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Research productivity of Indian Institute of Technology

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This paper made an attempt to gauge the research output of IIT Delhi, one of prime intuitions of engineering and technology India. The research output for the period of 1964-2010 as indexed by “Scopus” was collected and analyzed for set objectives. It was found that a total of 15476 research papers from the institute were published in journals and conference proceedings for the study period. The average citations count of institution is 4.09. “Engineering” is the dominant discipline with 6,267 papers, whereas “Chemistry” is highly cited subject field with total of 14,264 citations. The institution has collaborated in 3057 and 1209 papers at national & international level respectively.

Key word: IIT, Delhi, research output, Engineering and Technology, research output.

INTRODUCTION

Research is a continuous process and research institutes and centers are the sources of knowledge, enlightenment and progress in society. Research alone can bring revolutionary changes in the society and on the whole to the nation. Research is a key ingredient in the national and international identity of an institution and an indispensable prerequisite for a successful programme of teaching and public service. Nations that are weak in research risk the intellectual erosion of their programmers of strength, lose their critical ability to assess claims to knowledge, and become dependent on outside for supply of knowledge. Hence, it is very imperative that a dynamic nation with future eye makes consistent strides to reach new conclusions and innovation to make human society progressive.

In this context, IIT in India is making good strides to achieve technological advancement in South Asia and professional pass outs; both P.G (Post graduate) and research students have made good contribution in taking India to 21st century. IIT Delhi is one such institution established in early 1960 is known for its reputation as one of the leaders in research and development activities. IIT was first introduced in a report in the year 1945 by Sh.

N.M. Sircar, then member of Education on Vicerory's Executive Council. Following his recommendations, the first Indian Institute of Technology was established in the year 1950 in Kharagpur. In his report, Sircar had suggested that such institutes be established in different parts of the country. The Government decided to establish more Institutes of Technology with the assistance of friendly countries. The first offer of help came from USSR who agreed to collaborate in the establishment of an institute through UNESCO at Bombay. This was followed by the Institutes of Technology at Madras, Kanpur and Delhi (1961) with collaborations with West Germany, USA and UK respectively (Indian Institute of Technology Delhi, 2013 n.d.). The main aim of IIT DELHI is to offer instruction in Applied Science and Engineering of a standard comparable to the best in the world and provide adequate research facilities to meet the needs of specialized research workers and teachers and make atmosphere conducive to conduct interdisciplinary research.

In this milieu, it was deemed fit to measure the research production of IIT Delhi as indexed by Scopus; one of the leading indexing database covers more than 20500

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journals from over 5,000 international publishers, of which 19,500 are peer-reviewed journals in the scientific, technical, medical, and social sciences including arts and humanities (Scopus, 2013).

Problem

This is the era of information and information is continuously added to the treasure of knowledge by researchers. Research is being promoted and carried out in all spheres of life and in all fields of human knowledge. It is considered an important activity in present technological scenario with each subject field contributing its research outputs for the betterment of a nation. The decent portion of the research contribution of India comes from IIT which continuously adds valuable research findings in the field of engineering and technology; as such helps in the development of the nation technologically, socially and economically. In this milieu, the present study made an endeavor to explore and analyze research contribution of IIT Delhi.

Scope

The present work explores and analyzes research productivity of IIT Delhi as indexed by Scopus and confined to only articles and conference papers published from year 1964-2010.

Objectives

1. To explore and analyze the research contribution of IIT Delhi in different subject fields.
2. To trace the research trends in various subject fields.
3. To measure the citation rate of research output.
4. To gauge research collaborations of IIT Delhi at national and international level.

METHODOLOGY

The above mentioned objectives were achieved by implementing systematic and scientific methodology. The study was divided into 3 phases

First phase

In first phase "affiliation search" feature of "Scopus" indexing database was employed to harvest the research output of IIT Delhi. The output as such retrieved was further refined by subject limiting search feature of the database that helped to ferret out subject wise contribution of the institute.

Second phase

The records retrieved in first phase were further processed for

observing the citation rate and collaborations of institute at national and international level. Besides the records were also analyzed for preferred journals of IIT, Delhi

Third phase

The data were then categorized in different sections and analyzed and interpreted with the help of tables.

