Collaborative Approach among Management Professionals: Scientometric approach

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Abstract - Collaborative approach, frequently referred to as a co-authored publication, has been used as a basic counting unit to measure collaborative activity. A variety of data analysis methods are employed during Scientometric analysis including co-authorship analysis, and citation analysis, indexes etc. In this study new derived method known as Chelvan and Gopal method of measures of reach of scientific output was made using Reach percentage (RP); Reach Activity Index (RAI); Unreach/Reach Activity Index (URAI); Unreach Activity Index (UAI) and Richness Factor Index (RFI) factors of authorship pattern has been used. In India, management education was way back to the 19th century. Since 1980's management education got increased importance and received a professional education level status since management education aims to develop knowledge about overall business and also its different functions. Indian Institute of Management (IIM), a pioneering institution, recognized globally producing management professionals. There exist 20 IIMs of which 6 of them were established after 2015. In this study, the publications 13 IIMs those are included in the scopus alone taken for analyzing the collaborative approach. The research output data from Scopus, a multidisciplinary online database which is an international indexing and abstracting database, have been downloaded using the search terms as individual institutions. A total of 6061 publications have been identified and downloaded which were published between 1965 and 2017. Although there are several strategies such as citation analysis, indices, uncited publications, mapping the output outlined in number of studies, in this study a method thus derived giving due importance to number of papers and number of authors of the organization in calculating the Richness factor index and Reach Activity Index. It seems the factors that has been identified that attributed for reach and richness of publications seems to be meaningful instead of taking citation alone has a criteria to predict the value of the paper.

Key words: Collaborative approach, Scientometric approach, Management professionals; Richness Factor Index (RFI), Reach Activity Index (RAI), Unreach/Reach Activity Index (URAI), Unreach Activity Index (UAI)

I. INTRODUCTION

Scientometric, common research tool, has been widely applied in scientific production and research-trend studies in many disciplines of science and engineering (Almind & Ingwersen, 1997; Cronin, 2001; Moed, Debruin, & Vanleeuwen, 1995). The popularity in adaptation of these techniques in various disciplines stimulated stupendous growth of literature on scientometric and its related areas. The dimensional changes in these tool paved way for few innovative methods in measuring the trend of a particular domain.

For decades the multiple-author publication, frequently referred to as a co-authored publication, has been used as a basic counting unit to measure collaborative activity. Smith was one of the first researchers to observe an increase in the incidence of multiple-author papers and to suggest that such papers could be used as a proxy measure for collaboration among groups of researchers.

Measures of collaboration to show the trend towards multiple authorships in a discipline, many studies have used the mean number of authors per paper, termed the CI by Lawani (1980) and the proportion of multiple authored papers, called Degree of Collaboration (DC) by Subramanyam (1983) as a measure of the strength of collaboration in a discipline. Assuming that these two measures were seems to be inadequate, Ajiferuke et al. (1988), who derived a single measure that incorporates some of the merits of both of the above. Ideally, it is desired that a quantification of collaboration should have a value between 0 and 1, with 0 corresponding to single authored papers, and 1 for the case where all papers are maximally authored, i.e. every publication in the collection has all authors in the collection as coauthors. All the above mentioned formulas to find the collaboration coefficient (CC) value have one or other demerit. To overcome some of the demerits of previously explained measures, and propose a simple modification of CC, which is represented as the Modified Collaboration Coefficient (MCC), which

improves its performance in this respect. Let the collection K be the research papers published in a discipline or in a journal during a certain period of interest. In the following, we write fj is the number of papers having j authors in collection K; N is the total number of papers in K. N = Rjfj; and A is the total number of authors in collection K.

In this paper attempt has been made to identify the collaborative approach among management professionals with respect to Indian environment.

II. MANAGEMENT EDUCATION

In India, management education was way back to the 19th century. British government administration needs were fulfilled by this education to some extent. The graduates joined as clerks in the British administration. In Chennai in 1903 was set up the India's first commercial school of Pachiappa charities. In 1913, Sydenham College in Mumbai was the first college level business school to be founded. This was followed by Shri Ram College of commerce in Delhi in 1920. These management institutions followed the US type of systems in terms of pedagogy, curriculum and interfacing with industry.

