

# Mapping the Research Collaboration Trend in Centrally Funded Technical Institutes (CFTIs) of India

Shankar B. Chavan\*

Keshava\*\*

The main objective of the study is scientometric analysis of the trend of research collaboration patterns, the growth of international collaboration and the factors influencing the number of citations of CFTIs from 1991 to 2020. The 57 CFTIs, established before 2015 are considered for analysis. A total of 401171 publication records were extracted from the Scopus database and analysed using excel and scientometric techniques. The growth in the number of publications in 2020 was 17.88 times compared to 1991, and publications per institute increased by 9.40 times. Most of the publications (85.86%) were contributed by two, three, four and five authors. The trend of single-authored publications from 1991 to 2020 decreased from 10.19 % to 2.79%. The degree of collaboration is 0.96. The ratio of single-authored vs multi-authored publications is 4.34:95.66. The internationally collaborated publications of CFTIs continuously increased from 11.49% in 1991 to 22.28% in 2020. The trend of average citations for publications with multi-authored papers is higher than for single-authored publications. A similar trend was found in the publications of collaborated internationally than non-internationally collaborated; the difference in average citations is 10.96.

**Keywords:** *CFTIs, Research trend analysis; Scientometrics; Bibliometrics; Authorship pattern; Impact analysis; Citation analysis.*

## 1 INTRODUCTION

Before independence, the country had very few engineering colleges, where only graduate-level education in the field of basic engineering was popular, i.e.

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\* Research Scholar, Department of Studies & Research in Library-Information Science, Tumkur University, Tunkuru & Assistant Librarian, Indian Institute of Technology Delhi shankaraochavan@gmail.com

\*\* Professor & Chairman, Department of Studies & Research in Library-Information Science, Tumkur University, Tunkuru keshtut@gmail.com

Civil, Electrical and Mechanical Engineering. After 1950, India entered in the era of establishing the engineering and technological institutes at national, state and regional levels. Early four decades of engineering education were on the pattern of Americans and Britishers. After 1990, the boom in engineering education took place throughout the country. Currently, more than 8902 colleges and institutes are affiliated with AICTE. The centrally funded technical institutes in India were established as an institute of national importance under the institute of technology act, 1961. In the eleventh five-year plan, eight new IITs and five IISERs were established, and regional engineering colleges were declared as institutes of national importance with the national institute of technology act of 2007. Currently, there are 97 centrally funded technical institutes in India.

Garfield 1955<sup>1</sup>, "first given the idea of an impact factor in science and the signification of the article; citations is a quantitative value to measure the influence of the article." That leads to the publishing of the science citation index in the year 1961. Researchers and university administrators often assume that journal impact factor and citation count are the indicators of research quality<sup>2,3</sup>. It is also common for authors to equate impact factors and citations with quality<sup>4</sup>. Citation counts are generally recognised to be a reliable metric for the evaluations of individual papers<sup>5</sup>. Evaluating the quality of papers is a complex task. According to Garfield 2006<sup>6</sup>, "about 20% of papers achieve more than 80% of citations. Various studies have investigated the correlation of determinant variables with the frequency of citations". Visibility and accessibility are mentioned in a large number of studies to be related to citations<sup>7,8</sup>. The number of pages is an influential factor in the citations, especially during the initial years after the publication of the paper<sup>9</sup>. There is a positive correlation between journal impact factor and citations<sup>10</sup>. The mode of presentation of a paper is contributed to the number of citations it achieves. Journal papers obtain more citations per document and year than conference papers<sup>11</sup>. Well-known and highly cited authors achieve citations, simply due to their prominence and prestige in their field of study. If the reader well recognises an author, it causes an increase in the number of citation<sup>12</sup>. Many studies investigated the effect of author self-citation on the number of citations<sup>13,14</sup>. There is a significant relationship between authors' international and national cooperation, the number of countries and organisations producing papers and the frequency of citations<sup>15</sup>. Research projects (papers) that have received a higher level of funding and papers of authors who have received grants may receive more citations than non-funded papers<sup>16</sup>. Different citation sources lead to varying numbers of citations. In general, papers in Google Scholar receive citations faster than in Web of Science (WOS), and it shows more frequent citations than Scopus and WoS<sup>17</sup>.

This study mainly focuses on the research publications of CFTIs in India to explore the trend of collaborations and compare the citations received to papers with single authors versus multiple authors and publications of internationally collaborated versus non-international collaborated.

