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Measuring the Research Output of Indian Institute of Technology (IITs) with Special Reference to Web of Science (WoS) Database: A Bibliometric Approach

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Abstract:

Purpose: The study is an attempt to measure the research output of Indian Institute Technology (IITs) in quantitative manner as appeared in Web of Science (WoS) database from 1989 – 2018 (14.09.2018). In addition to measure the research output, the study aims to investigate the contribution made by the IITs, the most productive authors and their collaborative attitude with highly cited articles etc.

Design/Methodology/Approach: To accomplish the objectives of the study, the relevant data for the study was obtained from Web of Science (WoS) database. The bibliographical data were recorded in MS-Excel 2007 sheet for the analysis and interpretation.

Findings: The research output during the period of 1989-2018 (Till 14/09/2018) was 1,36,156 in total and the year 2017 appears to have the highest research output with 13,651 publications of the total 1,36,156. And year 1990 followed by 1999 and 2000 were found with least number of publications with negative growth.

Research Limitations/Implications: The present study is confined to the contribution of the IITs available in WoS database and the research results are confined to this database only.

Originality/Value: The study examines the research output of IITs with special reference to WoS database for the period of 29 years i.e. 1989 - Sept., 2018. In addition, the paper is relevant to those interested in bibliometric study and further the

paper also provides a comprehensive overview on different aspect of the literature like year-wise growth, language, and most prolific author etc.

Paper Type: Research Paper

Keywords: Indian Institute Technology (IITs); Bibliometrics; Web of Science; WoS; and Research output.

1. Introduction

Research is an important phenomenon that has been the part of the society from the beginning. And now, in the recent times, it has become the criteria to measure the development of an institute, society or country, more quality research leads to more development of the society. Consequently, research productivity is considered as the face of an institute that determines the quality of it. Indian Institutes of Technologies (IITs) are considered as the pioneer institutes providing the higher education in engineering and technical field. The IITs (Indian Institute of Technology) are the autonomous institutes for higher education in India and governed by Institutes of Technology Act 1961, that has given the status of institutes of national importance. At present, total 23 IITs are functional in India as follows:

S.N.	Name of IIT	Founded	Established as IIT	State
1.	IIT Kharagpur	1951	1951	West Bengal
2.	IIT Bombay	1951	1951	Maharashtra
3.	IIT Kanpur	1958	1958	Uttar Pradesh
4.	IIT Madras	1959	1959	Tamil Nadu
5.	IIT Delhi	1959	1959	Delhi
6.	IIT Guwahati	1961	1963	Assam
7.	IIT Roorkee	1994	1994	Uttarakhand
8.	IIT Ropar	1847	2001	Punjab
9.	IIT Bhubaneswar	2008	2008	Odisha
10.	IIT Gandhinagar	2008	2008	Gujarat
11.	IIT Hyderabad	2008	2008	Telangana
12.	IIT Jodhpur	2008	2008	Rajasthan
13.	IIT Patna	2008	2008	Bihar
14.	IIT Indore	2008	2008	Madhya Pradesh
15.	IIT Mandi	2009	2009	Himachal Pradesh

16.	IIT (BHU) Varanasi	2009	2009	Uttar Pradesh
17.	IIT Palakkad	1919	2012	Kerala
18.	IIT Tirupati	2015	2015	Andhra Pradesh
19.	IIT Dhanbad	2015	2015	Jharkhand
20.	IIT Bhilai	1926	2016	Chhattisgarh
21.	IIT Goa	2016	2016	Goa
22.	IIT Jammu	2016	2016	Jammu and Kashmir
23.	IIT Dharwad	2016	2016	Karnataka

Table: IITs in India (Source – Wikipedia)

2. Web of Science (WoS)

The Web of Science (WoS), previously known as Web of Knowledge is an online subscription-based scientific citation indexing services. It was originally introduced by the Institute for Scientific Information (ISI) and now maintained by the Clarivate Analytics (previously the Intellectual Property and Science Business of Thomson Reuters that provides comprehensive citation search (WoS). The Web of Science (WoS) is a database that provides the platform where one can access the quality literature published in selected core of journals and uniquely discover new information through meticulously captured metadata and citation connections. In short, it is popularly known as one of the best database for quality information among the scholars/academicians (https://en.wikipedia.org/wiki/Web_of_Science).