REVIEW OF LITERATURE

Enormous quantity of literature has been published screening the research output of various institutions all over the world. Some of the most relevant which study could ferret out and consulted are discussed here. Vasishta (2011) investigated the contribution and impact of research output on PEC University of technology as reflected in its publications covered in Scopus international multidisciplinary database and described broad characteristics of research publications of PEC during 1996-2009. She concludes that in all 177 research papers were published during 14 years by the nine departments of the PEC, showing an average of growth rate of 131.85%. Growth in the academic research output is seen after the PEC has attained a deemed university status. Contribution to engineering and technology literature from this institute is increasing steadily. Jeevan et al. (2009)'s study is based on the research publications generated by Structural Engineering Research Centre (SERC) during the years 2002-2006. They collected the data from the annual reports of SERC analysis which was based on impact factor provided by journal citation report and found that a small portion of R&D findings in engineering fields such as structural engineering are documented in non-journal format primary information sources such as proceeding of conferences/workshops/seminars/symposiums. Kumbar et al. (2008) analyzed the strong and weak areas of university research, their growth rate and impact of research in terms of average citation received and also studied the output and impact of research under different existing subject departments of the university and the collaboration. They conclude that the research activity of university of Mysore in Science and Technology is growing with an average rate of 23% per annum. The analysis was based on publication data consisting of 1518 research papers published by the university from 1996-2006. Bala et al. (2009) analyzed the research activities of the Government Medical College and Hospital (GMCH) Chandigarh as reflected in its 16 years (1992-2007) of 754 publications output covered in Scopus. It focused on publication growth, characteristics, format and media of communication, research impact and quality, patterns of collection, broad and narrow areas of research focus and most cited papers. They concluded that GMCH stands at 9th rank in research output, 13th in average citation per paper and 12th in h-index among the top 15 medical colleges of the country. GMCH has recorded an annual publication growth of 19.79% and impact as measured by average citation per paper as 0.89. Although 55.97% of its total papers received one or more citations, only 14 of its papers received 16 and above citation and only 2-3% of its papers involved international collaboration. Jeevan and Gupta (2002) studied the quantitative profile of research in university, with a view to get the idea about the performance and impact of research produced in each department and the comparison of the impact of research in various departments. They found that the researchers perform well when they collaborate more both at national and international levels. Okafor and Dike (2010) analyzed the research output of academics in the science and engineering faculties of Federal Government owned universities in Nigeria. Their study reveals that 30.6% of the academics published between 0-4 journals articles, that only 2.7% of them published 30 or more

Table 1. Year-wise research productivity of IIT Delhi.

Year	No. of articles published	Year	No of articles published	Year	No of articles published
1964	4	1980	117	1996	451
1965	6	1981	149	1997	413
1966	20	1982	170	1998	460
1967	17	1983	206	1999	425
1968	34	1984	273	2000	445
1969	33	1985	394	2001	398
1970	65	1986	354	2002	454
1971	82	1987	329	2003	468
1972	60	1988	279	2004	685
1973	88	1989	201	2005	833
1974	82	1990	226	2006	991
1975	79	1991	288	2007	1056
1976	82	1992	233	2008	1083
1977	76	1993	265	2009	1005
1978	61	1994	328	2010	1146
1979	145	1995	317	Total	15476

journal articles during the period and as many as 42.1% did not have any article in overseas journals. Jain and Gupta (2011) studied the measurement of research productivity of Indian scientists contributing to world soybean research for the period 1989-2008 based on the data available in the International Crop CD database. They concluded that Indian scientists, contributing to world soybean research, have higher publication share. India obtains 2nd rank in world publication on soybean research after USA with 13.64% share in the world. Adams et al. (2009) generated the report on annual output of scientific publications covering 1998-2007 of India, which reveals that from 1998-2000, the quantity of publication output steadily increased from roughly 16500 papers in 1998 to nearly 30000 in 2007. Thus, there has been an increase in the research output in scientific field of India from 1998-2007.

ANALYSIS AND INTERPRETATION

A total of 15,476 research papers of different types (articles, conference papers) were harvested for study period (1964-2010) from Scopus pertaining to IIT Delhi, which has been analyzed below under different headings.