## 2 OBJECTIVES

The main objectives of the study are to find the trend of authorship pattern, and collaboration with international researchers from 1991 to 2020. Also, to compare and analyse the impact of collaborations on the citations of the research publications of CFTIs in India.

## 3 SCOPE AND LIMITATIONS

The study covered the 57 CFTIs in India, i.e. IISc, IISERs, IITs and NITs, which were established before 2015. The study period is limited to three decades, from 1991 to 2020.

## 4 METHODOLOGY

Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books, conference proceedings, etc. The details of the CFTIs were collected from the Ministry of Education and institute websites. The scope of the study is limited to a total of 57 institutes which were established before 2015, i.e., 19 IITs, IISc, 6 IISERs, and 31 NITs. The search was made using the affiliation field for the individual institutes. The data was collected from the affiliations using the Scopus database with the publications year from 1991 to 2020. A total of 401171 publications were analysed using excel and scientometric techniques.

## 5 ANALYSIS AND FINDINGS

### *5.1 THE GROWTH OF PUBLICATIONS OF CFTIS FROM 1991-2020*

The number of CFTIs and publications is continuously growing from 1991 to 2020. Out of these, 57 institutes, i.e., IISc, IISERs, IITs and NITs, were taken for the study. In 1991 there were 30 institutes, which grew to 57 in 2015. The total number of publications spanning three decades from 1991 to 2020 is 401171, and the average publication per institute is 7038. The number of publications grew from 2462 in 1991 to 44043 in 2020, and the growth in the number of publications is 17.88 times in 2020 compared to 1991. The growth of publications per institute is from 82.07 in 1991 to 772.68 in 2020; the increase in 2020 per institute publication is 9.40 times compared to 1991.

### *5.2 AUTHORSHIP PATTERN OF RESEARCH PUBLICATIONS OF CFTIS FROM 1991-2020*

Table 1 presents the authorship pattern of research publications of CFTIs from 1991 to 2020. In 1991, single-authored publications were 251 of 2462 means 10.19% were authored by single authors, whereas in 2020, 1231 of 44043 publications were authored by single authors, which means 2.79%. This trend indicates that the movement of single-authored research publications is

decreasing and collaborated publications are continuously increasing. The trends of collaboration from 1991 to 2020 is research publications with two authors are 1089 (44.23%) of 2462 and 12492 (28.36%) of 44043, three authors publications is 743 (30.18%) to 12384 (28.12%), four authors publication is 250 (10.15%) to 7757 (17.61%), five authors publications 78(3.17%) to 4187 (9.51%). The publications authored by more than five authors was increased from 2.07% to 13.60%. The publication share of two, three, four and five authors in 1991 was 87.73% and in 2020 is 83.60%. The trend of collaboration for two authors was decreased, three authors is slightly low and the publications with more than three authors are increasing continuously.

**Table 1. Authorship pattern of Research Publications of CFTIs from 1991-2020**

S. No.	Year	No. of Authors											No of Pubs.
		1	2	3	4	5	6	7	8	9	10	>10	
1	1991	251	1089	743	250	78	27	12	6	1	1	4	2462
2	1992	242	1146	726	249	77	35	10	7	3	4	2	2501
3	1993	269	1174	771	275	92	32	16	9	3	2	1	2644
4	1994	254	1239	797	299	134	50	20	13	8	1	1	2816
5	1995	257	1240	805	348	114	52	12	13	4	4	4	2853
6	1996	311	1532	1116	432	191	79	33	21	2	9	8	3734
7	1997	348	1555	1090	449	173	79	34	21	7	3	8	3767
8	1998	348	1469	1042	475	182	71	38	21	10	3	15	3674
9	1999	319	1441	1082	443	178	85	35	18	4	7	8	3620
10	2000	380	1476	1122	484	221	104	39	23	11	5	14	3879
11	2001	372	1439	1202	506	223	100	46	26	8	8	14	3944
12	2002	322	1606	1307	618	306	137	49	31	18	10	12	4416
13	2003	411	1822	1621	714	337	142	64	34	27	12	21	5205
14	2004	393	2050	1833	945	399	172	87	45	25	13	28	5990
15	2005	462	2709	2175	1112	444	188	91	62	13	8	52	7316
16	2006	550	3179	2674	1296	526	249	123	70	29	18	67	8781
17	2007	515	3213	3139	1417	644	265	135	56	33	18	52	9487
18	2008	636	3838	3478	1731	742	346	176	92	47	26	66	11178
19	2009	618	3956	3835	1916	959	409	207	119	59	30	87	12195
20	2010	740	4468	4288	2193	1105	492	219	146	72	37	109	13869
21	2011	789	5159	4879	2535	1250	613	300	169	82	57	160	15993
22	2012	722	5623	5393	2904	1425	716	362	178	106	69	242	17740
23	2013	740	6234	5867	3260	1573	783	388	212	109	80	262	19508
24	2014	826	7253	6681	3699	1811	987	504	255	152	92	292	22552
25	2015	844	7983	7395	4057	2063	1067	604	338	193	112	373	25029
26	2016	972	8963	8473	4843	2405	1262	681	369	226	133	517	28844
27	2017	993	10221	9371	5553	2816	1557	808	452	271	158	554	32754
28	2018	1147	11654	11101	6709	3390	1799	960	569	306	198	703	38536
29	2019	1157	12251	11911	7162	3978	2054	1112	709	376	257	874	41841
30	2020	1231	12492	12384	7757	4187	2323	1338	711	459	257	904	44043
Total		17419	129474	118301	64631	32023	16275	8503	4795	2664	1632	5454	401171