3. Review of Related Literature

In the area of present study, significant studies can be as Kumar (2017) explores the growth and development of the periodical literature published by Emerald on the concept ‘Library Consortia’ and to provide the bibliography for ready reference on the subject from the study. Kumar (2014) presents a bibliometric analysis of the journal “Library Herald” for the period from 2011 to 2014 that covers mainly the number of articles, authorship pattern, subject wise distribution of articles, average number of references per articles, forms of documents cited, and year wise distribution of cited journals etc. The study finds that out of 114 articles single author contributed 65 (57.01%) articles while the rest 49 (42.98%) articles were contributed by joint authors. Further, the study reveals that most of the contributions are from India with 89.47 % and the rest 10.52 % only from foreign sources. Rath (2017) explores the growth and development of periodical literature published by Emerald on ‘mobile

technology and its application to libraries’. In the study, the author provides total no. of literature with trend published by Emerald on ‘mobile technology and its applications to libraries’.

4. Research Objectives

In order to accomplish the research, the research objectives of the study are to:

- (i) Examine the total production and year wise growth of publication in Indian Institute Technology (IITs);
- (ii) Find out the types of documents and subject wise publication in Indian Institute Technology (IITs);
- (iii) Identify the most productive authors in Indian Institute Technology (IITs);
- (iv) Examine the level of collaboration of other countries and institutes; and
- (v) Examine the highly cited publications among Indian Institute Technology (IITs).

5. Methodology Used for the Study

This present study explore and analyse the research output of Indian Institute Technology (IITs) from 1989-2018 (Till 14/09/2018). The study covers the literature published on Web of Science (WoS) citation database. In order to fulfil the purpose of the research, the information was taken from the WoS database by using the search term Indian Institute Technology (IITs). A total 136,156 results were found which were processed and analyzed further under different sub headings to get specific results. The data was retrieved on 14 September, 2018 from the database.

6. Data Analysis and Interpretation

Table 1: Year-wise Publication Growth

Year	Publication	Percentage	Percentage Growth
1989	1,546	1.136	--
1990	1,521	1.117	-1.617
1991	1,648	1.237	8.349
1992	1,713	1.258	3.944
1993	1,761	1.293	2.802
1994	1,915	1.407	8.745
1995	1,951	1.433	1.879

1996	2,020	1.484	3.536
1997	2,057	1.511	1.832
1998	2,079	1.527	1.069
1999	2,065	1.517	-0.673
2000	1,123	1.559	-45.617
2001	2,142	1.573	90.739
2002	2,276	1.672	6.256
2003	2,622	1.926	15.202
2004	3,068	2.253	17.009
2005	3,508	2.577	14.341
2006	4,172	3.064	18.928
2007	4,754	3.492	12.656
2008	5,248	3.855	10.391
2009	5,384	3.954	2.591
2010	5,731	4.209	6.445
2011	6,031	4.430	5.235
2012	6,407	4.706	6.234
2013	7,362	5.407	14.905
2014	8,479	6,228	15.172
2015	10,449	7.675	23.234
2016	12,141	8.917	16.193
2017	13,651	10.026	12.437
2018(till 14 th Sept., 2018)	10,291	7.559	-24.613