Research output - year wise growth

The study deciphers that a total of 15,476 articles have been contributed by IIT Delhi from year 1964-2010. The highest number of articles were contributed in the year 2010 having 1,146 articles followed by year 2009 (1,005) and 2008 (1,083) while 1964 is the least productive year with 4 articles followed by 1965 (6) articles. If one goes by year wise growth it is not phenomenal considering the potential of IIT as technical hubs of India, but the distance

it travelled from the 1960s to present time is encouraging. Table 1 provides detailed picture.

Subject wise research contribution (1964-2010)

The study explored the research contribution of IIT Delhi in 27 subject fields. A total number of 25,768 articles were retrieved while harvesting data under subject (limiting search) segment for IIT, Delhi. The higher retrieval of paper under subject search can be explained with an argument that at times single paper represents more than one subject field as such higher count compared to exact count given in year wise growth (15476). Due to this limitation of exaggerated count we have taken the same for deciphering results. "Engineering" is the dominant subject field with 24.32% papers followed by "Material Sciences" (13.20%) and "Physics and Astronomy" (13.14%); while the subject fields "Arts and Humanities" and "Veterinary Sciences" are the least contributors with 0.007% articles each. Besides, study also analyzed the decadal growth of research carried out in different subject fields. Table 2 offers a lucid picture.

Citation analysis: subject wise

A total of 1,05,514 citations have been received for 25,778 papers. Research papers in the field of "Chemistry" are highly cited with a record of 14,264 citations followed by "Physics and Astronomy" with

Table 2. Decade cum subject wise research output of IIT Delhi.

Rank	Subject area	Output from the year 1964-2010						%
		64-73	74-83	84-93	94-2003	4 till 10	Output	
1.	Engineering	82	372	1215	1715	2883	6267	24.32
2.	Material Sciences	50	251	660	961	1612	3534	13.20
3.	Physics and Astronomy	303	453	453	803	1374	3386	13.14
4.	Computer Science	9	59	175	455	1118	1816	7.04
5.	Chemistry	29	158	309	437	854	1787	6.93
6.	Energy	1	152	435	446	575	1609	6.24
7.	Chemical Engineering	15	59	231	458	731	1494	5.79
8.	Biochemistry, Genetics and Molecular Biology	9	61	156	303	498	1027	3.97
9.	Environmental Science	4	25	132	366	473	1000	3.88
10.	Mathematics	25	67	133	209	472	906	3.51
11.	Earth and Planetary Science	5	13	69	213	224	524	2.03
12.	Agriculture and Biological Sciences	0	16	48	128	280	472	1.83
13.	Business, Management and Accounting	0	4	32	96	259	391	1.51
14.	Immunology and Microbiology	1	11	47	47	102	281	1.09
14.	Social Sciences	4	19	36	48	164	271	1.05
15.	Decision Science	5	9	51	59	130	254	0.98
16.	Medicine	3	35	56	51	100	245	0.95
17.	Multidisciplinary Subjects	0	0	9	52	85	146	0.56
18.	Pharmacology, Toxicology and Pharmaceutics	0	3	28	25	80	136	0.52
	Undefined Fields	21	39	39	3	1	103	0.39
19.	Health Profession	1	8	8	8	14	39	0.15
20.	Economics, Econometrics and Finance	0	1	6	8	18	33	0.12
21.	Neuroscience	0	0	9	2	12	23	0.08
22.	Psychology	0	0	2	5	6	13	0.05
23.	Nursing	0	0	0	1	3	4	0.015
23.	Dentistry	0	0	0	3	0	3	0.011
24.	Arts and Humanities	0	0	1	1	0	2	0.007
25.	Veterinary Science	0	0	0	0	2	2	0.007
	Total	567	1815	4340	6903	12070	25768	

12,390 citations and “Material Sciences” (10,230). There is no citation in the field of “Arts and Humanities”. However, while measuring the mean citation subject field, “Psychology” proved to have the highest mean citation with 12.92 followed by “Immunology” and “Microbiology” (11.67) “Veterinary” has 0.5 citation value. The mean citation for IIT Delhi comes to 4.09. Table 3 presents a comprehensive outlook of different subject fields based on citations received.

