Making scientometric and econometric sense out of NIRF 2017 data

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We perform a comparative end-to-end research evaluation of leading engineering institutions in India separating out the bibliometric part of the chain from the econometric part. This combines size-dependent and size-independent terms based on quantity and quality (impact) in a meaningful way. Output or outcome at the bibliometric level is measured using a second-order composite indicator, and the productivity or efficiency terms follow accordingly using the input to output or outcome factors. Data are taken from the recent release of the National Institutional Ranking Framework (NIRF) 2017 in the public domain. Thus, the ranking based on NIRF scores of the Indian Institute of Technology, Madras as the best engineering institution in India is too simplistic a conclusion.

Keywords: Bibliometrics, comparative research evaluation, institutional ranking, size dependence and independence.

THE National Institutional Ranking Framework (NIRF) has just released its 2017 rankings of higher educational institutions across the country. A wealth of scientometric and institutional data are now available in the public domain. In this communication, we focus only on the aspect of research excellence as measured by publications, citations and impact from three different bibliometric databases for the top 25 engineering institutions ranked in 2017. An end-to-end comparative research evaluation of leading engineering institutions in India is performed by separating out the bibliometric part (inner core) of the chain from the econometric part (outer shell). This combines size-dependent and size-independent terms based on quantity and quality (impact) in a meaningful way. Output or outcome at the bibliometric level is measured using a second-order composite indicator, and the productivity or efficiency terms follow accordingly using the input to output or outcome factors.

Savithri and Prathap[1] showed that the research performance of leading higher education institutions in India and China can be summarized from the input end to the outcome end using six primary and secondary bibliometric indicators representing the entire chain of activity: input–output–excellence–outcome–productivity. Principal component analysis indicated that the primary indicators are orthogonal and represent size-dependent quantity and size-independent quality/productivity dimensions respectively. Composite indicators which combine size-dependent and size-independent terms were also needed to measure output and outcome. Data from the 2014 release of the SCImago Institutions Rankings (SIR) were used.

Abramo and D'Angelo[2,3] have recently argued that the use of size-independent citation indicators from the bibliometric part (inner core) of the chain to rank institutions for performance must be combined with the productivity and efficiency measures from the econometric outer loop of assessment. This requires the bibliometric core of the chain (measuring output or outcome using bibliometric indicators) to be separated from the econometric part (the outcome or output to input ratios). That is, to complete the evaluation chain, we must take up the econometric part where efficiency of the research production process is represented in terms of output and outcome productivities based on faculty size and budget or annual expenditures.

NIRF 2017 (https://www.nirfindia.org/EngineeringRanking.html) gives for all assessed institutions bibliometric data from three databases, the Indian Citation Index, Scopus and Web of Science. The total number of publications P reported by the institution and the total number of citations C reported for the three year window 2013–15 are the basic bibliometric data. It also gives the faculty size F and the total annual expenditure for 2016, which we call the spend S. These are all size-dependent or composite indicators of input and output[1–3].

At the inner core of the evaluation, we perform the scientometric or bibliometric assessment. Once a second-order indicator is computed, the efficiency and productivity measures form the econometric part which can be thought of as the outer shell. It is best to demonstrate this with an example. Table 1 shows the bibliometric and econometric assessment for the top institution in the engineering category according to NIRF 2017, namely the Indian Institute of Technology (IIT) Madras. We start with one primary size-dependent input parameter: the number of regular faculty, F. NIRF gives bibliometric data from three databases, as mentioned above. The total number of publications reported (P) and the total number of citations reported (C) for the three year window 2013–15 are the basic bibliometric data. From this, we can compute the impact $i = C/P$, which is an accepted proxy for the quality of the work reported in that database by the institution. Note that P is a size-dependent proxy of quantity of research output, i is a size-independent proxy of quality of research output and C is a composite size-dependent indicator which combines quality and quantity.

A single-valued composite outcome indicator for the research performance of each institution from each database can be computed as the second-order indicator[4] called the exergy term from the quantity (size) and quality (excellence) indicators, $X = i^2P = iC$. We see that X is a scalar measure of total research output. Therefore X/F

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Table 1. Bibliometric and econometric assessment for the top institution in the engineering category according to NIRF 2017, namely the Indian Institute of Technology, Madras

Institution	Indian Institute of Technology, Madras	
No. of regular faculty	F	598
Spend in crores 2015–16	S	530
Publication details		
Indian citation index 2013–15	Papers *P*	112
	Citations *C*	9
	Impact $i = C/P$	0.08
Scopus 2013–15	Papers *P*	3191
	Citations *C*	10,178
	Impact $i = C/P$	3.19
Web of Science 2013–15	Papers *P*	3205
	Citations *C*	10,522
	Impact $i = C/P$	3.28
Total eXergy	$X = \sum iC$	67,008.11
Per capita eXergy	X/F	112.05
Per spend eXergy	X/S	126.43
NIRF score		87.96