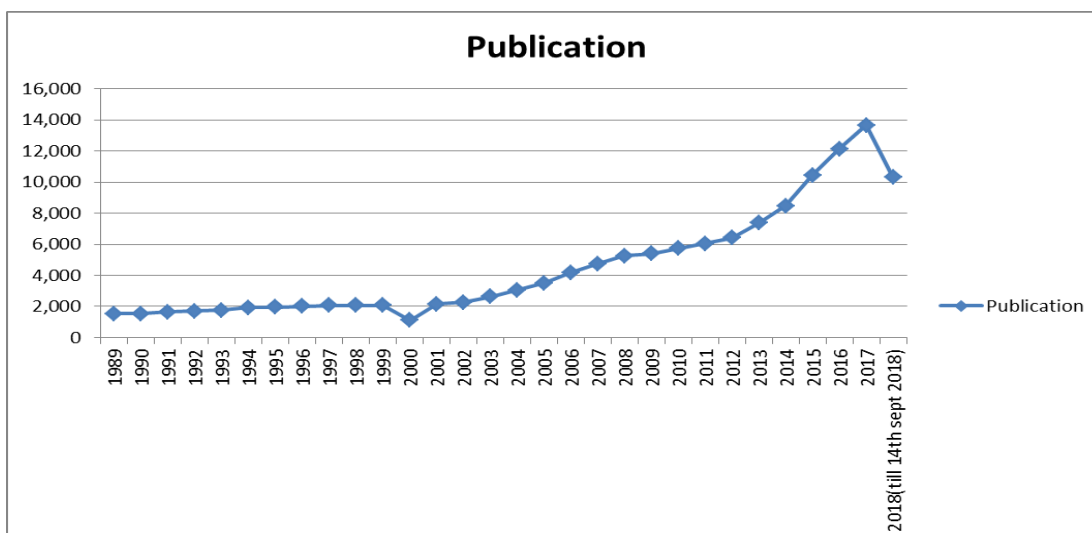


Table 1 depicts the year wise publication growth of Indian Institute Technology (IITs). It can be seen that total 1,36,156 results were found for the year 1989-2018 (Till 14/09/2018) and 2017 happens to be the year that has highest output with 13,651 publications. Further, the least number of publications were produced in the year 1990 with 1.117%, followed by 1999 with 1.517% and 2000 with 1.559% in which the production was in negative.

Table 2: Document type Distribution

Subject Area	Publication	Percentage	Rank
ARTICLE	127,669	93.770	1
PROCEEDING PAPER	5,129	3.767	2
REVIEW	3,167	2.326	3
MEETING ABSTRACT	1,353	0.994	4
EDITORIAL MATERIAL	1,328	0.975	5
NOTE	1,038	0.762	6
LETTER	581	0.427	7
CORRECTION	525	0.386	8
BOOK REVIEW	255	0.187	9
DISCUSSION	85	0.062	10

Table 2 presents the category of documents published with its percentage. It shows that most of the literature published in the form of articles which consist of 93.770% of the total publications with 1st ranks followed by the proceeding paper with 3.767% and Review with 2.326% comes out as 2nd and 3rd rank respectively. On the other

hand, Book review with 0.187% followed by discussion with 0.062% is the form of least used in production with 9th (second last) and 10th (bottom) rank respectively.

Table 3: Collaboration with other Institutes

Affiliation with others	Publication	Percentage	Rank
CSIR INDIA	63	12.702	1
INDIRA GANDHI INSTITUTE OF TECHNOLOGY	40	8.065	2
GGG INDRAPRASTHA UNIVERSITY	36	7.258	3
INDIAN INSTITUTE OF TOXICOLOGY	33	6.653	4
NATIONAL PHYSICS LABORATORY INDIA	18	3.629	5
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	17	3.024	6
DEPARTMENT OF SCIENCE TECHNOLOGY INDIA	15	3.024	7
UNIVERSITE COTE D AZUR COMUE	13	2.621	8
UNIVERSITY OF DELHI	11	2.218	9
DEFENCE RESEARCH DEVELOPMENT ORGANISATION DRDO	9	1.815	10
INSTITUTE FOR PLASMA RESEARCH IPR	9	1.815	
SRI GURU TEGH BAHADUR KHALSA COLLEGE	9	1.815	

Table 3 shows the collaboration of Indian Institute Technology (IITs) with others institutes. After IITs collaboration with each other, CSIR with 12.702% followed by Indira Gandhi Institute of Technology with 8.065% and GGS Indraprastha University with 7.258 are the most collaborative institute with 2nd and 3rd rank respectively. On the other hand, the Universite Cote D Azur Comue with 2.621% and University of Delhi with 2.218% are the least collaborative institute with Indian Institute Technology (IITs) holding the rank 8th and 9th respectively. In addition to this, it is also found that the three institutes namely DRDO, Institute for Plasma Research and Sri GTB Khalsa College with 1.815% each share the 10th rank which is the last.