In the initial years of business education, it was not popular. All bright students were expected to join science stream and take engineering at the IIT's or other technical institutes. Afterwards they joined companies as technical supervisors and then moved up to take up managerial positions. In 1961 two IIM's were launched. IIM Calcutta with collaboration from Sloan school of Management at MIT and IIM Ahmadabad started with Harvard business school help.

Since 1980's management education got increased importance and received a professional education level status since management education aims to develop knowledge about overall business and also its different functions. It was focused on graduate levels and help in developing future leaders. Some of the skills which management graduates were expected to have were good accounting skills and also operational management skills, marketing skills, good oral and written communications , critical thinking and as well team working skills. And also knowledge of information technology is required for leveraging its power in the business arena. The teaching pedagogy has been undergoing constant changes in the Management education to suit the above requirements.

III. INDIAN INSTITUTE OF MANAGEMENT

Indian Institute of Management (IIM), a pioneering institution, was initiated by Jawaharlal Nehru, the first Prime Minister of India, based on the recommendation of the Planning Commission. IIMs are registered as societies under the Indian Societies Registration Act. Each IIM is autonomous and exercises independent control over its day-to-day operations. However, the administration of all IIMs and the overall strategy of IIMs are overseen by the IIM council. The IIM Council is headed by India's Minister of Human Resource Development and consists of the chairpersons and directors of all IIMs and senior officials from the Ministry of Human Resource Development of the Government of India. There exist 20 IIMs of which 6 of them were established after 2015, in this study, the publications 13 IIMs are available in the scopus only taken for this study.

IV. REVIEW OF RELATED LITERATURE

A variety of data analysis methods are employed during Scientometric analysis including co-authorship analysis, and citation analysis (i.e., papers or authors often cited in cycle) Callon (1986); Callon, Courtiaol & Laville (1991); He (1999); Leydesdorff (1997); Peters & Van Raan (1993). Few indexing techniques such as h index (Hirsch,2005); h2 index (Kosmulski, 2006); g index (Egghe, 2006); a index (Jin, 2006); Normalized h index (hnom) (Sidiropoulos, Katsaros, and Manolopoulos 2007); r Index (Jin et al, 2007a); ar index, (Jin, 2007b); e index (Zhang, 2009); hg index, (Alonso 2010); p index (GanganPrathap, 2010); mapping techniques (Karpagam et al. 2011). Viswanathan and Tamizhchelvan (2014) analysed the growth on Spacecraft research during 2009-2013 based on the Scopus database. Bathrinarayanan and Tamizhchelvan (2014) studied Indian research output on MEMS literature using the Scopus database.

Lawani demonstrated that, as the number of authors per paper increases, the proportion of high-impact papers (i.e. papers earning a high number of citations) also increases.

In this study new derived method known as Chelvan and Gopal method of measures of reach of scientific output was made using Reach percentage (RP); Reach Activity Index (RAI); Unreach/Reach Activity Index

(URAI);Unreach Activity Index (UAI) and Richness Factor Index (RFI) factors of authorship pattern has been used. (Tamizhchelvan and Gopalakrishnan, 2018a, 2018b)

V. OBJECTIVES

The objective of the study were to identify the
- Collaborative approach among the management professionals.
- Reach of the paper
- Richness of the paper

VI. HYPOTHESES

Based on the objective the following hypotheses were formulated.
- There exist collaboration trend among IIMs professionals
- Collaborated papers have more citation then solo research papers
- There exist significant difference between citation and reach of publications
- There exist significant difference between citation and richness of the publications.
- There exist no significant difference between RAI, URAI and UAI among IIMs

VII. DATA ANALYSIS

For this study, the research output data have been downloaded using the search terms as follows *Query : ((AF-ID("Indian Institute of Management Ahmedabad" 60033308) OR AF-ID("Indian Institute of Management Calcutta" 60070899) OR AF-ID("Indian Institute of Management Bangalore" 60071271) OR AF-ID("Indian Institute of Management Lucknow" 60072366) OR AF-ID("Indian Institute of Management Indore" 60105397) OR AF-ID("Indian Institute of Management Kozhikode" 60079444) OR AF-ID("Indian Institute of Management Rohtak" 60107374) OR (...) OR AF-ID("Indian Institute of Management Tiruchirappalli" 60107376)))* from 'Scopus' a multidisciplinary online database which is an international indexing and abstracting database. For this study, a total of 6061 publications have been identified and downloaded which were published between 1965 and 2017.

