Late Professor V. Radhakrishnan

In his guest editorial, Arunan[1] has pondered upon the criterion that was used by the selection committee of Raman Research Institute (RRI), (the Raman Trust) for appointing V. Radhakrishnan, son of C. V. Raman, as the Director of the Institute in 1971.

Let me at the outset comment that during 1950s and 1960s, radio astronomers from many countries had made truly outstanding discoveries that revolutionized our understanding of the Universe, such as the discoveries of radio galaxies and quasars, HI from our Galaxy, Microwave Background Radiation that is a consequence of the Big Bang origin of the Universe, Pulsating radio sources (Pulsars) associated with the highly magnetized neutron stars, etc. In 1971, the selection committee of the Raman Trust would have been aware of the important contributions made by Radhakrishnan during 1960s to the rapidly evolving field of radio astronomy that I describe next. The Trust may have also considered that the TIFR had constructed a very large 530 m × 30 m size radio telescope at Ootacamund in South India that had become operational in early 1970, and that RRI scientists could also exploit it for research in the field of radio astronomy.

After his B Sc from the University of Mysore in 1950, Radhakrishnan joined the Chalmers Institute of Technology in 1955 and later the well-known radio astronomy group at Caltech, USA, in 1957. Using the Owens Valley interferometer consisting of two 90-ft parabolic dishes operating at 960 MHz, Radhakrishnan published several important papers during 1959–64 measuring the distributions of polarization in radio galaxies. Another important contribution was his measurement of the polarization of radio waves from the Van Allen-like belts surrounding Jupiter, published in *Physical Review Letters*. Subsequently, he joined the Radio Physics Division of CSIRO, Australia, in 1965 and stayed there till 1971. Using the 64 m Parkes Radio Telescope, Radhakrishnan and his colleagues made a survey of the absorption and emission of 21-cm line emission by the neutral hydrogen towards a large number of galactic and extragalactic radio sources, providing valuable information about the interstellar medium. His pioneering observations made during 1969s, that brought him further international recognition, were three papers (two in *Nature* and one in *ApJ Lett.*) that determined for the first time the rotational model and polarization structure of pulsars, that are associated with the highly magnetized neutron stars. The *ApJ Lett.* has 557 citations as of now. The total number of citations for 32 papers published by Radhakrishnan during 1960–1971 is 1290 (NASA-Astrophys Data System).

Arunan noted that 'to his credit Radhakrishnan has served RRI well during his tenure'. He has also mentioned that Radhakrishnan had built flying machines and boats. I may comment that I wish I had such hobbies! I would also like to note that due to his numerous important scientific contributions, Radhakrishnan was elected as a Fellow of the prestigious National Academy of Sciences in USA in 1996, an honour shared by only about 2000 persons in the world.

1. Arunan, E., *Curr. Sci.*, 2018, **114**(7), 1385–1386.

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Eighteen National Institutes of Technology in the top 100 NIRF engineering ranking

The National Institutional Ranking Framework (NIRF), launched in 2015 by the Ministry of Human Resource Development (MHRD), Government of India, ranks higher educational institutions (HEIs) in the country using India-specific parameters. The ranking for 2018 was announced recently and considers five broad parameters: teaching, learning and resources (30%); research and professional practices (30%); graduation outcomes (20%); outreach and inclusivity (10%), and perception (10%).

In NIRF 2018, 906 institutions participated in the rankings for engineering and NIRF assigned scores to the top 100. Predictably, 8 out of the top 10 positions went to the Indian Institutes of Technology. Out of the next tier of institutes of national importance in the country, namely the National Institutes of Technology (NITs), 18 appeared in the top 100.

In a recent exercise, Prathap[1] identified 20 leading HEIs on their perceived potential to join the ranks of the best universities in the world using a matrix totalization procedure[2] with data from NIRF 2017. As we now have the bibliometric and econometric data for the 18 NITs in NIRF 2018, we repeat this exercise to see how the NITs can be ranked for excellence in a socio-economic and research excellence perspective alone. Using the methodology outlined earlier[1,2], we examine if the research performance of the 18 NITs as well as their earnings related to innovation activities (sponsored research and consultancy) are commensurate with the inputs (faculty and total expenditure) deployed by the institutions. A simple output–input ratio becomes a measure of how the totalized input is productively (or efficiently) translated to output[1,2].

