Scientometric analysis of some disciplines: Comparison of Indian institutions with other international institutions

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We have carried out a three-part study comparing the research performance of Indian institutions with that of other international institutions. In the first part, the publication profiles of various Indian institutions were examined and ranked based on the h-index and p-index. We found that the institutions of national importance contributed the highest in terms of publications and citations per institution. In the second part of the study, we looked at the publication profiles of various Indian institutions in the high-impact journals and compared these profiles against that of the top Asian and US universities. We found that the number of papers in these journals from India was miniscule compared to the US universities. Recognizing that the publication profiles of various institutions depend on the field/departments, we studied the publication profiles of many science and engineering departments at the Indian Institute of Science (IISc), Bangalore, the Indian Institutes of Technology, as well as top Indian universities. Because the number of faculty in each department varies widely, we have computed the publications and citations per faculty per year for each department. We have also compared this with other departments in various Asian and US universities. We found that the top Indian institution based on various parameters in various disciplines was IISc, but overall even the top Indian institutions do not compare favourably with the top US or Asian universities.

Keywords: Indian and international institutions, publications, research performance, scientometric analysis.

DESPITE several ranking schemes that exist internationally[1,2], almost all of them rank institutions/universities globally, and very few Indian universities find mention in these rankings. Indian universities have been ranked recently[3] based on *p*-index[4]. Here, we have examined the publications, citations, *h*-index and *p*-index[4] of the top 100 institutions and grouped them under various sectors. Secondly, a brief analysis of the publications in high impact factor journals by various institutions has been carried out. The main objective of this part of the study was to examine the publication output of the top universities in the best journals.

While there is debate on the value of journal articles published in the open literature compared to technological development in terms of actual products, it has been well established that countries that publish large numbers (quantity) in high quality journals (quality) ultimately have critical knowledge in the field and are in the forefront of new innovation in technology. Further, research papers are written mostly by graduate students and thus often serve as an indicator of the level of graduate school training and the human resource development. Thus, papers can be thought of as a leading indicator of engineering products in the future[5].

The comparison of institutions, especially Indian universities, can lead to erroneous conclusion. This is because many institutions, especially in India, focus entirely on one field like engineering, physical science, biological science, social sciences, etc. and there are few universities that offer doctoral programmes in all fields. However, it is well known that the number of publications, citations, etc. is dependent on the fields and sub-fields. Therefore, in this article, the departments in various institutions and universities around the world have been compared based on the number of journal publications and citations. To achieve these objectives, the institutions selected for the study included the Indian Institute of Science (IISc), Bangalore, the Indian Institutes of Technology (IITs) and other top universities in India, as well as top institutions from Asia and USA for each discipline. Such studies have been reported for aerospace[5] and chemical engineering[6]. The scope of this study was limited to physics and chemistry in sciences, and civil, chemical, electrical and mechanical in the engineering discipline.

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Methodology

The search commands used in the ISI web of science for extracting the data were as follows. The ISI web of science (http://www.isiknowledge.com) includes papers and citations from 1945 and conference proceedings from 1991. The period considered were the years from 2002 to 2006. The analysis was not carried out beyond 2006 because the number of citations for papers published after 2007 would be significantly influenced depending on the date the analysis was carried out. This analysis was carried out in June 2009 and, therefore, there would be a small change in the number of citations if the analysis were to be carried out later.

The general notation for the search used was 'ad=(University_name same discipline same country_name) and py = 2002–2006'. For example, in case of chemical engineering in Purdue University, USA, the command was 'ad=(Purdue Univ same chem engn same USA) and py=2002–2006'. The *h*-index reported[4] is defined if at least *h* papers each have been cited at least *h* times. Another index, namely the *p*-index or the mock *h*-index[4] defined as $(C^2/P)^{\wedge 1/3}$, where *C* is the number of citations and *P* the number of publications, has been used in the tables for ranking the universities.

It should be noted that this analysis is restricted to the output of the faculty from the particular department with the requirement that at least one of the authors has an affiliation of that department in the author field. For example, this analysis does not examine which departments publish in electrical engineering journals, but analyses the publications from electrical engineering departments in all journals. In some cases, faculty do not include their departmental affiliation in their papers and, therefore, it is not included in the database. Therefore, it does not appear in the analysis for the departmental affiliation.

The departments in various institutions and universities around the world were compared based on the number of journal publications and citations. It was recognized that the number of faculty in the same department varied widely across institutions. Therefore, the number of faculty was taken from the website of the university and the intensive parameters like publications per faculty per year (PFY) and citations per faculty per year (CFY) were obtained. The other parameters used were total publications, total citations and *h*-index. The *p*-index was not calculated for this part of analysis because PFY and CFY represent the more important parameters at a departmental level, and *p*-index can be directly calculated from the number of publications and citations.

Publication profiles of top 100 institutions during 2002–2006

The publication profile of top 100 institutions was studied in the following way. The *h*-index and the *p*-index[4] of all the institutions were determined for this purpose. The top 100 institutions were grouped into sectors like Institutes of National Importance (INI), autonomous R&D institutions, and universities and colleges. It was found that INI (total 10 institutions) published nearly 25% of the total publications of the top 100 institutions, whereas the autonomous R&D institutions (45 institutions) and universities and colleges (45 institutions) had a share of 38% and 37% respectively.

