Research performance of the National Institutes of Technology in India

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This article presents a bibliometric assessment of research performance of the National Institutes of Technology (NITs) in India. While many of these institutes were originally established in 1960s as Regional Engineering Colleges (RECs), they were upgraded to NITs around 2002 and later. Initially NITs offered only undergraduate programmes in engineering. However, during the last decade, several NITs have started postgraduate teaching and are focusing more on research activities. It is in this context that this article assesses the research performance of NITs during 2005–2016. The performance assessment uses research publication data obtained from the Web of Science index. The data collected are computationally analysed to identify productivity, productivity per capita, rate of growth of research, international collaboration pattern, citation impact and discipline-wise distribution of the research output for the NITs. The performance of NITs is also viewed vis-à-vis two top-performing Indian institutions, namely Indian Institute of Science, Bengaluru and Indian Institute of Technology Bombay, Mumbai. A simple single-value composite ranking of research performance of NITs is also presented by combining quantity and quality factors. The study presents an informative and useful account of assessment of research work in the NITs.

Keywords: Bibliometric assessment, research performance, scientometrics, technological institutes.

THE engineering and technology education and research in India is currently dominated by the Indian Institutes of Technology (IITs), a few Centrally Funded Technological Institutions (CFTIs) and the National Institutes of Technology (NITs). While IITs have earned a distinguished position over time, NITs have also started showing impressive performance. However, in comparison to IITs, NITs have traditionally focused more on undergraduate education and less on research activities until they were upgraded from Regional Engineering Colleges (RECs) to NITs. There are now 31 NITs in India, each in a different state. These include the 14 old NITs (known as RECs earlier) established before 1965, 6 institutions made NITs at later dates, 10 new NITs established in 2010 and the recent one in Andhra Pradesh. NITs are now quite autonomous in nature and are governed by the National Institutes of Technology, Science Education and Research Act, 2007 of Indian Parliament, which also declares them as Institutes of National Importance. These institutions receive special recognition and funding from the Government of India (GoI). They are among the top ranked engineering colleges in the country and have one of the lowest acceptance rates for engineering institutions. NITs, therefore, play an important role in engineering and technology education in India. During the last decade, many NITs have focused on promoting research activities. It is in this context, that the present study analyses research performance of NITs during the period 2005–2016, in terms of quantity as well as quality of research output.

Origin and transformation of RECs to NITs

The first Prime Minister of India, Jawaharlal Nehru, envisioned developing India as a leader in science and technology (S&T). This resulted in the establishment of higher technological institutions like the IITs and RECs. GoI started 14 RECs (jointly with State Governments) during the period 1959–1965 at Bhopal, Allahabad, Kozhikode, Durgapur, Kurukshetra, Jamshedpur, Jaipur, Nagpur, Rourkela, Srinagar, Surathkal, Surat, Tiruchirappalli and Warangal. A new REC in Silchar was established in 1967. Two more RECs at Hamirpur and Jalandhar were established in 1986 and 1987 respectively. RECs were jointly supported by the Central Government and the concerned State Government in a manner that non-recurring expenditure and that for postgraduate courses were borne by the Central Government, whereas recurring expenditure on undergraduate courses was shared equally by the Central and State Governments.

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In 2002, the Ministry of Human Resource Development (MHRD), GoI decided to upgrade RECs to NITs. Thus in 2003, 17 RECs were upgraded as NITs with greater functional autonomy and single-point financial support from the Central Government. These institutions were granted Deemed to be University status (under that University Grants Commission Act, 1956 (3 of 1956)) with effect from 26 June 2002. Many of these changes were based on recommendations of the high-powered review committee chaired by R. A. Mashelkar, which submitted its report in 1998 entitled 'Strategic Road Map for Academic Excellence of Future RECs'. In 2006, MHRD, GoI, granted NIT status to three more engineering colleges located at Patna, Raipur and Agartala. In August 2007, NITSER Act, 2007 was promulgated, in which NITs were pronounced as Institutes of National Importance under an Act of Parliament. In May 2009, the first Statutes of NIT were notified by the Central Government. The transformation from regional colleges to institutes of national importance created new opportunities for these institutions. Ten more NITs were announced in 2009 in the remaining States/Union Territories, making the total number of NITs in the country as 30. The most recent addition in the reorganized Andhra Pradesh is the 31st NIT, added to the list by an amendment Act of July 2016. Thus at present, we have NITs that have existed for a long-term and those which have been recently established.

On an average NIT funding has reached Rs 100 crores annually by 2011, in addition to Rs 20–25 crores that they have been receiving under the World Bank-funded Technical Education Quality Improvement Programme (TEQIP I and TEQIP II). In 2014, the Kakodkar committee submitted its report titled 'NITs as drivers for quality higher technical education: the way forward'[1], wherein it emphasized on the need of 'high quality faculty, innovative research, excellent teaching, learning and evaluation methods, industry linkages, and institutional social responsibility' in NITs. The report stated that 'the overriding aim of NITs must be to attract the brightest engineering talent in the country and shape them into excellent researchers or competent teachers'. NITs have recently started focusing on research activities, with some of them producing a significant amount of quality research output.