Table 4: Country wise Collaboration

Country	Publication	Percentage	Rank
USA	10,523	7.729	1
GERMANY	4,908	3.605	2
ENGLAND	3,002	2.205	3
FRANCE	2,582	1.896	4
SOUTH KOREA	2,195	1.612	5
CANADA	2,085	1.531	6
CHINA	2,063	1.515	7
JAPAN	2,008	1.475	8
AUSTRALIA	1,693	1.243	9
ITALY	1,619	1.189	10

Table 4 reflects the collaboration of Indian Institute Technology (IITs) with other countries. It can be observed from the table that USA with 7.729% collaborate the most with Indian Institute Technology (IITs) with 1st rank followed by Germany with 3.605% at 2nd and England with 2.205% at 3rd rank. Whereas, Japan with 1.475% followed by Australia with 1.243% and Italy with 1.189% are on 8th, 9th, and 10th position respectively.

Table 5: Most Productive Author

Name	Publication	Percentage	Rank
KUMAR A	3,184	2.338	1
KUMAR S	2,408	1.769	2
KUMAR R	1,725	1.267	3
GHOSH S	1,681	1.235	4
DAS S	1,606	1.180	5
SHARMA A	1,422	1.044	6
KUMAR P	1,349	0.991	7
SINGH AK	1,209	0.888	8
KUMAR V	1,174	0.862	9
SINGH S	1,125	0.826	10

From the above table 5, it can be seen that from the among top 10 authors Kumar, A. is the most productive author with 3,184 (2.338%) publications out of total output of 136,156 publications followed by Kumar, S. contributing with 2,408 (1.769%) at no. 2 and Kumar, R with 1725 (1.267%) at no. 3. The least productive authors in top 10

are Singh, AK with 1,209 (0.888%) followed by Kumar, V. with 1,174 (0.826%) and Singh, S. with 1,125 (0.826%) publications and hold the rank of 8th, 9th, and 10th respectively.

Table 6: Subject wise Publication

Research Area	Publication	Percentage	Rank
ENGINEERING	38,714	28.434	1
CHEMISTRY	27,654	20.311	2
PHYSICS	24,038	17.655	3
MATERIAL SCIENCE	23,250	17.076	4
SCIENCE TECHNOLOGY OTHER TOPICS	8,655	6.357	5
COMPUTER SCIENCE	8,161	5.994	6
MECHANICS	6,766	4.969	7
MATHEMATICS	6,300	4.627	8
ENERGY FUELS	5,281	3.879	9
METALLURGY METALLURGICAL ENGINEERING	5,011	3.680	10

The subject-wise top 10 rank distribution of literature is listed in above Table 5, where the subjects Engineering followed by Chemistry and Physics with 28.434%, 20.311% and 17.655% respectively are higher in the publication of literature in Indian Institute Technology (IITs) and holds the rank of 1st, 2nd and 3rd respectively. On the other hand, as far as the least contributing subject are concerned, the Mathematics with 4.627% followed by Energy Fuels with 3.879% and Metallurgy Metallurgical Engineering with 3.680% holds the rank of 8th, 9th, and 10th respectively.

Table 7: Highly Cited Articles

Title	Author	Source of Publication	Time Cited	Rank
A fast and elitist multiobjective genetic algorithm: NASA-II	Deb, K.; Pratap, A.; Agarwal, S; et al.	IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION	12,676	1
A review of chitin and chitosan applications	Kumar, MNVR.	REACTIVE & FUNCTIONAL	2,191	2

		POLYMERS		
Comparison of Multiobjective Evolutionary Algorithms: Empirical Results	Zitzler, Eckart.; Deb, Kalyanmoy.; Thiele, Lothar.	EVOLUTIONARY COMPUTATION	2,191	
Guidelines for the use and interpretation of assays for monitoring autophagy	Klionsky, Daniel J.; Abdalla, Fabio C.; Abeliovich, Hagai; et al.	AUTOPHAGY	2,100	3
Experimental and theoretical challenges in the search for quark-gluon plasma: The STAR Collaboration's critical assessment of the evidence from RHIC collisions	Adams, J; Aggarwal, MM; Ahammed, Z; et al.	NUCLEAR PHYSICS A	2,073	4
The B73 Maize Genome: Complexity, Diversity, and Dynamics	Schnable, Patrick S.; Ware, Doreen; Fulton, Robert S.; et al.	SCIENCE	1,865	5
An efficient constraint handling method for genetic algorithms	Deb, K	COMPUTER METHODS IN APPLIED MECHANICS AND ENGINEERING	1,622	6
Technical aspects of biodiesel production by transesterification – a review	Meher, LC; Sagar, DV; Naik, SN	RENEWABLE & SUSTAINABLE ENERGY REVIEWS	1,608	7

