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Research Performance of Top Engineering and Technological Institutes of India: A Comparison of Indices

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ABSTRACT

This study evaluates the application of *h*-index, *g*-index, and *p*-index on Indian engineering and technological institutes. A total of 40 institutes in India have been ranked by the three indices. The analysis focused on the cluster analysis to segregate these institutes on the basis of ranks generated by these indices. The degree of correlation among the indices were also been evaluated. The results have shown that *g*-index and *h*-index performed much on the similar lines. An attempt has thus been made to use other indices like *p*-index and ACPP method to find a viable segregation on the basis of attributes these indices deal with.

Keywords: *h*-index, *g*-index, *p*-index, cluster analysis, research performance

1. INTRODUCTION

Over a period of time, India has created one of the largest infrastructures of engineering and technological institutes in the country. This could be attributed to the growth of industries in the country, the increasing difficulty in getting a respectable job, and the growing clientele of the young people desiring to enter this arena. India produces a huge number of engineering and technology graduates every year[1].

Data from scientific publications show that the world's scientific hierarchy has remained remarkably stable over the past decade, with the postindustrial nations of the United States, Europe, and Japan continuing to dominate in many fields[2]. A similar trend is witnessed in the research performance of the Indian engineering and technological institutes of India. Some of these Indian institutes are very prestigious and make it to the list of top universities in the world. Very few institutes among the major Indian engineering and technological institutes, account for most of the research output of the country. Most of the other institutes, however, have paltry research output[1].

Comparison of performance of these indices on various data sets has been of interest for researchers, e.g., determination of relation between the *h*-index and Egghe's g-index for some simple models[3] and compare the values of *h* and *g* in the study of 26 physicists from the Institute of Physics at Chemnitz University of Technology[4]. In a study, Huang & Chi[5] compared the application of *h*-index, *g*-index, and *A*-index in institutional level research evaluation of 99 universities in Taiwan. Egghe[6] also commented, "It would also be interesting to work out more practical cases (in other fields) of *h*- and *g*-index comparisons". Bar-Ilan[7] compared the *h*-indices of a list of highly-cited Israeli researchers based on citations counts retrieved from the *Web of Science, Scopus*, and *Google Scholar*, respectively.

2. PURPOSE OF STUDY

The purpose of this study is to demonstrate correlations among the ranking methods of Indian engineering and technological institutes to determine if a relationship exists and whether or not these indices are consistent with the type of institutes.

This study moves beyond previous pair-wise comparisons to engage in multidimensional analysis that allows for the examination of many indices simultaneously. The intent is to articulate specific ranking patterns, and then use them to make inferences about how Indian engineering and technological institutes might choose research priorities and develop research policies.

3. SIGNIFICANCE OF RESEARCH

It is assumed that priority with which an institute has been established has implications for scientific research output. When specific patterns are made clear, then it becomes possible to suggest how institute's researchers could maximise publications in peer-reviewed journals for which they are best suited. The attributes, in question here, are the quality and quantity, productivity and impact and quality and consistency.

4. RESEARCH QUESTIONS

To learn more about patterns of ranking of Indian institutions in engineering and their relationships, The following research questions were considered:

(a) Are patterns of ranking of Indian institutions inengineering discernable according to their typology?

(b) Which Indian institutions in engineering show similar and different research performance trends?

(c) Which ranking methods agree with each other most often?

5. CONCEPTUAL FRAMEWORK

Five methods of assigning ranks to these institutes are used. These ranking systems are ranking in terms of papers; ranking by ACPP, ranking by *p*-index (ranking by quality and quantity combined); ranking by *h*-index (ranking by productivity and impact) and ranking by *g*-index (ranking by the quality and consistency).

Some old insights are reinforced and some new insights emerged. The *h*-index and *g*-index are somewhat related. For an individual or institution, the definitions are as follows:

- ACPP is the ratio of citations (C) and papers (P)
- *h*-index is the highest count h of publications such that each publication has at least h citations.
- *g*-index is the highest count g of publications, such that taken together, has an average of at least g citations per publication.
- *p*-index is also geometric mean of C and C/P modified to the correct dimensionality.

6. METHODOLOGY

6.1 Data Sources and Data Collection

A total of 40 Indian engineering and technological institutes with comparatively higher output of publications during a ten-year period (2000-2009) were identified. These institutes together have published 32926 papers during this period, according to publication data downloaded from *Scopus,* International multidisciplinary bibliographical database. The citations received by papers of these Indian engineering and technological institutes are considered for first three years (three-year citation window) from the date of their publications (C). This allows the average number of citations per paper (C/P) to be computed for each of these institutes for the three-year citation window. Also *h*-indices for these institutes for the same period (i.e., 2000–2009) were determined from the *Scopus* database.