VIII. MEASURE OF REACH AND RICHNESS

The scientific research output primarily depends on reach of the paper and richness of the paper. Even there were many methods adopted, in this paper the method suggested by Chelvan and Gopal has been adopted (Tamizhchelvan and Gopalakrishnan 2018a, 2018b) **–** Shown in Annexure I and II.

IX. COLLABORATIVE TREND OF IIM RESEARCH

Out of 6061 papers, single author papers and collaborated author papers were identified and the same has been shown in Table 1.

Table 1 Authorship pattern of IIM Publications

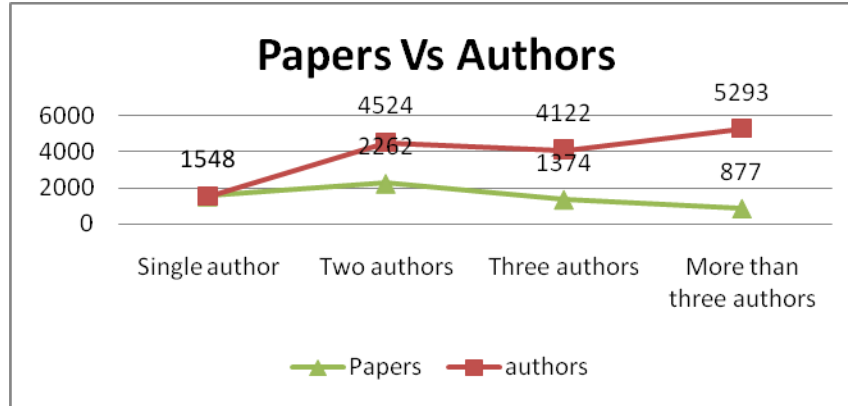| S.No	Authorship pattern	No of Papers	%	No. of authors	%
1	Single author	1548	25.54	1548	10.00
2	Two authors	2262	37.32	4524	29.21
3	Three authors	1374	22.67	4122	26.62
4	More than three authors	877	14.47	5293	34.17
	Total	**6061**	**100.00**	**15487**	**100.00**

Figure 1 Papers Vs Authors

Out of 6061 papers, 1548 (25.54%) papers were of single author publications. It is followed by two authors (2262, 37.32%); three authors (1374, 22.67%) and More than three authors (877, 14.47%). Nearly 74.46% of papers were collaborative in nature. These 6061 papers were contributed by 15,487 authors. Only 10% of authors were single author papers. Remaining 90% were two authors, three authors and more three authors.

The trend of solo research and collaborated research among different IIMs were analysed and the same has been shown in Table 2

Table 2 Total publication, Solo and Collaborate papers

S.No.	IIMs	Total Papers	%	Solo papers	%	Collaborated papers	%
1	IIM-A	1542	25.44	485	31.45	1057	68.55
2	IIM-B	1156	19.07	303	26.21	853	73.79
3	IIM-C	1285	21.20	279	21.71	1006	78.29
4	IIM-I	393	6.48	101	25.70	292	74.30
5	IIM-Kashipur	83	1.37	20	24.10	63	75.90
6	IIM-K	387	6.39	79	20.41	308	79.59
7	IIM-L	567	9.35	154	27.16	413	72.84
8	IIM-Raipur	169	2.79	14	8.28	155	91.72
9	IIM-R	74	1.22	4	5.41	70	94.59
10	IIM-Rohtak	185	3.05	70	37.84	115	62.16
11	IIM-S	66	1.09	14	21.21	52	78.79
12	IIM-T	65	1.07	12	18.46	53	81.54
13	IIM-U	89	1.47	13	14.61	76	85.39
	Total	6061	100.00	1548	25.54	4513	74.46