Preferred journals - top 20

The researchers at IIT Delhi prefer to publish their findings in journal “Energy Conversion and Management” with 380 papers followed by “Journal of Applied Polymer

Science” which ranks 2nd (285) whereas “Journal of Applied Physics” (246) ranks 3rd. Table 4 shows the top 20 journals in which the articles of IIT Delhi have been mostly published from 1964-2010.

Collaboration - international

The study shows that out of 15476 articles and conference papers contributed only 1209 articles are having international collaboration. The study also unfurls that mere 72 institutions at global level have collaborated with IIT Delhi. The highest number of affiliations is observed with “University of Maryland” having collaboration in 47 papers, followed by “National University Cooperation University of Fukui” and “Stanford University” (30 each).

Table 3. Subject wise citation analysis and mean citation count.

Subject field	Output	Number of times cited	Mean citation
Engineering	6267	4491	0.72
Materials Science	3534	10230	2.89
Physics and Astronomy	3386	12390	3.66
Computer Science	1816	10206	5.62
Chemistry	1787	14264	7.98
Energy	1609	8232	5.12
Chemical Engineering	1494	9697	6.49
Biochemistry, Genetics and Molecular Biology	1027	8386	8.17
Environmental Science	1000	5562	5.55
Mathematics	906	5013	5.53
Earth and Planetary Sciences	524	2622	5.00
Agricultural and Biological Sciences	472	3365	7.13
Business, Management and Accounting	391	1615	4.13
Immunology and Microbiology	281	3282	11.67
Social Sciences	271	1288	4.75
Decision Sciences	254	2055	8.09
Medicine	245	387	1.57
Multidisciplinary	146	409	2.80
Pharmacology, Toxicology and Pharmaceutics	136	1082	7.95
Health Professions	39	235	6.03
Economics, Econometrics and Finance	33	266	8.06
Neuroscience	23	101	4.39
Psychology	13	168	12.92
Nursing	4	8	2
Dentistry	3	5	1.67
Arts and Humanities	2	0	0
Veterinary	2	1	0.5
Undefined	103	154	1.50
Total	25768	105514	4.09

Least collaboration has been observed with “Florida State University” and “Princeton University” (10). Table 5 offers a detailed view of facts and figures.

Collaboration – national level

A decent portion of research is pursued in IIT Delhi in collaboration with various institutes in India. A total of 3,057 papers have been found with collaborations at national level with 87 institutions. The highest number of affiliations have been found with “IEEE” (206) followed by “National Physical Laboratory” (216); while least alliance was found with “Indira Gandhi Centre for Atomic Research” (10). Table 6 offers a comprehensive view of all collaborating institutes.

Collaboration - cumulative

The study provides cumulative figures of collaborations at

national and international levels. Out of total 15476 articles contributed by IIT Delhi from 1964-2010, a total number of 4266 articles are having national and international collaboration, in which 1,209 articles are internationally collaborated while 3,057 articles are having national collaboration. Table 7 offers a vivid picture.

Conclusion

Research is emerging as an important factor for overall development of various subject fields. IIT Delhi is encouraging research and allied activities for the overall benefit of scholarship. The following findings are drawn from the study:

1. A total number of 15,476 research papers (articles and conference proceedings) have been contributed by IIT Delhi between year 1964 - 2010.
2. “Engineering” is the dominant discipline with 6,267

Table 4. Preferred journals of IIT Delhi-Top 20.

Rank	Name of the journal	Articles published
1	Energy Conversion and Management	380
2	Journal of Applied Polymer Science	285
3	Journal of Applied Physics	246
4	Indian Journal of Fiber and Textile Research	222
5	Optics Communications	177
6	Physics of Plasmas	137
7	Proceedings of SPIE the International Society for Optical Engineering	134
8	Thin Solid Films	133
9	Journal of Physics D Applied Physics	122
10	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	110
11	Applied Energy	88
12	Journal of Sound and Vibration	84
12	International Journal of Energy Research	84
13	IETE Journal of Research	77
14	Applied Physics Letters	76
15	Wear	74
16	Solar Energy	68
17	Journal of the Textile Institute	65
18	2010 Joint International Conference on Power Electronics Drives and Energy Systems Pedes 2010 and 2010 Power India	64
19	Journal of the Institution of Engineers India Electrical Engineering Division	64

papers followed by “Material Science” (3,574), “Physics” (3,386) and “Computer Science” (1,816) papers.