Table 2. Summary of bibliometric indicators for the top 25 institutions in the engineering category according to NIRF 2017

NIRF rank	Name of the institution	*F*	*S*	*X*	*X/F*	*X/S*	NIRF score
1	Indian Institute of Technology, Madras	598	530	67,008.11	112.05	126.43	87.96
2	Indian Institute of Technology, Bombay	590	436	85,265.64	144.52	195.66	87.87
3	Indian Institute of Technology, Kharagpur	628	329	123,077.48	195.98	374.15	81.93
4	Indian Institute of Technology, Delhi	547	249	112,630.73	205.91	452.99	81.08
5	Indian Institute of Technology, Kanpur	447	354	57,573.45	128.80	162.56	76.83
6	Indian Institute of Technology, Roorkee	396	248	101,638.95	256.66	409.16	73.10
7	Indian Institute of Technology, Guwahati	372	359	47,806.94	128.51	133.27	72.30
8	Anna University	867	354	45,333.91	52.29	128.06	63.97
9	Jadavpur University	322	92	48,698.15	151.24	530.39	62.59
10	Indian Institute of Technology, Hyderabad	176	85	13,215.97	75.09	154.66	60.24
11	National Institute of Technology, Tiruchirappalli	324	141	29,845.20	92.11	211.67	59.44
12	National Institute of Technology, Rourkela	301	136	24,959.51	82.92	183.66	58.78
13	Vellore Institute of Technology	1596	516	25,001.86	15.67	48.46	58.16
14	Institute of Chemical Technology	108	97	48,643.91	450.41	504.07	57.97
15	Indian Institute of Technology, Indore	99	71	17,140.65	173.14	241.66	57.70
16	Birla Institute of Technology and Science, Pilani	469	335	17,950.59	38.27	53.52	55.43
17	Indian Institute of Engineering Science and Technology, Shibpur	224	100	14,899.84	66.52	148.67	54.42
18	Indian Institute of Technology, Bhubaneswar	122	60	14,606.08	119.72	242.09	54.32
19	Indian Institute of Technology, Patna	122	54	6,109.88	50.08	112.24	54.02
20	Jamia Millia Islamia	103	24	17,035.45	165.39	706.58	53.70
21	Indian Institute of Technology, Ropar	84	68	18,354.98	218.51	269.69	52.93
22	National Institute of Technology, Surathkal	270	108	7,528.79	27.88	69.60	52.87
23	Indian Institute of Technology (Indian School of Mines)	308	176	28,388.22	92.17	161.07	52.58
24	College of Engineering, Pune	243	86	1,219.41	5.02	14.16	52.14
25	Shanmugha Arts Science Technology and Research Academy (Sastra)	587	89	18,214.69	31.03	203.79	51.44
	Minimum	84	24	1,219.41	5.02	14.16	51.44
	Maximum	1596	530	123,077.48	450.41	706.58	87.96
	Maximum/minimum	19	22	100.93	89.76	49.91	1.71
	Pearson's correlation	*F*	*S*	*X*	*X/F*	*X/S*	NIRF score
	F	1.00	0.77	0.30	–0.31	–0.28	0.32
	S	0.77	1.00	0.53	–0.10	–0.31	0.71
	X	0.30	0.53	1.00	0.50	0.39	0.86
	X/F	–0.31	–0.10	0.50	1.00	0.71	0.28
	X/S	–0.28	–0.31	0.39	0.71	1.00	0.13
	NIRF score	0.32	0.71	0.86	0.28	0.13	1.00

and *X*/*S* are size-independent measures of productivity or efficiency of the institution. This exercise is repeated for the top 25 institutions in the NIRF 2017 rankings for engineering.

Table 2 provides a summary of bibliometric indicators of the top 25 institutions in the engineering category according to NIRF 2017. Within these there is a huge range in size, from IIT, Ropar with 84 faculty members to Vellore IIT with 1596 regular faculty, i.e. 19 times more. Jamia Millia Islamia had the lowest annual expenditure during 2015–16 at 24 crores of rupees; IIT Madras (Rs 530 crores) spent twenty-two times as much. College of Engineering, Pune had the lowest output as measured in exergy terms (1219.41) and Indian IIT Kharagpur had the highest (123,077.48), i.e. hundred times more. In terms of per capita output, College of Engineering, Pune was the lowest performer and Institute of Chemical Technology, Mumbai was the best performer, by a factor of 89.76. With respect to the output per crore of rupees of annual expenditure: College of Engineering, Pune was the lowest performer and Jamia Millia Islamia was the best performer, by a factor of 49.91. This range is not seen in the NIRF scores, where the academic aspect which accounts for only a small fraction of the total score along with those from all the other heads and sub-heads has been telescoped into a narrow band, a feature noticed last year as well[5].

