Alagappa Univ. (31.07%), Panjab Univ. (30.02%), Sri Vankateshwar Univ. (26.15%), North East Hill Univ. (25.69%), Univ. of Hyderabad (24.93%), Pondicherry Univ. (24.03%), Univ. of Delhi (22.62%), Univ. of Pune (22.42%), Univ. of Mysore (22.35%), Madras Univ. (19.74%), Jawaharlal Nehru Univ. (19.72), M.G.Univ. (19.36), Guru Nanak Dev Univ. (19.26), Univ. of Lucknow (19.08), Jammu Univ. (18.91), Anna Univ. (18.74), Jadavpur Univ. (18.14) and Madurai Kamraj Univ. (18.05).

The average H-Index recorded by these 50 universities is 27.24. Of the total universities, 19 universities have scored above the average H-Index of these total 50 universities. Among these 19 universities, the largest H-index (49) during 1999-08 is scored by Univ. of Hyderabad, followed by Univ. of Delhi (45), Panjab Univ. (44), Jadavpur Univ. (43), Banaras Hindu Univ. (42), Univ. of Pune (37), Univ. of Mumbai (36), Jawaharlal Nehru Univ. (35), Anna Univ. (35), Madras Univ. (34), Annamalai Univ. (33), Univ. of Calcutta (32), Aligarh Muslim Univ. (32), Karnatak Univ. (31), Burdwan Univ. (30), Bharathiar Univ. (29), Guru Nanak Dev Univ. (29), Visva Bharti (29) and M.G.Univ. (28).

Table 2 presents ranking of 50 Indian universities, based on the new performance indicator (p), which is a composite of quantity and quality (Table 2). The average value of p for 50 Indian universities varies from 10.94 to 37.02, with an average value of p as 19.34. Eighteen Indian universities have scored the value of p abpve the average value of p for all 50 Indian universities. Among these 18 universities, the highest value of p (37.02) is scored by Univ. of Hyderabad, followed by Univ. of Delhi (32.75), Panjab Univ. (32.66), Jadavpur Univ. (30.30),

Banaras Hindu Univ. (27.56), Univ. of Madras (27.12), Pune Univ. (25.62), Annamalai Univ. (24.57),

Jawaharlal Nehru Univ. (24.55), Anna Univ. (24.54), Univ. of Rajasthan (23.31), Guru Nanak Dev Univ. (22.96), Jammu Univ. (21.15), Karnatak Univ. (20.83), Jamia Millia Islamia (20.80), Univ. of Calcutta (20.73), Burwan Univ. (20.72) and Aligarh Muslim Univ. (20.59).

There is a strong correlation (0.94) between citation parameter (C), a measure of quality and new performance index p. In addition, there is a strong correlation (0.92) between h-index and new performance indicator p. A comparative less strong correlation (0.84) exists between number of international collaborative papers and new performance indicator. Table 3 presents correlation matrixes that confirm that h- and p-indices are good proxies that combine quantity and quality in a single figure of merit.

Conclusion

The above study have used a more rational procedure for ranking the research performance of Indian universities by identifying the indicators that are best correlated with each other and then using a composite indicator emerging as the product of these.

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