6.2 Analysis Tools

Literal meaning of clustering is to gather to congregate or draw together. In terms of data management, clustering means dividing the data in such a way that similar data points come together. The objective of clustering is forming the groups that are heterogeneous but homogeneous within. With the help of clustering, one can segment the data into small similar regions and thus comment on the overall distribution patterns of the data. Clustering is done on the basis of a similarity measure–attributes/variables to derive the clusters so that data points in one cluster are more similar to another (homogeneous) and data points in separate clusters are less similar or dissimilar to the data points of another cluster. *k*-means clustering uses the partition algorithm which determines all clusters at once. The *k*-means algorithm assigns each point to the cluster whose centroid is the nearest to that point. The centroid is the average of all the points in the cluster.

6.3 Data Analysis

Table 1 show the complete raw data for top 40 Indian engineering and technological institutes, i.e., the number of papers published (P), the citations obtained during the citation window (C) and the average number of citations per paper (C/P). Table 1 shows Hirsch *h*-index[8], *p*-index[1] ($h_m = (C^2P)^{1/3}$, and *g*-index[6]. The ranks of these institutes are calculated the basis of four methods shown in the Table 2 and then *k*-means cluster analysis is applied to segregate the institutes into different clusters. The aim of doing this exercise is to find institutes that display similar research performance.

Table 1. Ranking of Indian institutions in engineering, 2000-09

S. No.	Name	Papers (*P*)	Citations (*C*)	ACPP (*C*/*P*)	*h*-index	*p*-index	*g*-index
1.	Indian Institute of Science, Bengaluru	3559	7770	2.18	46	25.69	76
2.	Indian Institute of Technology, Delhi	3193	6759	2.12	45	24.28	62
3.	Indian Institute of Technology, Kharagpur	3155	5667	1.80	37	21.67	51
4.	Indian Institute of Technology, Chennai	2956	5495	1.86	36	21.70	67
5.	Indian Institute of Technology, Bombay	2298	4740	2.06	36	21.38	51
6.	Indian Institute of Technology, Kanpur	2194	4576	2.09	36	21.21	87
7.	Indian Institute of Technology, Roorkee	1557	2779	1.79	30	17.06	46
8.	Jadavpur University, Kolkata	1488	2362	1.59	24	15.54	44
9.	Anna University, Chennai	1452	1822	1.26	26	13.18	39
10.	University of Delhi, Delhi	720	1152	1.60	20	12.26	30
11.	Indian Institute of Technology, Guwahati	724	1467	2.03	21	14.38	30
12.	Indian Statistical Institute, Kolkata	619	2975	4.81	38	24.27	64
13.	National Institute of Technology, Jamshedpur	540	714	1.32	15	9.81	22
14.	National Institute of Technology, Tiruchirappalli	599	787	1.31	18	10.11	24
15.	PSG College of Technology, Coimbatore	507	334	0.66	12	6.04	18
16.	Bengal Engineering and Science University, Sibpur	483	664	1.38	14	9.70	19
17.	Institute of Technology, Banaras Hindu University	480	786	1.64	16	10.87	22
18.	Cochin University of Science and Technology, Kochi	441	766	1.74	17	11.00	23
19.	Aligarh Muslim University, Aligarh	413	765	1.85	21	11.23	36
20.	University of Calcutta, Kolkata	382	439	1.15	12	7.96	24
21.	National Institute of Technology, Rourkela	378	433	1.15	18	7.91	28
22.	Annamalai University	325	57	0.17	13	2.15	17
23.	University of Bombay, Mumbai	306	692	2.26	19	11.61	29
24.	Banaras Hindu University, Varanasi	302	538	1.78	14	9.86	24
25.	Birla Institute of Technology and Science, Pilani	293	776	2.65	21	12.71	35
26.	Motilal Nehru National Institute of Technology, Allahabad	276	374	1.36	14	7.98	17
27.	University of Pune, Pune	244	815	3.34	19	13.97	23
28.	Osmania University, Hyderabad	265	209	0.79	7	5.48	12
29.	International Institute of Information Technology, Hyderabad	243	325	1.34	7	7.57	15
30.	Thiagarajar College of Engineering, Madurai	280	388	1.39	12	8.13	22
31.	Birla Institute of Technology, Mesra	238	397	1.67	12	8.72	17
32.	Netaji Subhas Institute of Technology, Delhi	236	417	1.77	13	9.04	22
33.	Thapar University, Patiala	233	298	1.28	11	7.24	16
34.	Pondicherry Engineering College	253	278	1.10	9	6.74	17
35.	Jawaharlal Nehru Technological University, Hyderabad	236	190	0.80	7	5.35	11
36.	Andhra University	229	183	0.80	10	5.28	15
37.	Shivaji University, Kohlapur	206	384	1.86	13	8.94	20
38.	Kurukshetra University	202	277	1.37	10	7.24	13
39.	Rashtreeya Vidyalaya College of Engineering, Bengaluru	213	124	0.58	9	5.27	15
40.	Vellore Institute of Technology, Vellore	208	252	1.21	8	6.74	15