Related work

There exist few previous studies on research performance assessment of Indian technological institutions. Some of them focus exclusively on a group of institutions, such as IITs[2], IISERs[3] and Central Universities[4]; whereas some others focus on top-performing institutions or regions[5]. Some of the notable past works on Indian institutions are as follows: the top 30 Indian engineering and technological institutions were identified according to their research performance in the time period 1999–2008 (ref. 6). In a later work[7], research performance of seven older IITs was benchmarked based on research output data from the Web of Science (WoS) and Scopus. In a more recent work[8], the research performance of higher educational institutions in India was mapped using SCImago Institutions Rankings (SIR) World Reports of 2013 (ref. 9), which in turn was based on the indexed data from Scopus for the period 2007–2011. In another study[10], authors performed an impact–citation–exergy (iCX) trajectory analysis of leading research institutions in India for some top performing institutions. The only previous work found exclusively for NITs is by Bala and Kumari[11]. It focused on bibliometric analysis of research performance of NITs as a set and used research publication data indexed in Scopus[12] for the period 2001–2010. Research performance assessment of 20 NITs was made in the study. The present study provides detailed bibliometric analysis on parameters of total papers (TP), total citations (TC), average citations per paper (ACPP), *h*-index, international collaborative paper (ICP), etc. and ranks the set of 31 NITs on quantity and quality parameters. It also identifies the most prolific authors, top publication sources, most cited papers and discipline-wise distribution of research output.

Data

The research performance analysis is based on research output data for the period 2005–2016 for the 31 NITs collected from the WoS database[13]. The older NITs have publications throughout the period, whereas the newer ones have started publishing only recently. The data have been collected through an institution-wise search using search strings of the form: (CU = INDIA AND OG = (NIT BHOPAL OR MAULANA AZAD COLL ENGN and TECHNOL OR MAULANA AZAD NATIONAL INSTITUTE OF TECHNOLOGY BHOPAL)), which is the search string used for NIT Bhopal. The publication records were analysed computationally by writing programs in R language. The publication records were also grouped into different subject categories for visualization of discipline-wise research performance results.

Research productivity

Table 1 presents basic data about establishment year, existing faculty strength and total research output of all the NITs. It can be observed that older NITs have substantially more research output than the newer ones. NIT Trichy (NITT) is the most productive institution for the whole 12-year period (2005–2016). Here is relevant to note that all NITs taken together contribute about 3.12% to the total research papers published from India (650,754) as

Table 1. Data for 31 National Institutes of Technology

Institution	Abbreviation	Year of establishment	Conversion to NIT	Existing faculty strength*	Total Research output (2005–2016)	Total Research output (2005–2010)	Total Research output (2011–2016)
NIT Trichy	NITT	1964	2003	228	2749	807	1942
NIT Rourkela	NITRKL	1961	2002	315	2621	545	2076
NIT Surathkal	NITK	1960	2002	229	1400	385	1015
NIT Durgapur	NITDGP	1960	2003	190	1345	266	1079
NIT Surat	SVNIT	1961	2003	174	1329	201	1128
NIT Warangal	NITW	1959	2002	245	1113	275	838
Motilal Nehru NIT, Allahabad	MNNIT	1961	2001	213	1112	246	866
NIT Kurukshetra	NITKKR	1963	2002	213	999	270	729
NIT Calicut	NITCLC	1961	2002	152	992	234	758
Dr B.R. Ambedkar NIT, Jalandhar	NITJLN	1960	2002	113	974	234	740
NIT Hamirpur	NITHP	1986	2002	132	910	272	638
Visvesvaraya NIT, Nagpur	VNIT	1960	2002	424	874	185	689
Malaviya NIT, Jaipur	MNIT	1963	2002	213	772	127	645
Maulana Azad NIT, Bhopal	MANIT	1960	2002	188	667	117	550
NIT Silchar	NITS	1967	2002	145	508	71	437
NIT Agartala	NITAG	1965	2006	225	432	14	418
NIT Raipur	NITRR	1956	2005	244	403	38	365
NIT Srinagar	NITSRI	1960	2003	111	229	60	169
NIT Jamshedpur	NITJSR	1960	2002	168	215	54	161
NIT Uttarakhand	NITUK	2010	NA	77	174	50	124
NIT Patna	NITP	1886	2004	124	147	6	141
NIT Meghalaya	NITMGH	2007	NA	73	103	0	103
NIT Manipur	NITMNP	2010	NA	67	45	0	45
NIT Delhi	NITDEL	2010	NA	40	44	0	44
NIT Arunachal Pradesh	NITAR	2010	NA	53	35	0	35
NIT Puducherry	NITPY	2010	NA	32	35	0	35
NIT Goa	NITGOA	2010	NA	36	28	0	28
NIT Nagaland	NITNL	2010	NA	42	22	0	22
NIT Mizoram	NITMZ	2010	NA	32	19	0	19
NIT Sikkim	NITSKM	2010	NA	36	11	0	11
NIT Andhra Pradesh	NITAP	2015	NA	53	–	–	–

*Data collected between 15 and 31 December 2017.

indexed in WoS for the period 2005–2016. It can be seen that 7 NITs have output more than 1000 (during 2005–2016, i.e. annual average output of more than 80 papers). For a better understanding of the growth of research output, data were divided into two time periods of six years each, i.e. 2005–2010 and 2011–2016. The first important result from Table 1 is that during the recent six-year period (2011–2016), all NITs taken together show 3.5 times more research output compared to the older six-year period (2005–2010), a growth rate of more than 350%. In the time-period 2005–2010, NITT leads the list, whereas for 2011–2016, NITRKL is the most productive institution. For the time period 2011–2016, five NITs (NITRKL, NITT, NITDGP, NITK and SVNIT) have research output more than 1000 papers each (which amounts to an average annual output of more than 160 papers). Thus, it can be concluded that NITs have doubled their annual research output during the recent six years compared to the period 2005–2010. Among the newer NITs, NITUK obtains impressive research output.