Table 1. Publications and citations by various institutions in India for the period 2002–2006

Sector	Publications	Citations
Institutes of National Importance (10)	19,319 (24.5%)	142,198
Mission oriented R&D sector (45)	30,069 (38.13%)	268,341
Universities and colleges (45)	29,462 (37.36%)	178,776

Among the INI sector, IISc, Bangalore topped the list with 4611 publications, *h*-index of 56 and *p*-index of 68.84, followed by IIT Kanpur and IIT Kharagpur based on *p*-index. However, the publications of IIT Kharagpur were higher compared to IIT Kanpur.

Among the autonomous R&D institutions, the Tata Institute of Fundamental Research (TIFR), Mumbai had an impressive *p*-index of 71.44, whereas the Bhabha Atomic Research Centre (BARC), Mumbai followed with a *p*-index of 57.89. However, BARC topped the list of number of publications with 2865 publications whereas TIFR was second with 1806 publications. The Indian Institute of Chemical Technology (IICT), Hyderabad and the National Chemical Laboratory (NCL), Pune were the top CSIR institutions.

Among the universities and colleges, Panjab University with a *p*-index of 59.45 topped the list followed by University of Delhi. The output of Panjab University was, however, skewed due to extensive international collaboration in physics, involving several countries. University of Delhi had the highest number of publications. University of Hyderabad and Banaras Hindu University, Varanasi were the other top institutions in the universities and colleges sector.

Publications in top journals

Publications in high impact journals often reflect high quality research and Table 5 gives the output of major institutions in these journals. We first consider three journals, viz. *Nature*, *Science* and *Cell*. IISc and all IITs together published 16 papers in these journals. As a comparison, MIT alone published more than 350 papers in these journals. Almost all top Asian universities published more than the Indian institutions. Next, we evaluated the publications in the top three society journals in chemistry, physics and biology. Three journals, viz. *Journal of American Chemical Society* (*JACS*), *Physical*

Table 2. Institutes of National Importance

Institution	Publications	Citations	*h*-index	*p*-index
Indian Inst Sci	4611	38,783	56	68.84
Indian Inst Technol Kanpur	2045	18,707	44	55.52
Indian Inst Technol Kharagpur	2664	17,804	38	49.19
Indian Inst Technol Mumbai	1963	14,757	39	48.05
All India Inst Med Sci	1854	13,633	37	46.45
Indian Inst Technol Delhi	2227	13,325	34	43.04
Indian Inst Technol Madras	1935	11,915	34	41.86
Indian Inst Technol Roorkee	998	7,182	36	37.25
Indian Stat Inst	918	5,398	27	31.66
Indian Inst Technol Guwahati	104	694	13	16.67

Table 3. Autonomous R&D sector

Institution	Publications	Citations	*h*-index	*p*-index
Tata Inst Fundamental Res	1806	25,661	57	71.44
Indian Inst Chem Technol	2048	22,254	46	62.30
Natl Chem Lab	1787	20,093	49	60.91
Bhabha Atom Res Ctr	2865	23,575	52	57.89
Jawaharlal Nehru Ctr Adv Sci Res	755	11,338	45	55.43
Indian Assoc Cultivat Sci	1383	12,852	41	49.25
Harish Chandra Res Inst	266	4,875	34	44.70
Inst Phys	422	5,857	38	43.32
Phys Res Lab	785	7,375	34	41.07
Ctr Cellular & Mol Biol	445	5,454	31	40.58
Natl Phys Lab	997	7,138	31	37.11
Bose Inst	416	4,520	29	36.62
Raman Res Inst	307	3,815	28	36.19
Saha Inst Nucl Phys	790	6,086	32	36.06
Cent Drug Res Inst	725	5,404	25	34.28
Cent Salt & Marine Chem Res Inst	328	3,596	28	34.03
Cent Leather Res Inst	600	4,702	26	33.28
Indian Inst Chem Biol	471	4,129	27	33.08
Postgrad Inst Med Educ & Res	1039	5,772	26	31.77
Ind Toxicol Res Ctr	365	3,401	24	31.65
Sanjay Gandhi Postgrad Inst Med Sci	594	4,099	23	30.47
Cent Food Technol Res Inst	604	4,129	25	30.45
Christian Med Coll & Hosp	526	3,484	26	28.47
Indian Agr Res Inst	785	4,059	22	27.58
Natl Bot Res Inst	307	2,395	22	26.54
Indira Gandhi Ctr Atom Res	726	3,681	22	26.53
Tata Mem Hosp	250	2,146	21	26.41
Indian Council Med Res	406	2,732	21	26.39
Natl Inst Mental Hlth & Neurosci	263	2,179	19	26.23
Ctr Adv Technol	458	2,776	24	25.62
Indian Inst Astrophys	295	2,180	20	25.26
Inst Math Sci	326	2,284	23	25.20
Birla Inst Technol & Sci	254	1,756	20	22.98
SN Bose Natl Ctr Basic Sci	346	2,028	19	22.82
Def Res & Dev Estab	247	1,700	19	22.70
Cent Electrochem Res Inst	391	1,985	18	21.60
Natl Inst Oceanog	412	2,003	17	21.35
Natl Met Lab	345	1,802	18	21.11
Natl Geophys Res Inst	431	1,939	17	20.59
Kasturba Med Coll & Hosp	261	1,454	15	20.08
Vikram Sarabhai Space Ctr	311	1,581	17	20.03
Ctr Nucl Sci	225	1,315	17	19.73
Indian Vet Res Inst	754	2,358	18	19.46
Natl Dairy Res Inst	270	643	10	11.53