**53 SINGLE VS MULTIAUTHORSHIP PATTERN AND DEGREE OF  
COLLABORATION OF CFTIS FROM 1991-2020**

Table 2 presents the single vs multi authorship pattern and degree of collaboration of research publications of CFTIs from 1991 to 2020. Table 2 clearly denotes that the trend of single authored is decreased from 10.17% to 2.79% and multi authored publications increased from 89.81% to 97.21 %. In total, single authored publications are 17419 (4.34%) and multiauthored publications are 383752 (95.66 %) of 401171 publications. The degree of collaboration is 0.96.

**Table 2. Single vs Multi Authorship pattern and Degree of Collaboration of CFTIs from 1991-2020**

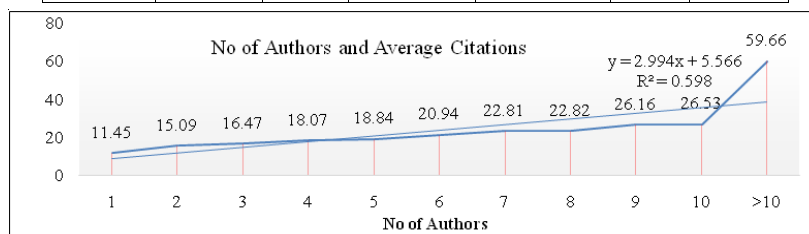
S No	Year	Single Author	%	Multiple Authors	%	Total No Pub.	Degree of Collaboration
1	1991	251	10.19	2211	89.81	2462	0.90
2	1992	242	9.68	2259	90.32	2501	0.90
3	1993	269	10.17	2375	89.83	2644	0.90
4	1994	254	9.02	2562	90.98	2816	0.91
5	1995	257	9.01	2596	90.99	2853	0.91
6	1996	311	8.33	3423	91.67	3734	0.92
7	1997	348	9.24	3419	90.76	3767	0.91
8	1998	348	9.47	3326	90.53	3674	0.91
9	1999	319	8.81	3301	91.19	3620	0.91
10	2000	380	9.80	3499	90.20	3879	0.90
11	2001	372	9.43	3572	90.57	3944	0.91
12	2002	322	7.29	4094	92.71	4416	0.93
13	2003	411	7.90	4794	92.10	5205	0.92
14	2004	393	6.56	5597	93.44	5990	0.93
15	2005	462	6.31	6854	93.69	7316	0.94
16	2006	550	6.26	8231	93.74	8781	0.94
17	2007	515	5.43	8972	94.57	9487	0.95
18	2008	636	5.69	10542	94.31	11178	0.94
19	2009	618	5.07	11577	94.93	12195	0.95
20	2010	740	5.34	13129	94.66	13869	0.95
21	2011	789	4.93	15204	95.07	15993	0.95
22	2012	722	4.07	17018	95.93	17740	0.96
23	2013	740	3.79	18768	96.21	19508	0.96
24	2014	826	3.66	21726	96.34	22552	0.96
25	2015	844	3.37	24185	96.63	25029	0.97
26	2016	972	3.37	27872	96.63	28844	0.97
27	2017	993	3.03	31761	96.97	32754	0.97
28	2018	1147	2.98	37389	97.02	38536	0.97
29	2019	1157	2.77	40684	97.23	41841	0.97
30	2020	1231	2.79	42812	97.21	44043	0.97
<b>Total</b>		<b>17419</b>	<b>4.34</b>	<b>383752</b>	<b>95.66</b>	<b>401171</b>	<b>0.96</b>