Figure 2 Solo Vs Collaborated papers
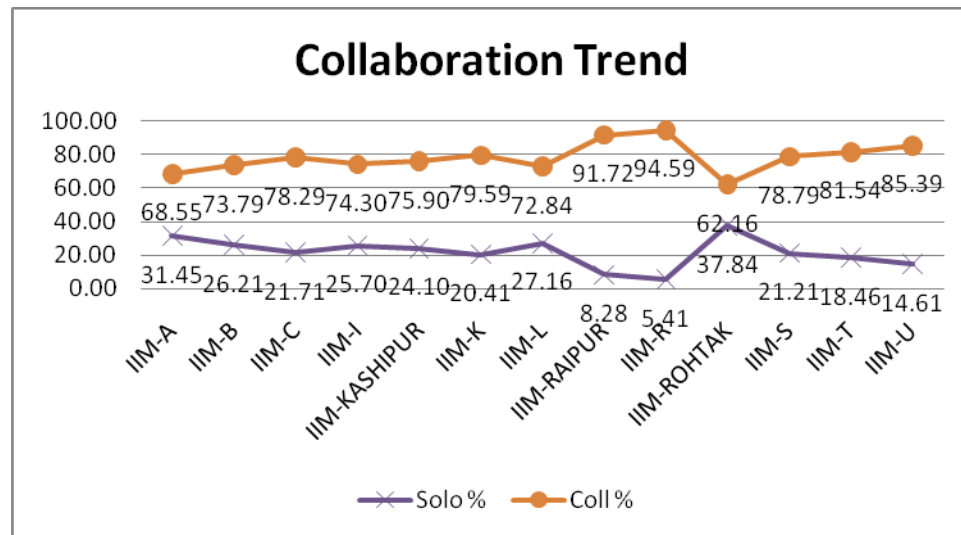
Figure 3 IIMs Vs Solo and Collaborated papers

The solo research papers were ranges between 5.41% and 31.45%. Out of the contributed papers of individual IIMs, maximum solo research paper can be seen in IIM – Rohtak (37.84%). It is followed by IIM-A (31.45%); IIM-L (27.16%); IIM-B (26.21%); and IIM-I(25.70%). Similarly in the case of collaborated papers, it ranges between 62.16% and 94.59%. Maximum number of collaborated papers can be seen from IIM-R (94.59%). It is followed by IIM- Raipur (91.72%); IIM-U (85.39%); IIM-T (81.54%). Least number of collaborated papers can be seen in IIM-Rohtak (62.16%) and IIM-A (68.55%).

X. COLLABORATED PAPERS

A total of 4513 (74.56%) papers were collaborated in nature. Collaborated papers were further analysed based on

- Two Author Papers - 2262 Papers – 4524 Authors
- Three Author Papers - 1374 Papers - 4122 Authors
- More than Three authors papers - 877 Papers – 5293 Authors

Two author papers

Out of collaborated 4513 papers, 2262 papers were two authors; these 2262 papers were contributed by 4524 authors. These two authors were further analysed based on position of IIM authors and the same has been shown in Table 3.

Table 3 Collaborated Papers in IIMs – Two author papers

S.No.	IIMs	Total Papers	Collaborated Papers	Two Authors paper	First Author	Second Author from other IIM	Second Author from same IIM	Authors from Outside IIM	Total No. of Two Authors
1	IIM-A	1542	1057	537	477	60	35	502	1074
2	IIM-B	1156	853	379	340	39	12	367	758
3	IIM-C	1285	1006	532	483	49	17	515	1064
4	IIM-I	393	292	180	155	25	9	171	360
5	IIM-Kashipur	83	63	34	30	4	6	28	68
6	IIM-K	387	308	165	151	14	4	161	330
7	IIM-L	567	413	221	182	39	18	203	442
8	IIM-Raipur	169	155	41	31	10	8	33	82
9	IIM-R	74	70	36	30	6	3	33	72
10	IIM-Rohtak	185	115	61	58	3	1	60	122
11	IIM-S	66	52	15	15	0	0	15	30
12	IIM-T	65	53	23	13	10	0	23	46
13	IIM-U	89	76	38	21	17	1	37	76
		6061	4513	2262	1986	276	114	2148	4524

Out of 2262 papers, 1986 papers IIM faculties were first author and 276 were second author. 114 authors were belonging to IIM. 2148 papers were one author from IIM and another from outside IIM. In other words out of 4524 authors, 2148 authors were outside IIM.