Table 4. Universities and colleges

Institution	Publications	Citations	*h*-index	*p*-index
Panjab Univ	1007	14,545	52	59.45
Univ Delhi	2045	15,272	38	48.50
Univ Hyderabad	928	9,892	41	47.24
Banaras Hindu Univ	1623	12,502	41	45.84
Anna Univ	1225	9,239	33	41.15
Jadavpur Univ	1628	10,219	34	40.03
Natl Inst Technol	1197	7,995	33	37.66
Univ Jammu	304	3,766	31	36.00
Univ Rajasthan	819	6,001	32	35.30
Univ Madras	1416	7,766	27	34.92
Guru Nanak Dev Univ	634	4,407	25	31.29
Jawaharlal Nehru Univ	670	4,330	22	30.36
Univ Calcutta	1017	5,305	25	30.25
Annamalai Univ	745	4,505	25	30.09
Univ Bombay	503	3,337	23	28.08
Aligarh Muslim Univ	1012	4,702	23	27.96
Cochin Univ Sci & Technol	684	3,773	26	27.51
Sri Venkateswara Univ	541	3,233	19	26.83
Bharathidasan Univ	556	3,262	23	26.75
Univ Burdwan	460	2,959	22	26.70
Punjabi Univ	545	3,217	23	26.68
Bharathiar Univ	468	2,970	23	26.61
Karnatak Univ	551	3,207	23	26.53
Jamia Millia Islamia	405	2,622	21	25.70
Madurai Kamaraj Univ	559	2,895	21	24.66
Shivaji Univ	375	2,215	21	23.56
Alagappa Univ	263	1,760	18	22.75
Univ Kalyani	358	2,036	17	22.62
Andhra Univ	539	2,487	20	22.56
Mangalore Univ	407	2,159	21	22.54
Univ Mysore	799	3,023	18	22.53
Maulana Azad Med Coll	284	1,700	15	21.67
Pondicherry Univ	313	1,718	16	21.13
Maharaja Sayajirao Univ Baroda	445	1,970	17	20.58
Osmania Univ	553	2,173	19	20.44
Sardar Patel Univ	311	1,600	18	20.19
Univ Lucknow	450	1,909	17	20.08
Univ Allahabad	429	1,834	18	19.87
NE Hill Univ	317	1,556	16	19.69
Sree Chitra Tirunal Inst Med Sci	270	1,334	16	18.75
Bangalore Univ	388	1,465	15	17.69
Pune Univ or Poona Univ	63	584	15	17.56
Kurukshetra Univ	288	1,081	13	15.95
Punjab Agr Univ	656	1,408	13	14.46
Govind Ballabh Pant Univ Agr & Technol	412	838	12	11.95

Review Letters (*PRL*) and *Journal of Biological Chemistry* (*JBC*) were chosen. Institutions like MIT and University of California, Berkeley had more than 1000 publications in these journals over the five-year period. IISc was the only Indian institution which had more than 100 papers in all these journals put together. These numbers were still significantly lower than the top Asian universities.

The total number of papers published from India in each of these journals is also given in Table 5. In journals like *Science*, *Nature* and *JBC*, the contribution of INIs to the overall total was roughly 25%, on par with the overall contribution. In case of publication in *JACS*, the share of INI was 45%. In each of the journals except for *PRL*, the highest number of papers published in each of these journals was from IISc. In case of *PRL*, out of the 445 papers published from India, 100 were published from INIs whereas 139 papers were published by Panjab University. A closer inspection revealed that this was due to a mega-collaboration between several countries and most of the papers published from Panjab University had in excess of 25 authors each.

Publications and citation profiles of various institutions in different disciplines

The number of publications, citations, etc. are highly dependent on the fields and subfields and, therefore,

Table 5. Publications in *Nature*, *Science*, *Cell*, *Journal of American Chemical Society* (*JACS*), *Physical Review Letters* (*PRL*) and *Journal of Biological Chemistry* (*JBC*) during the period 2002–2006

	Institution	*Nature*	*Science*	*Cell*	*JACS*	*PRL*	*JBC*
USA	MIT	158	159	53	281	626	131
	UMinn	32	58	9	174	167	167
	Purdue	15	21	8	108	194	69
	PSU	57	53	5	125	150	137
	MSU	24	16	3	80	206	81
	OSU	20	31	7	99	306	182
	Caltech	127	213	20	215	380	55
	UCB	178	181	37	307	563	145
	UTexas	99	105	65	226	345	937
Asia	Natl Univ Singapore	11	6	4	45	54	88
	Tsing Hua Univ, China	3	4	2	19	60	29
	Seoul Natl Univ, South Korea	10	7	7	64	269	131
	Natl Taiwan Univ, Taiwan	7	6		30	127	72
	Kyushu Univ, Japan	22	11	3	95	32	154
	Chinese Academy of Sciences	46	44	6	188	289	113
India	Total from India	20	30	6	102	445	222
	IISc	2	6	1	25	59	48
	IIT-K	1			15	11	2
	IIT-B		1		1	16	6
	IIT-M					9	
	IIT-KGP	1	1		5	3	
	IIT-D					3	
	IIT-R	2	1			1	
	IIT-G						

direct comparison of universities and institutions with varying disciplines leads to erroneous conclusions. Therefore, in this article, the departments in various institutions and universities around the world were compared based on the number of journal publications and citations and intensive parameters such as the number of papers per faculty per year and number of citations per faculty per year.