#### 54 AUTHORSHIP PATTERN OF RESEARCH PUBLICATIONS OF CFTIS AND AVERAGE CITATIONS

Table 3 and fig. 1 presents the authorship pattern of research publications of CFTIs and an average number of citations. The highest number of publications are two authored 129474 (32.27%), followed by three authors 118301 (29.49%), four authors 64631 (16.11%), five authors 32023 (7.98%), and single authored 17419 (4.34%). A significant share of publications (77.87%) was contributed by two, three, and four authored publications; publications contributed by one, five, and six authors were 16.38%, and more than six authored contributed 5.75 %. The comparison of the percentage of contributed papers, percentage of publications without citations and average citations is as: single-authored publications are 4.34%, publications without citations are 31.58%, and average citations are 11.45; two, three, four and five authored publications without citations are 16.44%, 14.7%, 12.66%, 11.05% and average citations is 15.09, 16.47, 18.07, 18.84. It is indicated that the number of citations is more in the case of multiple authors, and the number of citations is proportionately increased with the number of authors.

**Table 3. Authorship pattern of Research Publications of CFTIs and Average Citations**

No of Authors	No. of Publications	%	Publications Without Citation	% of Publications Without Citations	Total Citation	Average Citations
1	17419	4.34	5501	31.58	199394	11.45
2	129474	32.27	21291	16.44	1954292	15.09
3	118301	29.49	17387	14.7	1948669	16.47
4	64631	16.11	8181	12.66	1167907	18.07
5	32023	7.98	3540	11.05	603177	18.84
6	16275	4.06	1473	9.05	340875	20.94
7	8503	2.12	711	8.36	193911	22.81
8	4795	1.20	324	6.76	109408	22.82
9	2664	0.66	175	6.57	69691	26.16
10	1632	0.41	103	6.31	43296	26.53
>10	5454	1.36	295	5.41	325373	59.66
Total	401171	100.00	58981	14.70	6955993	17.34



**Fig. 1 Authorship pattern of Research Publications of CFTIs and Average Citations**

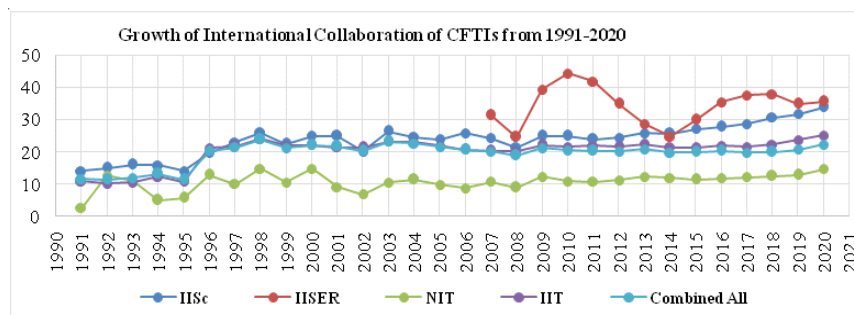
#### 55 GROWTH OF INTERNATIONAL COLLABORATION OF CFTIS FROM 1991-2020

Table 4 and fig 2 presents the growth of international collaboration in the publications of CFTIs from 1991 to 2020. The percentage of international

collaborated research publications of IISc was 14% in 1991 and 33.80% in 2020; the rate of international collaboration continuously increased. The internationally collaborated publications of IITs grew from 10.91% in 1991 to 25.11% in 2020. Internationally collaborated publications of NITs from 2.56% in 1991 to 14.65 in 2020 and IISERs from 31.25% in 2007 to 35.56% in 2020. The internationally collaborated publications of CFTIs continuously increased from (11.49%) in 1991 to 22.28% in 2020. The average collaborated publications of IISc (25.64%), IITs (21.84%), NITs (12.31%), IISERs (37.35%) and combined all the institutes (20.32%). The trend of international collaboration of research is continuously increasing in IISc, IITs, IISERs, and in NITs, it is unstable, and after 2010 it is raised. The publication share of IISERs is less than IITs, NITs, and IISc but the percentage of internally collaborated publications is the highest.