Table 2 presents computed scientometric indicator values for the 30 NITs (except the newly established NIT Andhra Pradesh) for the recent five-year period (2012–2016). It can be seen that NITT leads the table in almost all the indicators, except TP, ACCP and highly cited papers (HiCP). For TP, NITRKL leads the table with 1906 research publications. For ACPP, MANIT ranks highest, but its total output is not even in the top-10 most productive NITs (510). NITT is not far behind with regard to this indicator value as well. For HiCP, SVNIT ranks highest among all NITs. From these entire computed indicator values, NITT seems to have the most promising research activity with impressive indicator values among all NITs. Among the new NITs, NITUK obtains high values in almost all indicators, except ACCP. NITMGH has the highest ACPP value (3.456) among new NITs. For *h*-index, NITT obtains the highest value of 40, followed by NITRKL with a value of 36. The quality parameters of research output (*h*-index and HiCP) are further analysed in a sliding time window of 5 years each (Table 3). The NITT has consistently highest *h*-index for all eight sliding windows. For HiCP, MANIT has highest values for most of the sliding windows, except the three recent ones.

For a better visualization of publications per capita, in Figure 1 TP versus existing faculty strength for NITs for period 2012–2016 is plotted. Here, faculty strength value

Table 2. Computed indicator values for NITs during 2012–2016

Institutes	TP	PPC	TC	ACPP	HiCP	ICP	*h*-index
NITRKL	**1906**	6.051	13,655	7.164	19	256	36
NITT	1710	**7.5**	**13,857**	8.104	11	**331**	**40**
SVNIT	1021	5.868	8,538	8.362	**20**	162	34
NITDGP	961	5.058	7,439	7.741	15	131	33
NITK	865	3.777	4,849	5.606	5	200	26
MNNIT	798	3.746	5,852	7.333	9	139	31
NITW	762	3.11	4,390	5.761	6	98	25
NITCLC	680	4.474	3,909	5.749	9	83	27
NITKKR	676	3.174	3,360	4.97	2	69	24
NITJLN	662	5.858	3,502	5.29	3	89	24
VNIT	626	1.476	3,617	5.778	7	91	24
MNIT	606	2.845	3,622	5.977	8	136	26
NITHP	543	4.114	3,715	6.842	4	67	29
MANIT	510	2.713	5,007	**9.818**	**20**	88	35
NITS	409	2.821	2,208	5.399	0	24	18
NITAG	402	1.787	1,921	4.779	3	29	19
NITRR	349	1.43	1,553	4.45	2	39	17
NITJSR	158	0.94	943	5.968	1	24	15
NITSRI	155	1.396	577	3.723	0	22	12
NITP	133	1.073	436	3.278	0	31	10
NITUK	112	1.455	384	3.429	0	20	10
NITMGH	103	1.411	356	3.456	0	12	8
NITMNP	45	0.672	80	1.778	0	3	5
NITDEL	44	1.1	378	8.591	2	21	8
NITAR	35	0.66	80	2.286	0	3	5
NITPY	34	1.063	140	4.118	0	4	7
NITGOA	28	0.778	112	4	1	7	6
NITNL	22	0.524	57	2.591	0	3	4
NITMZ	19	0.594	64	3.368	0	2	5
NITSKM	11	0.306	39	3.545	0	1	3

TP, Total papers; TC, Total citations; ACPP, Average citations per paper; HiCP, Papers in top 1% cited papers; ICP, Internationally collaborative papers; PPC, Papers per capita.

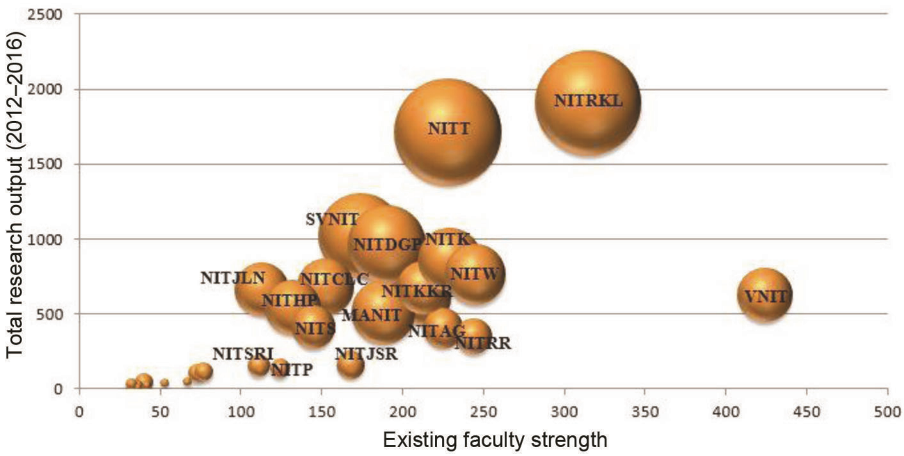

Figure 1. Research output–faculty strength plot of NITs (2012–2016).

lies on the *x*-axis and TP value on the *y*-axis. The bubble sizes are proportional to TC values. It can be observed that NITT and NITRKL have higher publications per capita (PPC) value than other NITs, which shows higher faculty productivity of these older established NITs. As budget data for whole time period for all NITs were not available, the economic aspect of productivity could not be evaluated. It is also interesting to observe that during the last five-year period the total research output of all NITs together is 14,385 compared to 20,307 for the period 2005–2016. This shows that most of the research papers (about 70%) have been published during the recent five-year period. Table 4 presents indicator values (namely TP, TC, ACPP and *h*-index) for two top