In case of the US universities, five from the top 10 and five from the top 20 to 50 universities were chosen based on the overall ranking for all disciplines. These were usually MIT, University of California at Berkeley (UCB), California Institute of Technology (Caltech) and University of Minnesota (UMinn) in the first category, and University of Texas (UTexas), Ohio State University (OSU), Michigan State University (MSU), Pennsylvania State University (MSU) and Purdue University (Purdue) in the second category. In some cases, data could not be obtained for all the disciplines in the 10 universities. For example, in MIT, electrical engineering is combined with computer science; in Caltech, the departments of chemistry and chemical engineering; civil engineering and applied mechanics are combined. Therefore, the abovementioned universities were not considered for these particular disciplines. Other than these 10 universities, additional universities like Georgia Tech were added in case that they had published the highest in that discipline.

In the case of Asian universities, the top university from each country was chosen and was kept constant irrespective of the discipline. Thus, National University of Singapore, Tsing Hua University, Seoul National University, National Taiwan University and Kyushu University were chosen to represent Singapore, China, Korea, Taiwan and Japan respectively. Similar to the US universities, additional universities were added if their performance was higher than or comparable to the selected universities.

In the case of analysis for India, the performance in terms of publications and citations for all IITs and IISc was considered for all disciplines. Universities and organizations in India that have published more papers than some IITs in a particular discipline were also included in the list for comparison.

Tables 6–11 describe the publication and citation profiles of various US, Asian and Indian institutions for different disciplines. In order to visually represent these profiles, two parameters, viz. the number of publications from a department and the number of citations per faculty per year were chosen. The first parameter represents the productivity and thus the quantity, whereas the second parameter represents the quality. Figures 1–6 show these parameters for the publication and citation profiles of various US, Asian and Indian institutions for different disciplines. This visual representation allows one to

Table 6. Citation analysis of physics during the period 2002–2006

Country/region	Institution	Total publications	Total citations	*h*-index	Faculty strength	PFY	CFY
USA	UCB	1934	63,138	102	106	3.6	119.1
	MIT	1801	59,578	93	124	2.9	96.1
	UTexas	1697	27,025	64	69	4.9	78.3
	PSU	1411	25,743	71	59	4.8	87.3
	MSU	1230	26,979	63	60	4.1	89.9
	Caltech	1183	34,829	79	55	4.3	126.7
	OSU	1124	26,799	61	80	2.8	67.0
	UMinn	1057	28,307	65	85	2.5	66.6
	Purdue	771	8,334	39	59	2.6	28.2
Asia	Osaka Univ, Japan	1949	21,380	57	92	4.2	46.7
	Tsing Hua Univ, China	1547	10,712	37	76	4.1	28.1
	Seoul National Univ	1271	16,356	51	45	5.6	72.7
	National Taiwan Univ	1207	11,289	46	41	5.9	55.1
	Natl Univ Singapore	1135	12,138	42	55	4.1	44.1
	Kyushu Univ, Japan	806	4,519	26	37	4.4	24.4
India	Saha Inst Nucl Phy	973	6,750	32	62	3.1	21.8
	Bhabha Atom Res Ctr	742	3,981	23			
	Natl Phys Lab	727	4,185	25			
	Phys Res Lab	697	4,839	27			
	IISc	683	6,277	32	41	3.3	30.6
	IIT-D	387	1,842	17	46	1.7	7.7
	IIT-K	367	2,504	19	36	2.1	13.9
	IIT-KGP	319	1,700	18	29	2.2	11.7
	IIT-M	271	1,432	17	38	1.4	7.5
	IIT-B	267	1,231	16	34	1.6	7.2
	IIT-R	127	440	9	20	1.3	4.4
	IIT-G	27	87	5	22	0.2	0.8
	Tata Inst Fund Res	628	5,806	36			

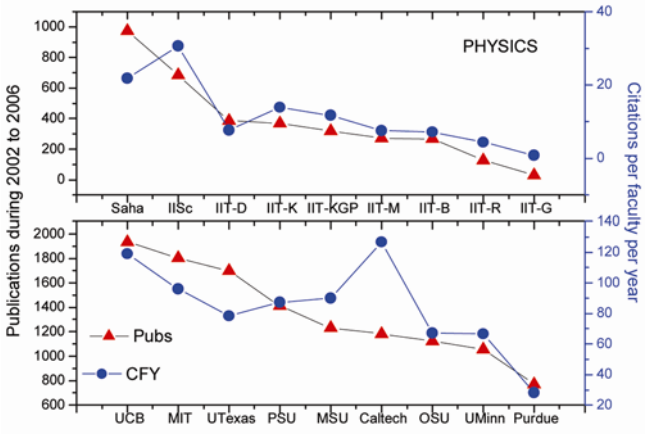

Figure 1. Quantity and quality indicators for the physics departments in USA and India.