Three and More than Three Authors

Similarly three authors and more than three authors were analysed and the same has been shown in Table 4.

Table 4 Three and more authors collaboration

S.No.	IIMs	Total Papers	Collaborated papers	Three authors	First author	Second Author From other IIM	Third authors from other IIM	2nd Author from same IIM	3rd Author from same IIM	Authors from Outside IIM	Total Authors	More than three authors	Within IIM	Outside IIM	Total Authors
1	IIM-A	1542	1057	293	255	35	3	24	4	558	879	227	262	1370	1632
2	IIM-B	1156	853	286	247	33	6	15	3	554	858	188	196	1253	1449
3	IIM-C	1285	1006	264	234	26	4	13	1	514	792	210	216	821	1037
4	IIM-I	393	292	76	49	22	5	2	0	150	228	36	40	173	213
5	IIM-Kashipur	83	63	21	18	3	0	1	0	41	63	8	11	22	33
6	IIM-K	387	308	102	91	8	3	6	1	197	306	41	48	150	198
7	IIM-L	567	413	139	115	22	2	8	0	270	417	53	59	184	243
8	IIM-Raipur	169	155	62	55	6	1	5	0	119	186	52	57	164	221

9	IIM-R	74	70	18	16	2	0	1	0	35	54	16	24	45	69
10	IIM-Rohtak	185	115	34	29	5	0	2	0	66	102	20	21	68	89
11	IIM-S	66	52	31	31	0	0	0	0	62	93	6	6	20	26
12	IIM-T	65	53	20	13	5	2	2	1	37	60	10	11	31	42
13	IIM-U	89	76	28	22	5	1	1	0	55	84	10	10	31	41
		6061	4513	1374	1175	172	27	80	10	2658	4122	877	961	4332	5293

Out of 1374 papers, 1175 papers from IIM faculties were first author and 172 papers were second author. 27 papers were third author and further 2nd and 3rd authors from the same IIM are from 90 papers. The same way, 5293 authors contributed 877 papers, out of 5293 authors 961 from IIMs and 4332 authors from outside IIM.

The citation of these 6061 papers were analysed and the same has been shown in Table 5. The total papers, total authors and total citations and the citations of solo and collaborated papers were calculated and presented.

XI. CITATIONS OF PAPERS

The citation of the solo and collaborated paper and authors presented is table 5. It is observed that the one fourth of the solo author papers and their citations 7889 and the remaining three fourth of collaborated author papers and their citations 36601.

Table 5 Citation papers for Solo and Collaborated Authors

S.No.	IIMs	Total Papers	Total authors	Total citation	Solo	Solo paper citation	Collaborated papers	Total collaborated authors	Collaborated paper citation
1	IIM-A	1542	4070	13852	485	2481	1057	3585	11371
2	IIM-B	1156	3368	10027	303	1435	853	3065	8592
3	IIM-C	1285	3172	10936	279	1376	1006	2893	9560
4	IIM-I	393	902	1758	101	366	292	801	1392
5	IIM-Kashipur	83	184	176	20	27	63	164	149
6	IIM-K	387	913	1946	79	349	308	834	1597
7	IIM-L	567	1256	3661	154	1401	413	1102	2260
8	IIM-Raipur	169	503	477	14	13	155	489	464
9	IIM-R	74	199	132	4	3	70	195	129
10	IIM-Rohtak	185	383	815	70	408	115	313	407
11	IIM-S	66	163	268	14	15	52	149	253
12	IIM-T	65	160	222	12	9	53	148	213
13	IIM-U	89	214	220	13	6	76	201	214
	Total	6061	15487	44490	1548	7889	4513	13939	36601

XII. REACH ACTIVITY INDEX AND RICHNESS FACTOR

Reach Activity Index and Richness factors were calculated using the formula of Chelvan and Gopal in the annexure for

- Total papers
- Solo authored papers

- Collaborated author papers

Total Papers

Reach Activity Index (RAI), Unreach / Reach Activity Index and Unreach Activity Index and Richness Factor Index are calculated for the total publications of the IIMs and presented in the table 6.