Table 2. Clusters on the basis of ranks by different methods

Variable	Cluster centroids				Institutes*
	Rank (ACPP)	Rank (*h*)	Rank (*p*)	Rank (*g*)	
Cluster 1 (7)	8.14	3.57	4.00	3.86	1, 2, 3, 4, 5, 6, 12
Cluster 2 (9)	13.78	11.56	12.00	12.33	7, 8, 9, 10, 11, 19, 23, 25, 27
Cluster 3 (13)	22.85	22.62	23.00	22.00	13, 14, 16, 17, 18, 20, 21, 24, 26, 30, 31, 32, 37
Cluster 4 (11)	30.82	33.82	34.82	33.82	15, 22, 28, 29, 33, 34, 35, 36, 38, 39, 40

**S. No. of institutions of Table 1*

7. RESULTS

Rank (ACPP) has the maximum disagreement with the other ranks. The correlation of rank (ACPP) with rank (*h*), rank (*p*) and rank (*g*) was found to be 0.631, 0.711, and 0.603, respectively. The correlations of rank (*p*) with rank (*h*) and rank (*g*) was found to be 0.937 and 0.916 respectively. Strongest correlation was between rank (*h*) and rank (*g*), which was 0.956.

In cluster 1, 7 institutes were segregated—Indian Institute of Science, Bengaluru; Indian Institute of Technology Delhi; Indian Institute of Technology Kharagpur; Indian Institute of Technology Madras; Indian Institute of Technology Bombay; Indian Institute of Technology, Kanpur, and Indian Statistical Institute, Kolkata.

Cluster 2 has 9 institutes—Indian Institute of Technology, Roorkee; Jadavpur University, Kolkata; Anna University, Chennai; University of Delhi; Indian Institute of Technology, Guwahati; Aligarh Muslim University; University of Bombay, Mumbai; Birla Institute of Technology and Science, Pilani; and University of Pune.

Cluster 3 has 13 institutes—National Institute of Technology, Jamshedpur; National Institute of Technology, Tiruchirappalli; Bengal Engineering and Science University, Sibpur; Institute of Technology, Banaras Hindu University, Varanasi; Cochin University of Science and Technology, Kochi; University of Calcutta , Kolkata; National Institute of Technology, Rourkela; Banaras Hindu University, Varanasi; Motilal Nehru National Institute of Technology, Allahabad; Thiagarajar College of Engineering, Madurai; Birla Institute of Technology, Mesra; Netaji Subhas Institute of Technology, Delhi; and Shivaji University, Kohlapur.

Cluster 4 constitutes of 11 institutes—PSG College of Technology, Coimbatore; Annamalai University; Osmania University, Hyderabad; International Institute of Information Technology, Hyderabad; Thapar University, Patiala; Pondicherry Engineering College; Jawaharlal Nehru Technological University, Hyderabad; Andhra University; Kurukshetra University; Rashtreeya Vidyalaya College of Engineering, Bengaluru; and Vellore Institute of Technology, Vellore.

8. DISCUSSIONS

The expectation that clustering will segregate institutes with varying productivity, impact, quality, and consistency was negated. The clusters have values of ranks on the basis of all the four indices in accordance. At the most, one can categorise the institutes as very high, high, low, and poor on productivity, impact, quality and consistency. This is demonstrated on the basis of aggregate cluster ranks for the four indices.

The ranks of ACPP method have the least agreement with ranks of other indices. The *g*-index was in agreement with *h*-index but *p*-index was also not very different.

9. CONCLUSIONS

The patterns of ranking of Indian institutions in engineering are distinguishable according to their typology. In the first cluster one can find top engineering and technological institutes in the country like IISc and the IITs. Cluster 2 depicts some Indian engineering and technological universities and private institutes that are doing reasonably better in terms of performance. One can find here newly-opened IITs and some established conventional universities. The third cluster portrays national institutes (recently upgraded to the status of institutes of national importance). Here, the finding replicates findings of Prathap & Gupta[1]. They commented, “Although the NITs have been around for a long time (earlier known as RECs), and have been upgraded to the statusof deemed universities and institutes of national importance, their research performance is still dismal”. The worst performance is in cluster 4, mainly constituting state universities.The analysis has been successful in discerning the institutions in showing similar and different research performance trends. The analysis also did well in commenting on the agreement of ranking methods with each other.

The study leaves an open question that can we find an index or a combination of indices which are capable to segregate institutes on the basis of attributes like quality and quantity, productivity and impact, and quality and consistency, e.g., can we segregate institutes that have high impact but are not consistent, or high in productivity but low on impact, etc?

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