**Table 4. Growth of International Collaboration of CFTIs from 1991-2020**

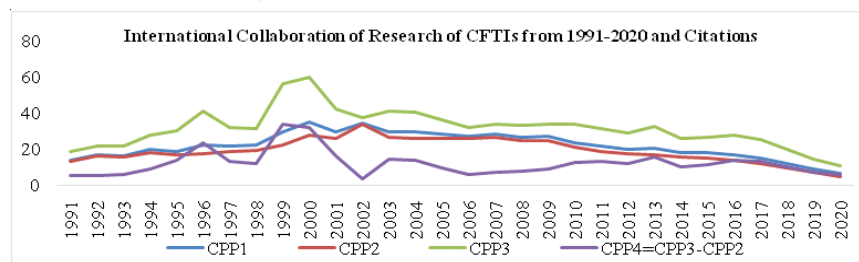
Table 4. Growth of International Collaboration of CFTIs from 1991-2020					
Year	IISc (%)	IISER (%)	NIT (%)	IIT (%)	Combined All (%)
1991	14.00		2.56	10.91	11.49
1992	14.87		12.66	10.13	11.40
1993	15.94		10.87	10.47	11.88
1994	15.84		4.94	12.27	13.10
1995	14.09		5.71	10.69	11.39
1996	19.57		12.82	21.17	20.33
1997	22.99		10.05	21.74	21.42
1998	26.02		14.75	24.07	23.84
1999	22.39		10.45	21.87	21.19
2000	24.95		14.76	22.02	22.07
2001	24.85		9.13	21.44	21.70
2002	20.10		6.80	21.29	20.29
2003	26.26		10.58	23.09	23.11
2004	24.62		11.32	22.97	22.67
2005	23.92		9.73	21.93	21.54
2006	25.82		8.77	20.56	20.58
2007	24.27	31.25	10.71	20.21	20.13
2008	21.44	24.47	8.89	20.15	18.89
2009	24.91	39.29	12.34	22.02	21.12
2010	24.89	44.33	10.94	21.59	20.51
2011	23.83	41.77	10.73	21.94	20.20
2012	24.30	34.87	11.23	21.76	20.09
2013	25.75	28.69	12.30	22.46	20.78
2014	25.63	24.78	11.85	21.39	19.79
2015	27.12	29.82	11.41	21.42	19.87
2016	27.75	35.40	11.79	21.82	20.23
2017	28.73	37.47	12.18	21.50	19.75
2018	30.68	37.89	12.45	22.24	19.95
2019	31.75	34.85	12.84	23.70	20.72
2020	33.80	35.56	14.65	25.11	22.28
<b>Total</b>	<b>25.64</b>	<b>37.33</b>	<b>12.31</b>	<b>21.84</b>	<b>20.32</b>



**Fig. 2. Growth of International Collaboration of CFTIs from 1991-2020**

### 56 INTERNATIONAL COLLABORATION OF RESEARCH OF CFTIS FROM 1991-2020 AND CITATIONS

Table 5 and fig 3 shows the number of publications of CFTIs with and without international collaboration and difference in the number of citations per publications. The trend of citations per publication from 1991 to 2000 was analysed year wise separately for publications with and without internationally collaborated and combined both. The trend shows that the citations per publications are in order of increasing from 1991 to 2000 and after that, it started decreasing. The average citations per publications is 17.34 and in case of publications without international collaboration is 15.11 and with international collaboration is 26.17. The difference in citations in publications between with and without international collaboration is 10.96. The comparison of growth of international collaboration and citation per publications, publications in continuously grown but the citation per publications is increased till 2000 and after that in decreasing order.