Table 3. Key scientometric parameters in sliding windows

	2005–09		2006–10		2007–11		2008–12		2009–13		2010–14		2011–15		2012–16	
Institution	*h*-index	HiCP	*h*-index	HiCP	*h*-index	HiCP	*h*-index	HiCP	*h*-index	HiCP	*h*-index	HiCP	*h*-index	HiCP	*h*-index	HiCP
NITT	47	2	53	4	55	8	56	11	56	13	53	14	46	14	40	11
NITRKL	46	1	50	4	51	6	51	8	50	9	44	12	40	15	36	19
MANIT	36	15	39	17	34	14	36	12	38	14	36	13	35	15	35	20
NITK	35	2	39	2	39	2	38	1	37	1	32	1	29	3	26	5
NITCLC	32	4	36	2	36	1	34	1	32	1	30	2	29	7	27	9
NITHP	31	1	34	1	35	2	35	2	34	2	32	3	30	4	29	4
NITW	30	0	29	1	26	1	26	1	29	3	29	5	27	4	25	6
MNNIT	29	4	33	5	36	5	38	6	38	8	36	8	33	8	31	9
NITDGP	29	0	37	2	39	5	40	10	40	11	39	12	36	14	33	15
NITKKR	29	0	29	1	29	1	29	1	28	1	26	1	26	1	24	2
SVNIT	28	1	36	0	37	1	39	4	41	10	40	13	36	17	34	20
NITJLN	23	2	27	2	29	3	28	3	27	3	27	1	26	2	24	3
VNIT	23	0	26	0	30	1	30	1	29	1	29	2	26	5	24	7
NITS	22	2	22	2	26	4	26	4	25	2	25	2	24	2	18	0
MNIT	19	0	24	0	24	0	24	0	26	0	28	2	26	3	26	8
NITJSR	14	1	13	1	13	1	12	1	13	0	15	0	15	0	15	1
NITSRI	11	0	12	0	13	0	12	0	13	0	12	0	12	0	12	0
NITUK	11	0	12	0	12	0	12	0	12	0	10	0	10	0	10	0
NITRR	8	0	12	0	15	0	15	0	15	0	17	0	18	0	17	2
NITAG	6	0	8	0	10	0	13	0	16	0	18	0	19	0	19	3
NITP	2	0	3	0	6	0	7	0	8	0	10	0	10	0	10	0
NITAR	–	0	–	0	–	0	–	0	–	0	1	0	4	0	5	0
NITDEL	–	0	–	0	–	0	–	0	4	0	8	2	8	2	8	2
NITGOA	–	0	–	0	–	0	–	0	–	0	3	0	5	0	6	1
NITMNP	–	0	–	0	–	0	1	0	3	0	4	0	5	0	5	0
NITMGH	–	0	–	0	–	0	–	0	2	0	5	0	8	0	8	0
NITMZ	–	0	–	0	–	0	–	0	2	0	3	0	4	0	5	0
NITNL	–	0	–	0	–	0	–	0	2	0	3	0	4	0	4	0
NITPY	–	0	–	0	–	0	–	0	1	0	6	0	7	0	7	0
NITSKM	–	0	–	0	–	0	1	0	2	0	2	0	3	0	3	0

Table 4. Data for two top performing Indian institutions (2012–2016)*

Institution	Year	TP	TC	ACPP	*h*-index
Indian Institute of Technology Bombay (IITB), Mumbai	2012	934	12,989	13.91	47
	2013	1041	16,841	16.18	51
	2014	1156	12,599	10.90	41
	2015	1361	8,770	6.44	31
	2016	1487	4,920	3.31	23
Indian Institute of Science (IISc), Bengaluru	2012	1602	22,066	13.77	52
	2013	1714	21,534	12.56	51
	2014	1827	16,906	9.25	43
	2015	1942	12,303	6.34	35
	2016	1928	7,013	3.64	23

*Data as on 15 January 2018 in the Web of Science (WoS).

performing institutions, viz. IITB and IISc for the period 2012–2016 to help assess relative research performance of NITs. Significant difference in indicator values of these two top performing institutions and NITs can be clearly observed. It is observed that during 2012–2016, the most productive NIT (NITRKL) published a total of 1906 research papers compared to 5979 research papers by IITB and 9013 by IISc for the same period. Similarly, ACPP value for most of the NITs is around 7–8 compared to values in the range 12–16 for IITB. These comparative values show that NITs will have to focus more on research activity to achieve the research performance levels of top performing engineering institutions.

Citations and impact

The cited–uncited papers ratio is computed to examine the usefulness of research outputs of NITs. Figure 2 plots

Table 5. Twenty-five most cited papers from NITs research output data (2005–2016)

Publication year	Title	Authors	Affiliation	Citations	WoS category
2006	Heart rate variability: a review	Acharya, U. R., Joseph, K. P., Kannathal, N., Lim, C. M. and Suri, J. S.	NITCLC and Others (ICP)	667	Computer science, Interdisciplinary Applications; Engineering, Biomedical; Mathematical and Computational Biology and Medical Informatics
2005	Biodiesel production from high FFA rubber seed oil	Ramadhas, A. S., Jayaraj, S. and Muraleedharan, C.	NITCLC	627	Energy and Fuels; Engineering, Chemical
2011	Teaching–learning-based optimization: A novel method for constrained mechanical design optimization problems	Rao, R. V., Savsani, V. J. and Vakharia, D. P.	SVNIT	579	Computer Science, Software Engineering
2009	Perspectives for chitosan based antimicrobial films in food applications	Dutta, P. K., Tripathi, S., Mehrotra, G. K. and Dutta, J.	MNNIT and others	537	Chemistry, Applied; Food Science and Technology; Nutrition and Dietetics
2013	Astropy: a community Python package for astronomy	Robitaille, T. P., Tollerud, E. J., Greenfield, P., Droettboom, M., Bray, E., Aldcroft, T., Davis, M., Ginsburg, A., Price-Whelan, A. M., Kerzendorf, W. E., Conley, A., Crighton, N., Barbary, K., Muna, D., Ferguson, H., Grollier, F., Parikh, M. M., Nair, P. H., Guenther, H. M., Deil, C., Woillez, J., Conseil, S., Kramer, R., Turner, J. E. H., Singer, L., Fox, R., Weaver, B. A., Zabalza, V., Edwards, Z. I., Bostroem, K. A., Burke, D. J., Casey, A. R., Crawford, S. M., Dencheva, N., Ely, J., Jenness, T., Labrie, K., Lim, P. L., Pierfederici, F., Pontzen, A., Ptak, A., Refsdal, B., Servillat, M. and Streicher, O.	SVNIT & Others (ICP)	505	Astronomy and Astrophysics
2012	Simple one-step synthesis of highly luminescent carbon dots from orange juice: application as excellent bio-imaging agents	Sahu, S., Behera, B., Maiti, T. K. and Mohapatra, S.	NITRKL and others	496	Chemistry, Multidisciplinary
2012	Bioethanol production from agricultural wastes: an overview	Sarkar, N., Ghosh, S. K., Bannerjee, S. and Aikat, K.	NITDGP	445	Green and Sustainable Science and Technology; Energy and Fuels
2009	Pretreatments of natural fibres and their application as reinforcing material in polymer composites – a review	Kalia, S., Kaith, B. S. and Kaur, I.	NITJLN and others	422	Engineering, Chemical; Polymer Science
2008	Adsorption of phenolic compounds on low-cost adsorbents: a review	Ahmaruzzaman, M.	NITS	404	Chemistry, Physical