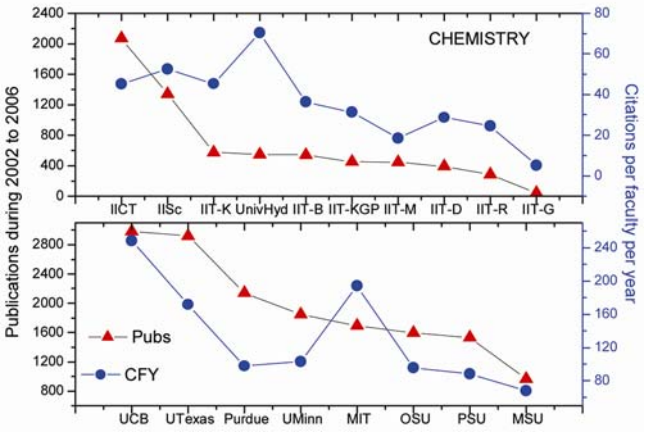

Figure 2. Quantity and quality indicators for the chemistry departments in USA and India.

easily determine the best institutions in terms of both quality and quantity.

Physics

Table 6 and Figure 1 describe the publication and citation profiles of various institutions in the area of physics. University of California, Berkeley topped the list with 1934 publications followed by MIT with 1801 publications. Many American universities had PFY less than Asian universities, but had a higher CFY. Two particular cases of UCB and Caltech had CFY greater than 100.

In Asia, though Osaka University had the largest number of publications (1949), its PFY and CFY were lesser than the Seoul National University and National Taiwan

Table 7. Citation analysis of chemistry during the period 2002–2006

Country/region	Institution	Total publications	Total citations	*h*-index	Faculty strength	PFY	CFY
USA	UCB	2982	77,060	111	62	9.6	248.6
	UTexas	2921	43,777	72	51	11.5	171.7
	Purdue	2143	27,394	60	56	7.7	97.8
	UMinn	1850	26,834	64	52	7.1	103.2
	MIT	1693	42,688	87	44	7.7	194.0
	OSU	1593	19,568	52	41	7.8	95.5
	PSU	1531	20,779	59	47	6.5	88.4
	MSU	970	12,914	51	38	5.1	68.0
Asia	Tsing Hua Univ, China	3156	34,658	63	61	10.4	113.6
	Natl Univ Singapore	2195	26,988	58	45	9.8	119.9
	Kyushu Univ, Japan	1875	21,901	51	46	8.2	95.2
	National Taiwan Univ	1287	14,039	43	60	4.3	46.8
	Seoul National Univ	1239	15,722	51	45	5.5	69.8
India	Indian Inst Chem Technol	2072	22,169	45	98	4.2	45.2
	Natl Chem Lab	1758	19,206	50			
	IISc	1341	13,382	43	51	5.3	52.5
	Bhabha Atom Res Ctr	1103	7,667	32			
	IIT-K	574	6,567	36	29	4.0	45.3
	Univ Hyderabad	545	9,157	41	26	4.2	70.4
	IIT-B	543	5,464	27	30	3.6	36.4
	IIT-KGP	452	4,692	31	30	3.0	31.3
	IIT-M	443	3,150	24	34	2.6	18.5
	IIT-D	393	3,161	24	22	3.6	28.7
	IIT-R	285	2,834	25	23	2.5	24.6
	IIT-G	43	519	12	20	0.4	5.2

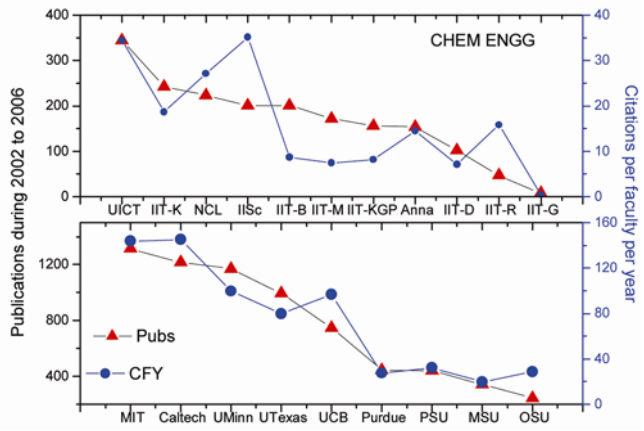

Figure 3. Quantity and quality indicators for the chemical engineering departments in USA and India.