Table 6 Total Papers – RAI, URAI, UAI and RFI

S.No.	IIMs	Total Papers	Total authors	Total Cited Papers	Total citations	Rank	RAI	Rank	URAI	Rank	UAI	Rank	RFI	Rank
1	IIM-A	1542	4070	999	13852	1	1.03	4	0.92	10	0.95	10	0.002207	13
2	IIM-B	1156	3368	752	10027	3	1.03	2	0.91	12	0.94	12	0.002575	12
3	IIM-C	1285	3172	867	10936	2	1.07	1	0.82	13	0.88	13	0.002683	11
4	IIM-I	393	902	203	1758	6	0.82	8	1.59	6	1.30	6	0.004959	10
5	IIM-Kashipur	83	184	41	176	12	0.79	10	1.74	4	1.36	4	0.011524	4
6	IIM-K	387	913	251	1946	5	1.03	3	0.92	11	0.95	11	0.005508	8
7	IIM-L	567	1256	358	3661	4	1.00	6	0.99	8	0.99	8	0.005141	9
8	IIM-Raipur	169	503	84	477	8	0.79	9	1.71	5	1.35	5	0.005611	7
9	IIM-R	74	199	32	132	13	0.69	12	2.22	2	1.53	2	0.008964	6
10	IIM-Rohtak	185	383	119	815	7	1.02	5	0.94	9	0.96	9	0.011502	5
11	IIM-S	66	163	40	268	9	0.96	7	1.10	7	1.06	7	0.024912	1
12	IIM-T	65	160	29	222	10	0.71	11	2.10	3	1.49	3	0.021346	2
13	IIM-U	89	214	36	220	11	0.64	13	2.49	1	1.60	1	0.011551	3
		6061	**15487**	**3811**	**44490**									

Based on total citation ranks were assigned to Individual IIMs. IIM-A were positioned first place with 13852 citations. It is followed by IIM-C; IIM-B, and IIM-L. Least rank were positioned by IIM-R (132 citations) and IIM- Kashipur (176).

The RAI, URAI, UAI and RFI, which gives importance to citation, total papers, total authors, were calculated using the formula stated in annexure – I and annexure – II. The ranks were assigned based on RAI, URAI, UAI and RFI and the same has been shown in Table -6.

According to RAI, the first three places were IIM-C; IIM-B and IIM-K. Least rank places were for IIM-U, IIM-R and IIM-T. Similarly based on URAI and UAI, the first three positions were for IIM-U, IIM-R and IIM-T. The least were for IIM-C; IIM-B and IIM-K.

The RFI for individual IIMs were calculated and the ranks were assigned. Based on RFI, IIM-S were positioned first. It is followed by IIM-T; IIM-U and IIM-Kashipur. Least positions were ranked by IIM-C, IIM-B and IIM-A.

Solo authored papers

Reach Activity Index (RAI), Unreach / Reach Activity Index and Unreach Activity Index and Richness Factor Index are calculated for the solo authored publications of the IIMs and presented in the table 7.