Table 2 also shows the Pearson's correlations. Figures 1–5 show some key relationships between *F*, *S*, *X*, *X*/*F*, *X*/*S* and NIRF score as scatter plots. In Figure 1, which is a scatter plot of exergy (*X*) versus faculty strength (*F*), we see that the NIRF ranking of IIT Madras as the best engineering institution in India is too simplistic a conclusion. Figure 2 repeats this story when a scatter plot of exergy versus spend is constructed. From Figure 3 we can propose an alternative ranking based on a second-order

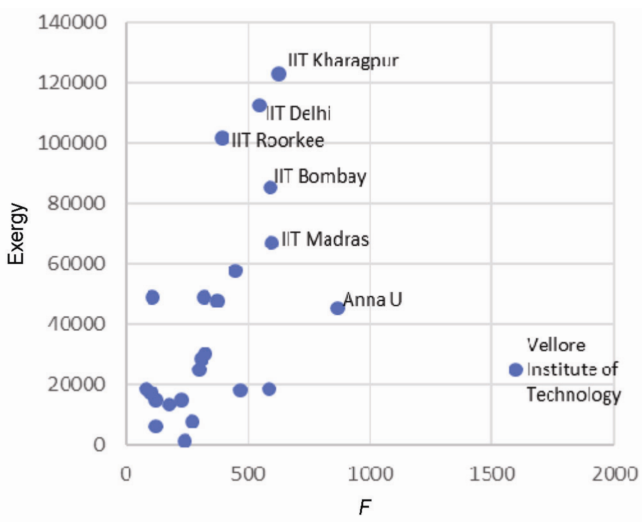

Figure 1. Scatter plot of exergy (*X*) versus faculty strength (*F*).

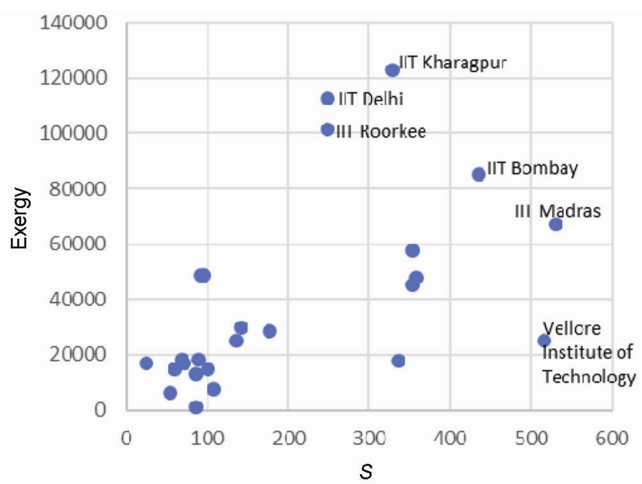

Figure 2. Scatter plot of exergy versus spend (*S*).

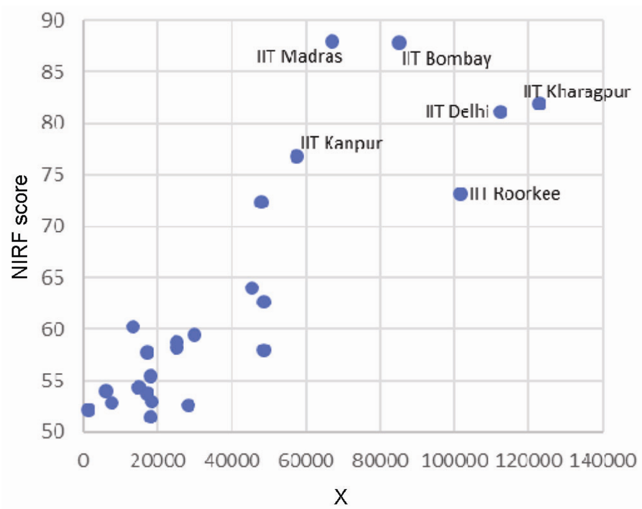

Figure 3. Scatter plot of NIRF score versus exergy (*X*).