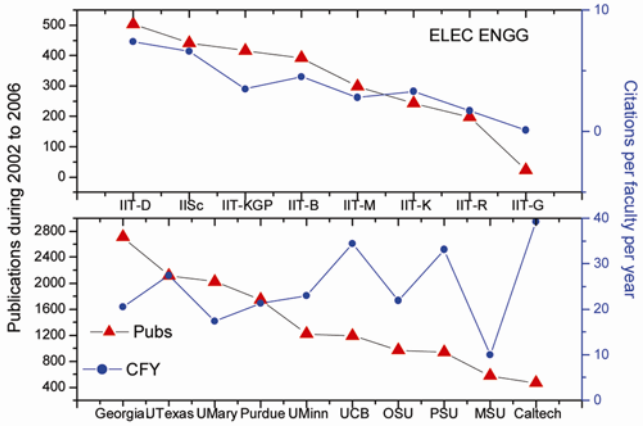

Figure 4. Quantity and quality indicators for the electrical engineering departments in USA and India.

University. These Asian universities had PFY of more than 5.5, a value higher than even the best universities in USA. However, their CFY was less than that of the top US universities like Caltech and University of California, Berkeley.

The Indian scenario showed that IISc led the table in terms of PFY and CFY. Its CFY of about 30 was the highest in the country and comparable to Purdue University, but below the top universities in the US and Asia.

Chemistry

Details of the publication profile of various institutions in chemistry are given in Table 7 and shown in Figure 2. Tsing Hua University, China topped the list with 3156 publications followed by University of California, Berkeley with 2982 publications. University of Texas had an impressive PFY of about 11, closely followed by Tsing Hua University of about 10. However, University of Cali-

Table 8. Citation analysis of chemical engineering during the period 2002–2006

Country/region	Institution	Total publications	Total citations	*h*-index	Faculty strength	PFY	CFY
USA	MIT	1313	27,341	72	38	6.9	143.9
	Caltech	1216	32,642	81	45	5.4	145.1
	UMinn	1171	20,459	58	41	5.7	99.8
	UTexas	993	16,803	57	42	4.7	80.0
	UCB	747	10,670	43	22	6.8	97.0
	Purdue	446	5,382	33	39	2.3	27.6
	PSU	441	3,875	28	24	3.7	32.3
	MSU	342	2,964	29	30	2.3	19.8
	OSU	246	2,750	25	19	2.6	28.9
Asia	Tianjin Univ, China	1485	6,342	25	52	5.7	24.4
	National Taiwan Univ, Taiwan	1294	9,414	34	39	6.6	48.3
	Seoul National Univ	987	16,214	54	40	4.9	81.1
	Tsing Hua Univ, China	986	5,996	28	69	2.9	17.4
	Natl Cheng Kung Univ, Taiwan	771	8,015	36	36	4.3	44.5
	Hanyang Univ, South Korea	759	6,942	37	35	4.3	39.7
	Kyushu Univ, Japan	706	5,397	31	20	7.1	54.0
	Natl Tsing Hua Univ, Taiwan	632	6,376	31	28	4.5	45.5
	Natl Univ Singapore	358	5,346	32	44	1.6	24.3
India	UICT	344	3,099	25	18	3.8	34.4
	IIT-K	243	1,964	20	21	2.3	18.7
	Natl Chem Lab	223	2,710	25			
	IISc	201	1,753	17	10	4.0	35.1
	IIT-B	201	1,428	16	33	1.2	8.7
	IIT-M	172	897	15	24	1.4	7.5
	IIT-KGP	156	939	14	23	1.4	8.2
	Anna Univ	154	1,592	20			
	Univ Bombay	119	1,233	19			
	IIT-D	102	822	15	23	0.9	7.1
	IIT-R	47	711	16	9	1.0	15.8
	IIT-G	8	43	4	20	0.1	0.4

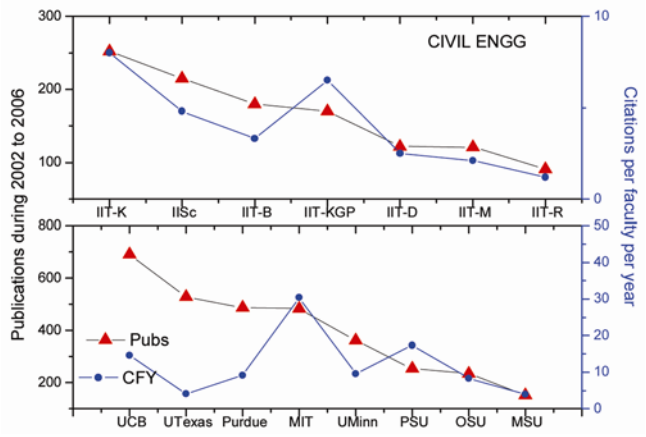

Figure 5. Quantity and quality indicators for the civil engineering departments in USA and India.

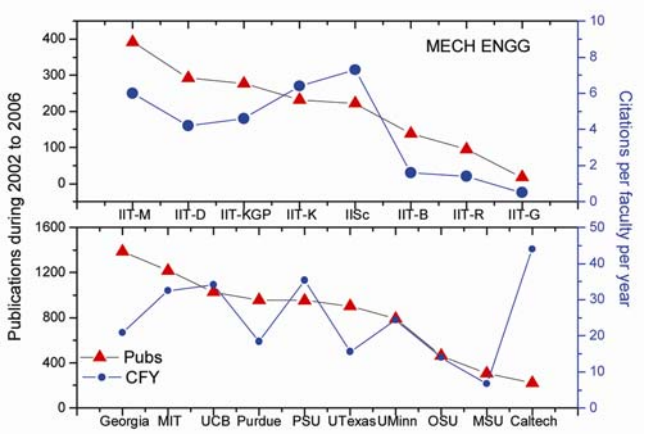

Figure 6. Quantity and quality indicators for the mechanical engineering departments in USA and India.

fornia, Berkeley and MIT had a better CFY of about 249 and 194 respectively.