3. Almost all the subject fields show a very little contribution from 1964-1975 but there is an inclination in research output from 1980-2010.

4. “Chemistry” is highly cited subject field with total of 14,264 citations followed by “Physics and Astronomy” with 12,390 citations.

5. A total number of 3,057 and 1,209 papers of IIT Delhi have National and International level collaborations respectively.

The above findings clearly depict that there is need to have a consistent approach towards supporting and promoting research. High quality academic research output in an institution crafts a knowledge hub and motivates the faculty and students to cater for a learning environment par excellence. Growth in research output is positive after the Indian Institute of Technology Delhi has acquired the Institution of National Importance. Contribution to the field of Engineering and Technology from this institute is steadily increasing since then; what was 4 articles in 1964, 60 in 1972 has reached 1146

articles in 2010. But the international collaborative research activity in the institution is still limited (1209). There is strong requirement to develop suitable research environment and upgrade infrastructural facilities. Some of the suggestions to develop appropriate management strategies to attain the objective of increasing the impact of IIT Delhi academic research output are:

1. There is need to explore new opportunities for collaborative research with countries from the developed and emerging world especially in the new areas of research in Engineering and Technology.
2. Faculty should be encouraged to do research projects in collaboration with institutions of higher learning and industrial research laboratories in India, which will give them the vital exposure to the work culture and state-of-the-art facilities available with such institutions.
3. Channelizing and attracting research support from external faculty and to develop multi-disciplinary research departments.
4. Draw short term and long term plans for future research endeavors.
5. Motivation and incentive for faculty for exceptional

Table 5. Collaboration of IIT Delhi at International level.

Name of institution	Collaboration	Name of institution	Collaboration
University of Maryland	47	Xiamen University	14
National University Corporation University of Fukui	30	Technion - Israel Institute of Technology	14
Stanford University	30	Rensselaer Polytechnic Institute	14
Alcatel-Lucent Bell Labs	28	Columbia University in the City of New York	14
Rowan University	27	North Carolina State University	13
Massachusetts Institute of Technology	26	Hong Kong University of Science and Technology	13
University of Southampton	25	Universitetet i Oslo	13
University of Saskatchewan	23	University of Texas at Austin	13
SantLongowal Institute of Engineering and Technology	23	International Business Machines	13
Universite Pierre et Marie Curie	22	University of Notre Dame	13
Nanyang Technological University	22	University of California, Los Angeles	13
University of Manitoba	22	Ecole Polytechnique Federale de Lausanne	13
National University of Singapore	22	University of Ottawa, Canada	13
Technische Universität Dresden	22	Rutgers, The State University of New Jersey	13
The University of Hong Kong	21	University of Wisconsin Madison	13
Hong Kong Polytechnic University	21	Technische Universiteit Eindhoven	13
Université du Québec à Montréal	21	Defence Materials and Stores Research and Development Establishment	13
Carnegie Mellon University	21	Optical Society of America	13
MMH College	21	University of Illinois at Urbana-Champaign	12
University of Calgary	20	Duke University	12
Ecole de Technologie Supérieure	20	Georgia Institute of Technology	12
Pennsylvania State University	19	University Michigan Ann Arbor	12
Purdue University	19	Abdus Salam International Centre for Theoretical Physics	12
IBM Thomas J. Watson Research Center	19	Cornell University	11
University of Windsor	18	Leibniz-Institut für Polymerforschung Dresden e.V.	11
UC Berkeley	18	Technische Universität Darmstadt	11
University of Tokyo	18	University of Rochester Institute of Optics	11
Howard University	17	Multimedia University	11
Universität Duisburg-Essen	17	City University of Hong Kong	11
University of Southern California	16	Daneshgah-e-Semnan	11
University of Queensland	16	University of Oxford	11
Ecole Polytechnique	15	University of Rochester	11
Drexel University	15	Wesleyan University Middletown	11
University of Cambridge	15	Florida State University	10
Université Jean Monnet Saint-Etienne	15	Princeton University	10
Daneshgah Shahid Bahonar-e-Kerman	15	Total	1209
Université Nice Sophia Antipolis	15		

Table 6. Collaboration of IIT Delhi at national level.