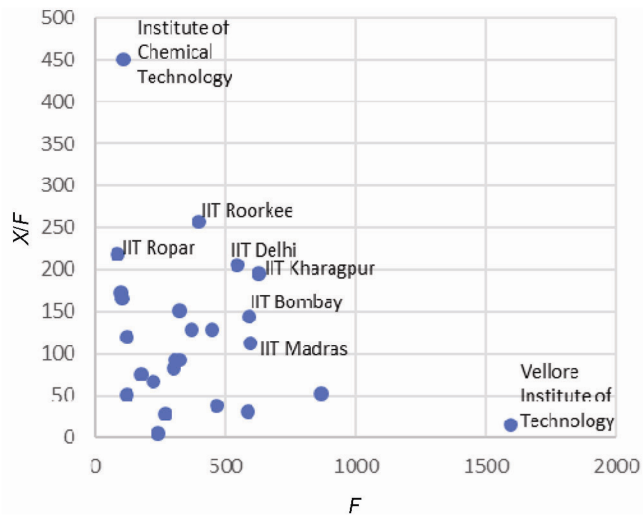

Figure 4. Scatter plot of exergy per faculty (*X*/*F*) score versus faculty strength (*F*).

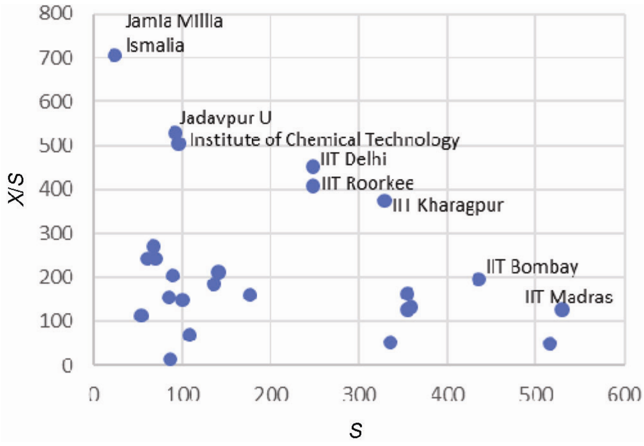

Figure 5. Scatter plot of exergy per crore of spending (*X*/*S*) score versus spend (*S*).

measure of scientometric performance – IITs Kharagpur, Delhi, Roorkee and Bombay rank ahead of IIT Madras. Figure 4 which is the scatter plot of exergy per faculty (*X*/*F*) score versus faculty (*F*) tells an entirely different story. The Institute of Chemical Technology, Mumbai is by far the best performer. In this scheme IIT Madras ranks thirteenth. Figure 5 which is a scatter plot of exergy per crore of spending (*X*/*S*) score versus spend (*S*) tells yet another story. Jamia Millia Islamia is the best performer, followed by Jadavpur University and the Institute of Chemical Technology, Mumbai. Now IIT Madras ranks twentieth. It would seem that throwing more money at the IITs reduces their productivity or efficiency in translating rupees to scientific wealth.

We used the bibliometric data that have been released through the NIRF 2017 rankings to see how the top 25 engineering institutions fare if only research excellence is considered. Performance is decomposed into a size-dependent exergy term and size-independent productivity and efficiency terms. The Pearson's correlation coefficients and scatter plots show that various alternative rankings can be made. A ranking based on a second-order measure of scientometric performance[4] shows that IITs Kharagpur, Delhi, Roorkee and Bombay rank ahead of IIT Madras. If a productivity measure such as exergy per faculty (*X*/*F*) score is chosen, the Institute of Chemical Technology, Mumbai is by far the best performer; here IIT Madras ranks thirteenth. If an efficiency measure such as exergy per crore of spending (*X*/*S*) score is considered, we find that Jamia Millia Islamia is the best performer, followed by Jadavpur University and the Institute of Chemical Technology, Mumbai; here IIT Madras ranks twentieth. It also seems that higher spending only reduces productivity or efficiency in translating rupees to scientific wealth.

The ranking based on NIRF scores of IIT Madras as the best engineering institution in India is too simplistic a conclusion – it is the tragedy of the single story indeed.

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Simulation and experimental validation of hill-climbing algorithm for maximum power point tracking of solar photovoltaic plant

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Variation of solar irradiances plays an important role in changing the parameters of a photovoltaic (PV) module. This communication includes a mathematical model, system design, control algorithm and experimental set-up to obtain the maximum power point on *P*–*V* and *I*–*V* curves of an array. Discussions have been done on all the units of the system and a simulation model developed in MATLAB software using the proposed method. The resultant system is capable of tracking maximum power point without steady-state oscillations and errors in changing environmental conditions. The feasibility and improved functionality of the proposed system have been tested successfully in the laboratory.

Keywords: Hill-climbing algorithm, maximum power point tracking, photovoltaic solar system.

To extract the maximum power from solar arrays of a power plant, the maximum power point (MPP) is tracked on the power–voltage (*P*–*V*) characteristic curve, where a global and local maximum is present. This implies that for different operating points of solar arrays, different output power is obtained; however, the maximum power

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