From NIRF data the two key inputs taken cognizance of are the total number of regular faculty, *F*, and the total expenditure, *S*, for three years (2014–17). The key outputs are the total earnings, *E*, for three years (2014–17), and the total bibliometric output, *X*, measured in units of exergy[3]. Both inputs and outputs are in incommensurable units. Here, we

Table 1. Multi-dimensional input and output in terms of total expenditure, *S*, in crores of rupees, total number of regular faculty, *F*, exergy of research output, *X*, and total earnings, *E*, also in crores of rupees, for the 18 NITs ranked in NIRF 2018

Institution	*S*	*F*	∑*X*	*E*
National Institute of Technology, Tiruchirappalli	451	346	44,831	48.13
National Institute of Technology, Rourkela	367	299	48,409	45.58
National Institute of Technology, Surathkal	313	302	16,465	47.85
National Institute of Technology, Warangal	451	309	12,625	28.29
Visvesvaraya National Institute of Technology, Nagpur	275	234	15,645	87.75
National Institute of Technology, Kurukshetra	252	282	10,314	16.95
National Institute of Technology, Durgapur	280	179	18,561	9.79
Motilal Nehru National Institute of Technology, Allahabad	310	215	18,922	16.02
National Institute of Technology, Calicut	274	310	8,828	8.71
Malaviya National Institute of Technology, Jaipur	321	462	17,886	34.06
Maulana Azad National Institute of Technology, Bhopal	156	306	22,011	12.27
National Institute of Technology, Silchar	190	245	11,631	6.98
Sardar Vallabhbhai National Institute of Technology, Surat	253	233	22,931	29.83
National Institute of Technology, Hamirpur	113	193	15,099	9.28
Dr B. R. Ambedkar National Institute of Technology, Jalandhar	189	208	9,379	9.54
National Institute of Technology, Raipur	134	242	7,242	13.45
National Institute of Technology, Agartala	122	228	7,668	10.33
National Institute of Technology, Meghalaya	59	75	1,686	7.00
Total	4,508	4,668	310,133	442

Table 2. Totalized input and output measures after fractionalizing using the conservation rule and recursive improvement, and ranked according to the productivity measure

Rank	Institution	Totalized input (*I*)	Totalized output (*O*)	Totalized *O–I* ratio
1	Visvesvaraya National Institute of Technology, Nagpur	0.056	0.128	2.30
2	National Institute of Technology, Rourkela	0.073	0.128	1.76
3	National Institute of Technology, Tiruchirappalli	0.087	0.126	1.44
4	Sardar Vallabhbhai National Institute of Technology, Surat	0.053	0.071	1.33
5	National Institute of Technology, Surathkal	0.067	0.082	1.22
6	National Institute of Technology, Hamirpur	0.033	0.034	1.04
7	Maulana Azad National Institute of Technology, Bhopal	0.050	0.048	0.97
8	Motilal Nehru National Institute of Technology, Allahabad	0.058	0.048	0.83
9	Malaviya National Institute of Technology, Jaipur	0.085	0.068	0.80
10	National Institute of Technology, Durgapur	0.051	0.040	0.79
11	National Institute of Technology, Meghalaya	0.015	0.011	0.75
12	National Institute of Technology, Raipur	0.041	0.027	0.67
13	National Institute of Technology, Agartala	0.038	0.024	0.64
14	National Institute of Technology, Warangal	0.083	0.053	0.63
15	National Institute of Technology, Kurukshetra	0.058	0.036	0.62
16	Dr. B. R. Ambedkar National Institute of Technology, Jalandhar	0.043	0.026	0.60
17	National Institute of Technology, Silchar	0.047	0.026	0.55
18	National Institute of Technology, Calicut	0.063	0.024	0.38
	Total	1.000	1.000	1.00

follow the procedure of space transformation using matrix multiplication that helps totalize the input and output and allows normalized productivity measures to be defined in terms of these totalized distance measures[4].

Table 1 shows the multi-dimensional input and output in terms of total expenditure in crores of rupees, total number of regular faculty, exergy of research output and total earnings also in crores of rupees, for the 18 NITs chosen from NIRF 2018. After matrix transformation which projects the information in the institution-input and institution-output spaces to an institution space[4], we could derive totalized input and output measures[2]. For this, fractionalizing using the conservation rule and recursive improvement using the network properties have been employed[2]. Table 2 displays the totalized input and output after the multi-dimensional input and output have been projected to an institution space.