(*Contd*)

Table 5. (*Contd*)

Publication year	Title	Authors	Affiliation	Citations	WoS category
2012	Photo-catalytic degradation of toxic dye amaranth on TiO_2/UV in aqueous suspensions	Gupta, V. K., Jain, R., Mittal, A., Saleh, T. A., Nayak, A., Agarwal, S. and Sikarwar, S.	MANIT and others (ICP)	384	Materials Science, Biomaterials
2009	Adsorptive removal of hazardous anionic dye 'Congo red' from wastewater using waste materials and recovery by desorption	Mittal, A., Mittal, J. Malviya, A. and Gupta, V. K.	MANIT and others	373	Chemistry, Physical
2012	Teaching-learning-based optimization: an optimization method for continuous non-linear large scale problems	Rao, R. V., Savsani, V. J. and Vakharia, D. P.	SVNIT	367	Computer Science, Information Systems
2013	A comparative study on maximum power point tracking techniques for photovoltaic power systems	Subudhi, B. and Pradhan, R.	NITRKL	358	Green and Sustainable Science and Technology Energy and Fuels; Engineering, Electrical and Electronic
2005	Performance and emission evaluation of a diesel engine fueled with methyl esters of rubber seed oil	Ramadhas, A. S., Muraleedharan, C. and Jayaraj, S.	NITCLC	328	Green and Sustainable Science and Technology; Energy and Fuels
2010	Life cycle energy analysis of buildings: an overview	Ramesh, T., Prakash, R. and Shukla, K. K.	MNNIT	320	Construction and Building Technology; Energy and Fuels; Engineering, Civil
2013	Synthesis of a novel and stable $g-C_3N_4–Ag_3PO_4$ hybrid nanocomposite photocatalyst and study of the photocatalytic activity under visible light irradiation	Kumar, S., Surendar, T., Baruah, A. and Shanker, V.	NITW and others	318	Chemistry, Physical; Energy and Fuels; Materials Science, Multidisciplinary
2009	Adsorption studies on the removal of coloring agent phenol red from wastewater using waste materials as adsorbents	Mittal, A., Kaur, D., Malviya, A., Mittal, J. and Gupta, V. K.	MANIT and others (ICP)	311	Chemistry, Physical
2011	Adsorption thermodynamics, kinetics and isosteric heat of adsorption of malachite green onto chemically modified rice husk	Chowdhury, S., Mishra, R., Saha, P. and Kushwaha, P.	NITDGP	297	Engineering, Chemical; Water Resources
2010	Removal and recovery of Chrysoidine Y from aqueous solutions by waste materials	Mittal, A., Mittal, J., Malviya, A. and Gupta, V. K.	MANIT and others (ICP)	294	Chemistry, Physical
2010	Adsorption of hazardous dye crystal violet from wastewater by waste materials	Mittal, A., Mittal, J., Malviya, A., Kaur, D. and Gupta, V. K.	MANIT and Others (ICP)	289	Chemistry and Physical
2007	Photochemical degradation of the hazardous dye Safranin-T using TiO_2 catalyst	Gupta, V. K., Jain, R., Mittal, A., Mathur, M. and Sikarwar, S.	MANIT and others	288	Chemistry, Physical
2012	Iron(III) selective molecular and supramolecular fluorescent probes	Sahoo, S. K., Sharma, D., Bera, R. K., Crisponi, G. and Callan, J. F.	SVNIT and others (ICP)	288	Chemistry, Multidisciplinary

(*Contd*)

Table 5. (*Contd*)

Publication year	Title	Authors	Affiliation	Citations	WoS category
2010	Experimental investigations and theoretical determination of thermal conductivity and viscosity of Al_2O_3/water nanofluid	Chandrasekar, M., Suresh, S. and Bose, A. C.	NITT	284	Thermodynamics; Engineering, Mechanical; Physics, Fluids and Plasmas
2006	Removal and recovery of the hazardous azo dye acid orange 7 through adsorption over waste materials: bottom ash and de-oiled soya	Gupta, V. K., Mittal, A., Gajbe, V. and Mittal, J.	MANIT	280	Engineering, Chemical
2010	Decoloration treatment of a hazardous triarylmethane dye, light Green SF (yellowish) by waste material adsorbents	Mittal, A., Mittal, J., Malviya, A., Kaur, D., and Gupta, V. K.	MANIT and others (ICP)	275	Chemistry, Physical

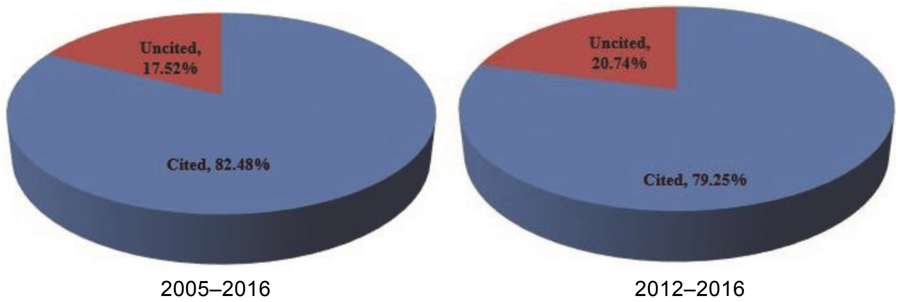

Figure 2. Cited versus uncited paper ratio.