The Indian scenario showed that the Indian Institute of Chemical Technology had 2072 publications, followed by National Chemical Laboratory with 1758 publications. However, IISc topped the list of Indian institutions in terms of PFY of about 5, whereas the University of Hyderabad had a higher CFY of about 70. This value was the highest

Table 9. Citation analysis of electrical engineering during the period 2002–2006

Country/region	Institution	Total publications	Total citations	*h*-index	Faculty strength	PFY	CFY
USA	GeorgiaTech	2710	14,633	43	143	3.8	20.5
	UTexas	2113	13,968	48	102	4.1	27.4
	UMaryland	2025	12,733	46	146	2.8	17.4
	Purdue	1746	15,112	49	142	2.5	21.3
	UMinn	1219	11,291	54	98	2.5	23.0
	UCB	1194	22,541	61	131	1.8	34.4
	OSU	969	6,138	29	56	3.5	21.9
	PSU	938	10,420	49	63	3.0	33.1
	MSU	577	2,602	22	52	2.2	10.0
	Caltech	467	5,882	36	30	3.1	39.2
Asia	Natl Taiwan Univ, Taiwan	2822	12,080	37	124	4.6	19.5
	Natl Univ Singapore	2402	12,378	41	105	4.6	23.6
	Seoul National Univ, South Korea	2287	12,550	41	74	6.2	33.9
	Natl Cheng Kung Univ, Taiwan	1560	6,762	29	80	3.9	16.9
	Kyushu Univ, Japan	938	4,115	28	22	8.5	37.4
	Hanyang Univ, South Korea	912	2,538	20	37	4.9	13.7
	Natl Tsing Hua Univ, Taiwan	740	2,360	20	52	2.9	9.1
India	IIT-D	503	1,661	21	45	2.2	7.4
	IISc	442	1,490	17	45	2.0	6.6
	IIT-KGP	416	1,053	15	61	1.4	3.5
	IIT-B	392	945	15	42	1.9	4.5
	IIT-M	298	706	11	51	1.2	2.8
	IIT-K	242	544	11	33	1.5	3.3
	IIT-R	197	511	12	59	0.7	1.7
	IIT-G	23	13	2	24	0.2	0.1

Table 10. Citation analysis of civil engineering during the period 2002–2006

Country/region	Institution	Total publications	Total citations	*h*-index	Faculty strength	PFY	CFY
USA	UCB	691	6360	32	87	1.6	14.6
	UTexas	527	2009	18	99	1.1	4.1
	Purdue	487	2914	26	64	1.5	9.1
	MIT	483	7451	44	49	2.0	30.4
	UMinn	361	2274	23	47	1.5	9.6
	PSU	254	3456	31	40	1.3	17.3
	OSU	235	1838	20	44	1.1	8.3
	MSU	152	860	16	43	0.7	4.0
Asia	Natl Univ, Singapore	643	3513	25	36	3.8	19.5
	Univ of Hong Kong, China	563	4238	27	71	1.6	11.9
	Hong Kong Univ Sci & Technol	460	2218	19	29	3.2	15.3
	Natl Taiwan Univ, Taiwan	338	1530	18	71	1.0	4.3
	Tsing Hua Univ, China	304	970	14	50	1.2	3.9
India	IIT-K	252	1117	16	28	1.8	8.0
	IISc	215	652	10	27	1.6	4.8
	IIT-B	180	586	12	36	1.0	3.3
	IIT-KGP	170	936	15	29	1.2	6.5
	IIT-D	122	506	12	41	0.6	2.5
	IIT-M	121	493	12	47	0.5	2.1
	IIT-R	91	323	10	52	0.4	1.2
	IIT-G	6	17	3			
	Aligarh Muslim Univ	38	65	4			

Table 11. Citation analysis of mechanical engineering during the period 2002–2006

Country/region	Institution	Total publications	Total citations	*h*-index	Faculty strength	PFY	CFY
USA	GeorgiaTech	1387	10,026	42	96	2.9	20.9
	MIT	1217	15,257	50	94	2.6	32.5
	UCB	1027	9,538	40	56	3.7	34.1
	Purdue	956	6,079	29	66	2.9	18.4
	PSU	953	7,782	40	44	4.3	35.4
	UTexas	902	6,611	33	85	2.1	15.6
	UMinn	792	7,184	32	59	2.7	24.4
	OSU	464	3,571	26	51	1.8	14.0
	MSU	307	1,577	18	47	1.3	6.7
	Caltech	223	3,960	33	18	2.5	44.0
Asia	Tsing Hua Univ, China	2139	9,396	37	82	5.2	22.9
	Natl Univ Singapore	1708	13,780	45	69	5.0	39.9
	Shanghai Jiao Tong Univ, China	1210	4,272	26	75	3.2	11.4
	Natl Taiwan Univ, Taiwan	1192	4,271	23	56	4.3	15.3
	Korea Adv Inst Sci & Technol	1169	3,999	20	52	4.5	15.4
	Seoul Natl Univ, South Korea	906	4,292	23	66	2.8	13.0
	Natl Cheng Kung Univ, Taiwan	830	3,169	21	65	2.6	9.8
	Kyushu Univ, Japan	573	4,221	28	102	1.1	8.3
India	IIT-M	392	1,778	16	59	1.3	6.0
	IIT-D	292	994	13	47	1.2	4.2
	IIT-KGP	277	936	13	41	1.4	4.6
	IIT-K	232	1,283	15	40	1.2	6.4
	IISc	222	1,096	14	30	1.5	7.3
	IIT-B	138	492	10	60	0.5	1.6
	IIT-R	95	272	8	39	0.5	1.4
	IIT-G	18	56	5	22	0.2	0.5
	Jadavpur Univ	71	211	7			
	Anna Univ	51	207	8			