Application of low-cost adsorbents for dye removal – A review	Gupta, V. K.;	JOURNAL OF ENVIRONMENTAL MANAGEMENT	1,539	8
Electrospinning: A fascinating fiber fabrication technique	Bhardwaj, Nandana; Kundu, Subhas C.	BIOTECHNOLOGY ADVANCES	1,531	9
Bounding the role of black carbon in the climate system: A scientific assessment	Bond, T. C.; Doherty, S. J.; Fahey, D.W.; etal.	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	1,486	10

The above table 7 shows the top 10 highly cited articles with the sources of publication. The table lists out the titles of those papers along with the number of citations received by them. Also the number of authors with name of the journal is mentioned. The total no. of highest citation received by an article is 12,676 and the lowest citation from the list is 1,486. The huge difference can be seen between the two publications holding the rank of 1st and 10th respectively.

7. Major Findings and Conclusion

On the basis of the study following findings can be pointed out:

- The research output during the period of 1989-2018 (Till 14/09/2018) was 1,36,156 in total;
- It is found that the year 2017 has the highest research output with 13,651 publications of the total 1,36,156; and 1990 with 1.117% followed by 1999 with 1.517% and 2000 with 1.559% were the years with least number of publications;
- The years 1990, 1999, 2000 and 2018 were found when the research growth was in negative. It may be noted that may be the year 2018 is not over yet may be by the end of 2018 the growth may not be in negative;
- Literature published in the form of articles which consist of 93.770% of the total publications holds 1st rank followed by the proceeding paper with 3.767% and Review with 2.326% comes out as 2nd and 3rd rank respectively;

- Book review with 0.187% followed by discussion with 0.062% are the form of least used in production with 9th (second last) and 10th (bottom) rank respectively.
- After IITs collaboration with each other, CSIR with 12.702% followed by Indira Gandhi Institute of Technology with 8.065% and GGS Indraprastha University with 7.258 are the most collaborative institute with 2nd and 3rd rank respectively.
- The Universite Cote D Azur Comue with 2.621% and University of Delhi with 2.218% are the least collaborative institute with Indian Institute Technology (IITs) holding the rank 8th and 9th respectively;
- Three institutes namely DRDO, Institute for Plasma Research and Sri GTB Khalsa College with 1.815% each share the 10th rank as far as the collaboration with IITs is concerned;
- It is found that USA with 7.729% collaborate the most with Indian Institute Technology (IITs) holds 1st rank followed by Germany with 3.605% at 2nd and England with 2.205% at 3rd rank;
- Japan with 1.475% followed by Australia with 1.243% and Italy with 1.189% holds 8th, 9th, and 10th position respectively among the top 10 institutes as far as the collaboration with IITs is concerned;
- Among the top 10 authors, Kumar, A. is the most productive author with 3,184 (2.338%) publications out of total output of 136,156 publications followed by Kumar, S. contributing with 2,408 (1.769%) at no. 2 and Kumar, R with 1725 (1.267%) at no. 3;
- The least productive authors in top 10 are Singh, AK with 1,209 (0.888%) followed by Kumar, V. with 1,174 (0.826%) and Singh, S. with 1,125 (0.826%) publications and hold the rank of 8th, 9th, and 10th respectively;
- The subjects Engineering followed by Chemistry and Physics with 28.434%, 20.311% and 17.655% respectively are higher in the publication of literature in Indian Institute Technology (IITs) and holds the rank of 1st, 2nd and 3rd respectively;
- And as far as the least contributing subject are concerned, the Mathematics with 4.627% followed by Energy Fuels with 3.879% and Metallurgy Metallurgical Engineering with 3.680% holds the rank of 8th, 9th, and 10th respectively;

- The total no. of highest citation received by an article among top 10 is 12,676 and the lowest citation from the list is 1,486.

After going through the findings, it can be concluded the study measure the research output of IITs during the period of 1989-2018 (till 14/09/2018) with special reference to Web of Science (WoS) and finds that the plenty of the literature has been contributed by the IITs in WoS database. And further the collaboration level with other institutes and countries can also be said as satisfactory. Further, it may be noted that the research results are confined to the WoS database and can't be generalised.

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