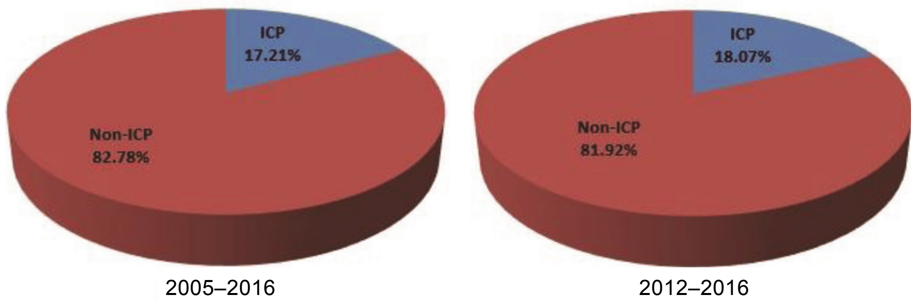

Figure 3. International Collaborative Papers (ICP) versus Non-ICP paper proportions.

cited–uncited percentages for combined research output of all NITs for 2005–2016 and 2012–2016. It is observed that more than 80% of total research papers of all NITs combined is cited. Further, citation-based indicators are also computed for NITs, including ACPP and HiCP values. The HiCP is computed for the set only, i.e. the top 1% most cited papers of the set is counted as HiCP. Table 5 presents the 25 most cited papers from among those published by all NITs taken together. It is observed that MANIT has the highest number of highly cited papers (7) followed by SVNIT (4). The Chemistry group from MANIT appears to have authored several of the highly cited papers. Similarly, there are other highly cited research groups in other NITs. Table 6 presents the proportionate contribution of all NITs to HiCP (the top 1% highly cited papers of the set). It can be seen that MANIT contributes 18.1%, followed by NITRKL with 11.9%, and SVNIT and NITDGP with 10.5% and 9.5% respectively. In terms of HiCP (as percentage of TP), MANIT has about 5.7% of its total publication as HiCP.

Table 6. Highly cited papers share within NITs (2005–2016)

NITs	HiCP	TP	HiCP as % of TP	% Share of HiCP of all NITs taken together
MANIT	**38**	**667**	**5.7**	**18.1**
NITRKL	25	2,621	1	11.9
SVNIT	22	1,329	1.7	10.5
NITDGP	20	1,345	1.5	9.5
NITT	19	2,749	0.7	9
MNNIT	14	1,112	1.3	6.7
NITCLC	13	992	1.3	6.2
MNIT	8	772	1	3.8
VNIT	8	874	0.9	3.8
NITK	7	1,400	0.5	3.3
NITW	7	1,113	0.6	3.3
NITJLN	6	974	0.6	2.9
NITHP	6	910	0.7	2.9
NITS	4	508	0.8	1.9
NITAG	3	432	0.7	1.4
NITKKR	3	999	0.3	1.4
NITDEL	2	44	4.5	1
NITJSR	2	215	0.9	1
NITRR	2	403	0.5	1
NITGOA	1	28	3.6	0.5
NITAR	0	35	0	0
NITMNP	0	45	0	0
NITMGH	0	103	0	0
NITMZ	0	19	0	0
NITNL	0	22	0	0
NITP	0	147	0	0
NITPY	0	35	0	0
NITSKM	0	11	0	0
NITSRI	0	229	0	0
NITUK	0	174	0	0

International collaboration

The ICP by NITs have also been identified. Figure 3 shows that around 18% of the total research output of all NITs taken together involves international collaboration. The international collaboration pattern for all NITs with top collaborating countries is identified by analysing data. Table 7 presents the number of ICP for all the NITs with major collaborating countries. It can be observed that USA accounts for the highest number of ICP. South Korea, Malaysia and UK are other major collaborating countries. This is slightly different from international collaboration patterns of universities in India. However, it is a welcome fact that NITs are producing internationally collaborated research output. NITT, NITK, NITRKL, etc., are some major NITs showing higher number of ICP.

Discipline-wise research output distribution

The present study also identifies discipline-wise distribution of research output of all NITs. For this, the publication records of all NITs taken together are processed to assign every research paper into a given subject discipline (based on discipline categorization proposed in an earlier work)[14]. Figure 4 presents the discipline-wise distribution of research output during 2005–2011 and 2012–2016. It can be observed that similar productivity patterns (with higher output in physics, materials science and chemistry) are obtained for both time periods. This shows that NITs have continued to do research in similar disciplines, with the same proportion, over the period of 12 years. Table 8 shows the discipline-wise research output levels of all NITs during 2005–2016. Physics, chemistry and materials science are highly researched disciplines in almost all NITs. NITT has the highest number of papers in physics, chemistry and most other disciplines as well. NITRKL leads the table in computer science (CS), biological sciences (BIO), mathematics (MATHS), etc.