among all disciplines for all universities in India. All other Indian institutions had significantly less CFY compared to the top US universities.

Chemical engineering

The publication profile of faculty in chemical engineering as shown in Table 8 and Figure 3 indicates that Tianjin University, China topped the list with 1485 papers followed by MIT with 1313. However, Kyushu University, Japan and MIT had a high PFY of about 7, whereas MIT and Caltech had an impressive CFY of about 144 and 145 respectively.

The Asian scenario showed that the National Taiwan University with 1294 publications and Tsing Hua University with 986 papers followed Tainjin University. None of the Indian institutions had more than 250 publications. The CFY of Indian institutions like IISc and UICT was high, but skewed due to the performance of just a couple of faculty in that particular institution. In most cases, the CFY was less than 10, indicating that the output was significantly lower than almost all major US and Asian universities.

Electrical engineering

The publication and citation profiles in electrical engineering are given in Table 9 and Figure 4. National Taiwan University topped the list with 2822 papers, followed by Georgia Institute of Technology with 2710 publications. However, Kyushu University, Japan had PFY of about 8 and Caltech had an impressive CFY of about 39.

Many Asian universities had more than 500 publications and CFY of a few institutions like Kyushu University was comparable to the best in the world. In India, only IIT-Delhi had 503 publications. CFY of none of the Indian institutions was more than 10, again indicating that the output was significantly lower than almost all major US and Asian universities.

Civil engineering

The publication and citation profiles of civil engineering are given in Table 10 and represented in Figure 5. University of California, Berkeley topped the list with 691 publications followed by National University of Singa-

pore with 643. The latter had the highest PFY of 4, whereas MIT had the highest CFY of 30. The total number of publications of Tsing Hua University was less because civil engineering in this university has been split into three different branches: civil, hydraulic and construction engineering, and the number presented here is only for civil engineering. In India, none of the institutions had more than 300 publications. Whereas IIT-K had a CFY of 8.0, almost all other institutions had CFY of less than 5.

Mechanical engineering

The publication and citation profiles of mechanical engineering are shown in Table 11 and represented in Figure 6. Tsing Hua University, China with 2139 publications and a notable PFY of 5 topped the overall list. Most of the top US and Asian universities had CFY of more than 10 with National University of Singapore having an impressive CFY of about 40. In India, IIT-Madras had the largest number of publications, whereas IISc had the highest PFY and CFY. However, the CFY value was still twice less than an average university in USA.

Summary

A few general conclusions can be made regarding the analysis. The number of papers and citations varies widely in different disciplines, and comparison of universities and institutions using the overall data would lead to wrong conclusions. For example, physical science-specific universities would have much higher number of publications and citations than a university that is specialized in engineering. Therefore, publications and citations in only specific disciplines should be compared. Further, there is a large variation in the number of faculty in a particular discipline and, therefore, comparisons based on the number of papers per faculty per year and the number of citations per faculty per year represent more realistic parameters.

In almost all disciplines, CFY of Indian institutions was lower than that of the US universities. Among the US universities, Caltech was an exception in that it had a lower number of publications compared to other US universities, but a high CFY. In India, IISc was the best institution based on various parameters and had the highest number of publications in the top journals. IISc also had the highest PFY and CFY in physics, chemical engineering and mechanical engineering among the Indian institutions. In chemistry, IISc had the highest PFY, whereas University of Hyderabad had the highest CFY. IIT-D and IIT-K had the highest PFY and CFY in electrical and civil engineering respectively. However, caution should be exercised while comparing the performance of Indian institutions in engineering based on PFY and CFY, because the numbers are small.

Conclusion

We have carried out a three-part study comparing the research performance of Indian institutions with the international universities. In the first part, the publication profiles of various Indian institutions were determined, and it was shown that the publications and citations per institution were the highest for the INIs. In the second part, the publication profiles of various institutions in the high-impact journals were examined. It was observed that the number of papers in these journals from India is miniscule compared to the US universities. The third part of the study focused on the publication profiles of specific science and engineering departments in the various Indian universities, and these were compared with the top Asian and US universities based on publications and citations per faculty per year for each department. The Indian institutions lag far behind the top US universities at the institutional level, especially if parameters like the total number of publications and citations per faculty are considered.

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