Visvesvaraya National Institute of Technology, Nagpur (VNIT) is seen to be the best NIT from the productivity or efficiency point of view. Note that faculty size and expenditure are totalized into a single input term, and earnings and bibliometric output are totalized into a single output term for each institution, and it is VNIT's relatively excellent performance in research and consultancy earnings that takes it to the top spot.

1. Prathap, G., *Curr. Sci.*, 2018, **114**(11), 2234–2238.
2. Prathap, G., *Scientometrics*, 2018, **115**(1), 577–583.
3. Prathap, G., *Scientometrics*, 2011, **87**(3), 515–524.
4. Krauze, T. K. and McGinnis, R., *Scientometrics*, 1979, **1**(5–6), 419–444.

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Is quantification of parameters essential for scientific substantiation?

The Guest Editorial about quantifying quality by Sathyamurthy[1] is highly pertinent in research disciplines. Currently all experimental results need to be projected in quantified measures. Various research fields such as nano, micro, small, medium, large and mega need to be examined from various angles of standardization or quantification. No uniform stick of quantification can be universally applied. For nano and micro-scale measurements one may be required to account for the Heisenberg uncertainty theorem during quantification. For small- and medium-scale measurements, the tolerance of accuracy level could be from Angstrom to a few millimetres. For large measurements such as roads of a few kilometres length, heavy and massive concreting, or displacement of water by a large cargo or passenger ship, quantification could be large. For mega-scale measurements such as astronomical distances in millions of light years, the error or tolerance could be as high as up to 50%. Such measurements are made at an interval of six months of the elliptic orbit of the earth.

I have been working in the fields of earthquake and allied sciences, including earthquake forecasting. I would like to recollect an incidence in 2001. There are documented historical reports that about 3–4 weeks before the occurrence of a large (magnitude > 7.5) earthquake, the groundwater sprouted. This was observed prior to the Great Kutch earthquake of 16 June 1819, Kangra earthquake of 4 April 1905 and Quetta earthquake of 30 May 1935.

During the first week of January 2001, there were reports that a large number of dry wells and nullahs in Kutch (Gujarat), Rajasthan and Sindh Province of Pakistan were suddenly flooded with water oozing out and at some locations water was sprouting in the form of springs. I had e-mailed the Gujarat Government that the sudden appearance of water is positively indicative of the occurrence of a large-magnitude earthquake within 2–3 weeks. Incidentally my email did not receive the desired priority and an earthquake occurred on 26 January 2001. However, my e-mail was subsequently acknowledged.

When I discussed the appearance of water as a reliable seismic precursor at a conference, I was told to quantify the oozing water. This is an impossible task. Another reliable seismic precursor often ridiculed or laughed at is the abnormal animal behaviour. One of the reasons is that it cannot be quantified. However, this has been observed and reported after all large earthquakes such as the Uttarkashi earthquake of 1991, Latur earthquake of 1993, Bhuj earthquake of 2001, Sumatran earthquake and tsunami of 2004 and Kashmir earthquake of 2005. The oldest record of abnormal animal behaviour before an earthquake is available for the Kangra earthquake of 4 April 1905 (ref. 2). At that time India and Pakistan were under British rule. The Lahore Zoo was a famous landmark of the then Punjab. The distance between Lahore and Kangra is about 180 km. The then British Zoo Superintendent at Lahore Zoo was awakened during the wee hours of 4 April 1905 by the shrilling noise of zoo animals. He went around the zoo with food and water, but no animal was ready for it. All the animals were hostile and aggressive.

Though abnormal animal behaviour has been observed and recorded before all medium to large earthquakes, it is not accepted because it cannot be quantified. Quantification of water oozing from the ground, and abnormal animal behaviour before a large magnitude earthquake cannot be quantified, but these are highly reliable and should be used by the authorities for mitigation measures.

Quantification of any parameter in scientific research is definitely required, but if the parameter cannot be quantified, its basic properties and reliability should not be disregarded.

1. Satyamurthy, N., *Curr. Sci.*, 2017, **113**(1), 7–8.
2. Bapat, A., *Curr. Sci.*, 2008, **95**(3), 318–319.

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