Composite rank of research performance

This study computes a composite rank of research performance of the set of NITs. Two composite ranks are computed based on the idea proposed by Basu *et al.*[15]. This is done by combining quantitative and qualitative indicators of research output. TP is taken as the quantity indicator and citations as the proxy of quality. HiCP is a well-known indicator of research excellence and ICP

Table 7. International collaborative paper for each NIT with top 10 collaborating countries (2005–2016)

Institutions	The United States	South Korea	Malaysia	United Kingdom	Saudi Arabia	Germany	Japan	Canada	Australia	Taiwan	Total
NITT	58	**70**	61	**35**	**38**	23	**58**	**25**	**39**	**47**	**454**
NITK	67	25	**145**	14	26	5	10	5	6	4	**307**
NITRKL	**103**	41	12	29	28	22	8	18	15	5	**281**
MNIT	31	8	0	30	13	12	11	22	8	0	**135**
SVNIT	26	24	4	13	10	6	3	9	8	24	**127**
MNNIT	12	26	1	13	6	**38**	1	3	8	9	**117**
NITCLC	28	10	5	15	10	17	4	3	1	5	**98**
NITDGP	43	5	4	10	0	7	9	8	6	6	**98**
NITW	42	20	0	3	7	3	2	4	12	1	**94**
NITHP	6	29	1	2	0	11	15	4	0	6	**74**
VNIT	16	23	7	5	2	18	1	0	2	0	**74**
NITKKR	32	3	8	9	0	5	1	0	2	2	**62**
MANIT	2	0	1	13	23	1	2	3	3	2	**50**
NITRR	20	2	0	8	1	2	10	5	1	1	**50**
NITS	7	0	2	2	4	1	4	7	6	1	**34**
NITJLN	7	1	1	9	7	2	0	5	0	0	**32**
NITAG	4	0	0	6	0	6	3	1	3	4	**27**
NITP	7	4	0	4	1	0	4	2	1	1	**24**
NITSRI	4	8	1	0	7	0	1	3	0	0	**24**
NITDEL	4	5	0	9	0	1	1	1	0	1	**22**
NITUK	3	8	1	0	5	0	1	2	0	0	**20**
NITJSR	0	5	0	2	3	0	0	0	3	0	**13**
NITMGH	2	2	0	2	2	0	0	0	0	0	**8**
NITPY	0	3	0	0	1	0	0	0	0	0	**4**
NITAR	0	0	0	1	0	0	0	0	2	0	**3**
NITGOA	1	0	0	0	0	2	0	0	0	0	**3**
NITMNP	1	0	0	0	0	1	0	0	0	0	**2**
NITSKM	0	1	0	0	0	0	0	0	0	0	**1**
NITMZ	0	0	0	0	0	0	0	0	0	0	**0**
NITNL	0	0	0	0	0	0	0	0	0	0	**0**
Total	**526**	**323**	**254**	**234**	**194**	**183**	**149**	**130**	**126**	**119**	

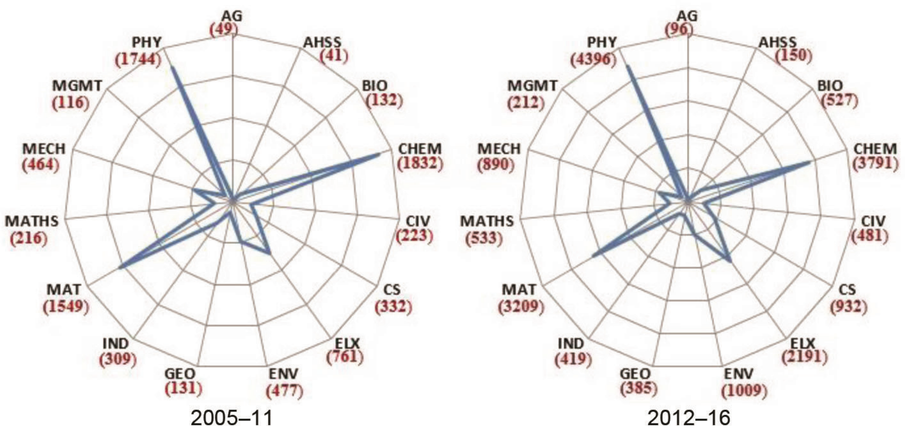

Figure 4. Discipline-wise research output size mapping.

does not directly indicate excellence but the study shows it attracts more attention. Two different composite indicators, QQCI(1) and QQCI(2), are designed using these measures, as proposed in a previous work[15]. Table 9 presents the two composite ranks (QQCI(1) and QQCI(2)) computed for the set of NITs and rank positions of the respective NITs provided by other ranks, namely NIRF[16], URAP[17] and Webometrics[18]. It can be observed that NITT gets composite rank position of 1 on QQCI(1) and QQCI(2). On NIRF, NITT is ranked first as well as in both international rankings (URAP and Webometrics); it is ranked at first place among NITs.

Table 8. Discipline-wise research strengths of NITs (2005–2016)