Name of institution	Collaboration	Name of Institution	Collaboration
IEEE	206	Jai Narain Vyas University, Jodhpur	20
National Physical Laboratory India	216	Banaras Hindu University	20
University of Delhi	168	Defence Metallurgical Research Lab India	19
Indian Institute of Technology, Kharagpur	105	University of Lucknow	18
All India Institute of Medical Sciences	105	National Institute of Technology Tiruchirappalli	18
Netaji Subhas Institute of Technology	105	Indian Space Research Organization	18
Indian Institute of Technology Roorkee	98	Bhabha Atomic Research Centre	18

Table 6. Contd.

Solid State Physics Laboratory India	89	NTPC Ltd.	17
University of Delhi, College of Engineering	79	Centre for Development of Advanced Computing India	16
Indian Institute of Technology, Kanpur	78	G B Pant University of Agriculture & Technology	16
Jawaharlal Nehru University	78	Jawaharlal Nehru Centre for Advanced Scientific Research	16
Inter University Accelerator Centre India	72	Northern India Textile Research Association	15
Aligarh Muslim University	62	Physical Research Laboratory India	15
Indian Institute of Science	57	National Institute of Technology Hamirpur	15
The Technological Institute of Textile and Sciences India	57	University of Rajasthan	15
Indian Institute of Technology, Madras	47	Institute of Armament Technology India	15
Dr B R Ambedkar National Institute of Technology	45	Laser Science and Technology Centre India	15
Indian Institute of Technology, Bombay	43	National Institute of Immunology India	14
Guru Gobind Singh Indraprastha University	41	University of Allahabad	14
Birla Institute of Technology and Science Pilani	40	Andhra University	14
Defence Research and Development Organisation India	38	National Institute of Technology Rourkela	13
Engineers India Limited	37	Indian School of Mines University	13
National Institute of Technology Kurukshetra	33	National Institute of Technology Jamshedpur	13
National Institute of Foundry and Forge Technology India	32	Tata Consultancy Services India	13
Nirma University of Science and Technology	32	Department of Science and Technology, Government of India	13
Motilal Nehru National Institute of Technology	31	Krishna Institute of Engineering and Technology	13
Jamia Millia Islamia	31	Ministry of Energy	12
India Meteorological Department	29	Devi Ahilya University of Indore	12
Ramjas College, Delhi	29	Institute of Nuclear Medicine and Allied Sciences India	12
Thapar University	28	Dayalbagh Educational Institute India	12
Malaviya National Institute of Technology	28	Institute of Technology Banaras Hindu University	12
Punjab University	28	Kurukshetra University	12
The Energy and Resources Institute India	28	N.R.E.C. College	11
IBM India Research Laboratory New Delhi	28	Acharya Narendra Dev College	11
Vellore Institute of Technology	27	Punjabi University Patiala	11
Indian Agricultural Research Institute	27	University of North Bengal	11
Shri GovindramSeksaria Institute of Technology and Science	27	Maharshi Dayanand University	11
Tata Institute of Fundamental Research	26	National Institute of Health and Family Welfare India	11
Indian Institute of Technology, Guwahati	23	National Institute of Oceanography India	11
Jadavpur University	22	National Chemical Laboratory India	11
Faculty of Engineering and Technology	21	Council of Scientific and Industrial Research India	11
Guru Nanak Dev University India	21	National Centre for Medium Range Weather Forecasting India	11
Guru Jambheshwar University of Science and Technology	21	Indira Gandhi Centre for Atomic Research	10
Raja Ramanna Centre for Advanced Technology	21	TOTAL	3057

Table 7. Cumulative collaborations of IIT Delhi.

Collaboration	Number
International	1209
National	3057
Total	4266

research capabilities and output activities.

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