**Fig 3. International Collaboration of Research of CFTIs from 1991-2020 and Citations**



**Table 5. International Collaboration of Research of CFTIs from 1991-2020 and Citations**

Year	All Publications			Publications without International Collaboration			Publications with International Collaboration			International Collaboration (%)	Difference in CPP
	TP1	TC1	CPP1	TP2	TC2	CPP2	TP3	TC3	CPP3	(TP3/TP1)*100	CPP4=CPP3-CPP2
1991	2462	33906	13.77	2179	28582	13.12	283	5324	18.81	11.49	5.70
1992	2501	42350	16.93	2216	36201	16.34	285	6149	21.58	11.40	5.24
1993	2644	43030	16.27	2330	36152	15.52	314	6878	21.90	11.88	6.39
1994	2816	55208	19.61	2447	45035	18.40	369	10173	27.57	13.10	9.16
1995	2853	52034	18.24	2528	42145	16.67	325	9889	30.43	11.39	13.76
1996	3734	83387	22.33	2975	51974	17.47	759	31413	41.39	20.33	23.92
1997	3767	80569	21.39	2960	54809	18.52	807	25760	31.92	21.42	13.40
1998	3674	80791	21.99	2798	53304	19.05	876	27487	31.38	23.84	12.33
1999	3620	105938	29.26	2853	62993	22.08	767	42945	55.99	21.19	33.91
2000	3879	135730	234.99	3023	84477	27.94	856	51253	59.88	22.07	31.93
2001	3944	116020	29.42	3088	79867	25.86	856	36153	42.23	21.70	16.37
2002	4416	152115	34.45	3520	118627	33.70	896	33488	37.38	20.29	3.67
2003	5205	154684	29.72	4002	105428	26.34	1203	49256	40.94	23.11	14.60
2004	5990	175491	29.30	4632	120774	26.07	1358	54717	40.29	22.67	14.22
2005	7316	207248	28.33	5740	150215	26.17	1576	57033	36.19	21.54	10.02
2006	8781	237553	27.05	6974	180010	25.81	1807	57543	31.84	20.58	6.03
2007	9487	266049	28.04	7577	201745	26.63	1910	64304	33.67	20.13	7.04
2008	11178	295808	26.46	9066	225887	24.92	2112	69921	33.11	18.89	8.19
2009	12195	326085	26.74	9619	238206	24.76	2576	87879	34.11	21.12	9.35
2010	13869	327849	23.64	11024	231914	21.04	2845	95935	33.72	20.51	12.68
2011	15993	339982	21.26	12763	237386	18.60	3230	102596	31.76	20.20	13.16
2012	17740	350594	19.76	14176	246351	17.38	3564	104243	29.25	20.09	11.87
2013	19508	398735	20.44	15454	265686	17.19	4054	133049	32.82	20.78	15.63
2014	22552	403077	17.87	18090	285967	15.81	4462	117110	26.25	19.79	10.44
2015	25029	439978	17.58	20055	306592	15.29	4974	133386	26.82	19.87	11.53
2016	28844	483803	16.77	23009	319637	13.89	5835	164166	28.13	20.23	14.24
2017	32754	484648	14.80	26286	320826	12.21	6468	163822	25.33	19.75	13.12
2018	38537	445604	11.56	30849	292626	9.49	7688	152978	19.90	19.95	10.41
2019	41841	362192	8.66	33170	238247	7.18	8671	123945	14.29	20.72	7.11
2020	44043	275535	6.26	34232	168395	4.92	9811	107140	10.92	22.28	6.00
Total	401172	6955993	17.34	319635	4830058	15.11	81537	2125935	26.07	20.32	10.96

## 6 CONCLUSION

The CFTIs in India were established as an institute of national importance under the institute of technology act, 1961. Initially, these institutes' primary focus was graduate-level engineering and technology education. With time, the focus shifted towards research programs in traditional engineering and interdisciplinary areas. In the eleventh five-year plan, eight new IITs and five IISERs were established, and regional engineering colleges were declared as institutes of national importance with the national institute of technology act,

2007. The growth of research publications in the last three decades continually increased from 1991 to 2020. In the first decade, from 1991 to 2000, the publication share was 7.9%; in the second decade, 2001 to 2010, it was 20.5%, and in the third decade, from 2011 to 2020, it was 71.5%. The trend of authorship pattern for single authors is decreasing, whereas multi-authored publications are continuously increasing. The average citation trend for the publications is proportionately increased as more the collaborated authors more the number of citations. The trend of collaboration with international institutes' authors has continuously increased from 1991 to 2020. The percentage of publications of NITs with international collaborations is low compared to other categories of institutes. In the case of IISERs, the publication share is less as these were established after 2006 and are a smaller number of institutes, but the percentage of internationally collaborated publications is higher than other categories of institutes. The average number of citation trends for internationally collaborated publications is proportionately higher comparing non-internationally collaborated publications. This study found that the number of citations is directly proportionate to the number of collaborated authors, and internationally collaborated publications have a higher citation rate. The number of collaborated authors and international collaborations are the influencing factors for the citations. The research collaboration of CFTIs is continuously increasing with researchers from international institutes. The internationally collaborated research is getting wide visibility, attracting more citations and impact. It increases the global ranking of the institutes and attracts more talent, researchers and funding sponsors. Overall, the study shows an interesting trend in the domain, and it would be further interesting to see and evaluate this trend in the future years. This study helps in understanding and decision-making for the researcher, educator, authorities, policymakers and funding bodies.

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