Institution	AG	AHSS	BIO	CHEM	CIV	CS	ELX	ENV	GEO	IND	MAT	MATHS	MECH	MGMT	PHY	Total
NITT	11	16	52	**813**	46	160	**438**	**214**	19	**219**	**866**	60	**259**	**62**	**827**	4062
NITRKL	8	**42**	**110**	697	58	**187**	372	147	**115**	77	782	**131**	193	48	637	3604
NITDGP	18	4	49	347	28	121	272	199	24	28	280	50	39	27	420	1906
SVNIT	**31**	6	40	584	49	47	100	152	32	35	203	86	75	26	306	1772
MNNIT	12	9	52	238	29	94	253	49	27	67	276	70	82	21	365	1644
NITW	5	3	32	406	45	47	151	40	13	30	288	46	77	10	273	1466
NITCLC	5	12	77	290	48	99	150	65	20	57	205	40	82	23	287	1460
NITKKR	6	10	11	201	36	88	194	54	37	46	176	15	89	17	344	1324
NITJLN	8	10	38	326	33	32	76	69	29	35	180	33	43	4	376	1292
NITK	4	10	26	436	34	30	61	72	46	12	238	30	34	3	213	1249
NITHP	5	5	3	215	45	47	114	26	12	21	246	26	91	9	382	1247
VNIT	7	8	32	228	72	34	121	104	17	10	248	22	67	5	226	1201
MNIT	4	6	18	155	**73**	68	155	81	12	33	123	10	52	26	252	1068
MANIT	3	4	42	114	23	41	96	90	19	8	103	18	28	6	248	843
NITS	5	5	4	122	38	40	105	44	11	18	109	22	26	9	174	732
NITAG	5	17	10	114	10	19	52	13	18	13	78	14	23	5	222	613
NITRR	4	2	49	117	9	43	65	33	19	1	64	11	18	10	105	550
NITSRI	0	4	1	49	6	3	31	4	10	0	89	14	14	2	115	342
NITJSR	4	3	0	27	6	11	10	10	9	12	54	11	22	7	100	286
NITUK	0	5	1	44	3	1	24	3	10	0	60	10	7	1	93	262
NITP	0	5	0	49	4	8	20	11	8	1	29	8	7	2	43	195
NITMGH	0	4	0	18	7	12	36	2	6	4	17	8	7	0	34	155
NITDEL	0	0	9	1	1	4	9	0	2	1	1	1	7	2	22	60
NITPY	0	1	2	3	1	6	8	0	0	0	7	6	6	3	11	54
NITMNP	0	0	1	10	0	5	3	2	1	0	12	1	1	0	13	49
NITGOA	0	0	0	0	0	7	15	0	0	0	4	3	4	0	9	42
NITAR	0	0	0	3	0	6	8	1	0	0	6	0	1	0	14	39
NITNL	0	0	0	4	0	2	6	1	0	0	7	1	0	0	14	35
NITMZ	0	0	0	10	0	2	5	0	0	0	5	0	0	0	9	31
NITSKM	0	0	0	2	0	0	2	0	0	0	2	2	0	0	6	14
Total	145	191	659	5623	704	1264	2952	1486	516	728	4758	749	1354	328	6140	

AG, Agricultural sciences; AHSS, Art, humanities and social science; BIO, Biological sciences; CHEM, Chemistry and chemical engineering, CIV, Civil engineering; CS, Computer science; ELX, Electronics; ENV, Environmental sciences; GEO, Geological sciences; IND, Industrial engineering; MAT, Materials science; MATHS, Mathematics; MECH, Mechanical engineering; MGMT, Management sciences; PHY, Physical science.

NITRKL, SVNIT, NITDGP, MANIT and MNNIT are among the other top-ranked institutions in the list. The QQCI ranks correlate with URAP and to some extent with NIRF ranks. Precisely, QQCI rankings of NITs are found to be positively correlated with URAP, which follows the same pattern as other Indian institutes[2,16]. Another important factor is that the top performing NITs on QQCI feature high in both national and international rankings. In another international ranking, i.e. THE[19], only NITRKL is ranked (601–800) among NITs. In other international rankings like ARWU[20], QS[21], etc., no NIT is being ranked. However, in two international rankings (URAP and Webometrics), the overall position of NITs is not even in the top 1200 institutions of the world. It may be relevant to mention that different ranking schemes use different databases, which result in different indicator values.

Conclusion

This study presents a detailed assessment of research performance of the 31 NITs in India. The analytical results help in identifying the productivity levels of different NITs for 10 as well as five-year periods. It is interesting to observe that all NITs taken together showed 3.5 times more research output in 2011–2016 compared to 2005–2010. NITT and NITRKL are found to be the two most productive institutions, much above the other NITs. In terms of publications per capita, NITRKL does relatively better than NITT. On parameters of citations, NITT has the highest number of total citations as well as highest *h*-index. The productivity and citation levels of NITs are however much less in comparison to institutions like IISc and IITB. The top 25 highest cited papers in the NIT publication data are also identified. NITs are found to be collaborating internationally in various disciplines as observed from international collaboration patterns extracted. The research performance of NITs is also ranked by combining quantity and quality parameters, and NITT is found to be the top performer in almost all rankings. One of the important outcomes of the study is the discipline-wise research output mapping of NITs for the two six-year periods. It is interesting to observe that most of the research output from NITs is in physics,

Table 9. Composite ranks (2012–2016) and related international rankings

Institution	QQCI 1	QQCI 2	NIRF 2016	URAP 15–16	Webometrics 2016
NITT	1	1	12	1,297	1,627
NITRKL	2	2	19	1,366	9,356
SVNIT	3	3	15	1,633	5,039
MANIT	4	5	–	–	2,641
NITDGP	5	4	30	1,661	2,438
MNNIT	6	6	23	1,816	2,309
NITK	7	7	22	1,886	2,173
MNIT	8	11	37	–	2,516
NITCLC	9	8	35	–	1,888
NITW	10	12	28	1,978	2,552
VNIT	11	14	18	–	2,870
NITHP	12	10	51	1,938	2,766
NITJLN	13	9	–	–	3,041
NITKKR	14	13	48	–	2,920
NITAG	15	16	52	–	8,360
NITS	16	15	–	–	3,857
NITRR	17	17	63	–	6,446
NITDEL	18	18	–	–	14,055
NITJSR	19	19	–	–	3,888
NITSRI	20	20	67	–	9,039
NITP	21	22	–	–	6,758
NITUK	22	21	–	–	14,275
NITMGH	23	23	57	–	13,361
NITGOA	24	24	–	–	13,622
NITPY	25	25	–	–	–
NITAR	26	26	–	–	12,979
NITMNP	27	27	–	–	15,883
NITMZ	28	28	–	–	14,872
NITNL	29	29	–	–	16,357
NITSKM	30	30	–	–	9,039

NITRKL features in Times Higher Education (THE) Ranking 2016–17 (601–800).

chemistry (including chemical engineering) and materials science. Electronics is the leading area of core engineering disciplines. Output in other engineering disciplines like civil and mechanical engineering is low. The disciplinary output proportions are roughly similar in both time-period blocks. Overall, this study presents a useful account of research performance assessment and characterization of NITs during the last 12 years.

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