Table 7 Solo Papers – RAI, URAI, UAI and RFI

S.No.	IIMs	Solo papers	Solo authors	Solo paper citation	Citation rank	RAI	Rank	URAI	Rank	UAI	Rank	RFI	Rank
1	IIM-A	485	485	2481	1	0.93	6	1.18	8	1.09	8	0.011	13
2	IIM-B	303	303	1435	2	1.04	5	0.90	9	0.94	9	0.016	12
3	IIM-C	279	279	1376	4	1.05	4	0.90	10	0.94	10	0.018	11
4	IIM-I	101	101	366	6	0.86	9	1.38	5	1.19	5	0.036	9
5	IIM-Kashipur	20	20	27	8	0.88	7	1.30	6	1.15	6	0.068	4
6	IIM-K	79	79	349	7	1.19	2	0.64	12	0.76	12	0.056	8
7	IIM-L	154	154	1401	3	1.10	3	0.79	11	0.87	11	0.059	7
8	IIM-Raipir	14	14	13	10	0.50	11	3.26	2	1.65	2	0.066	5
9	IIM-R	4	4	3	13	0.88	8	1.30	7	1.15	7	0.188	1
10	IIM-Rohtak	70	70	408	5	1.31	1	0.45	13	0.59	13	0.083	2
11	IIM-S	14	14	15	9	0.50	12	3.26	3	1.65	3	0.077	3
12	IIM-T	12	12	9	11	0.44	13	3.91	1	1.73	1	0.063	6
13	IIM-U	13	13	6	12	0.54	10	2.93	4	1.59	4	0.036	10
		1548	1548	7889									

Based on Solo research paper citation ranks were assigned to Individual IIMs. IIM-A were positioned first place with 2481 citations. It is followed by IIM-B (1435 citations); IIM-L(1401 citations, and IIM-C (1376 citations). Least rank were positioned by IIM-R (3 citations); IIM-U (6) and IIM- Rajpur (10).

The ranks were assigned based on RAI, URAI, UAI and RFI. According to RAI, the first three places were IIM-Rohtak; IIM-K and IIM-L. Least rank places were for IIM-R, IIM-U and IIM-T. Similarly based on URAI and UAI, the first three positions were for IIM-T, IIM-Raipur and IIM-S. The least were for IIM-Rohtak; IIM-K and IIM-L.

The RFI for individual IIMs were calculated and rank were assigned. Based on RFI, IIM-R were positioned first. It is followed by IIM-Rohtak; IIM-S and IIM-Kashipur. Least positions were ranked by IIM-A, IIM-B and IIM-C.

Collaborated authors' papers

Reach Activity Index (RAI), Unreach / Reach Activity Index and Unreach Activity Index and Richness Factor Index are calculated for the collaborated authors' publications of the IIMs and presented in the table 8.

Table 8 Collaborated Papers – RAI, URAI, UAI and RFI

S.No.	IIMs	Colla borated papers	Colla borated authors	Colla borated paper citation	Rank	RAI	Rank	URAI	Rank	UAI	Rank	RFI	Rank
1	IIM-A	1057	3585	11371	1	1.23	1	1.46	1	0.84	11	0.003	13
2	IIM-B	853	3065	8592	3	1.20	2	1.10	4	1.09	8	0.003	11
3	IIM-C	1006	2893	9560	2	1.00	3	1.24	2	0.80	13	0.003	12
4	IIM-I	292	801	1392	6	0.66	9	0.50	10	1.33	5	0.006	9
5	IIM-Kashipur	63	164	149	12	0.63	10	0.51	9	1.25	6	0.014	3
6	IIM-K	308	834	1597	5	0.80	7	0.78	6	1.03	9	0.006	7
7	IIM-L	413	1102	2260	4	0.81	6	0.83	5	0.98	10	0.005	10
8	IIM-Raipur	155	489	464	7	0.81	5	0.57	8	1.44	4	0.006	8
9	IIM-R	70	195	129	13	0.50	13	0.30	13	1.69	1	0.009	6
10	IIM-Rohtak	115	313	407	8	0.77	8	0.70	7	1.10	7	0.011	5
11	IIM-S	52	149	253	9	0.98	4	1.17	3	0.83	12	0.033	1
12	IIM-T	53	148	213	11	0.62	11	0.42	11	1.47	2	0.027	2
13	IIM-U	76	201	214	10	0.56	12	0.39	12	1.45	3	0.014	4
	Total	**4513**	**13939**	**36601**									

In regard to collaborated research paper citation ranks, IIM-A were positioned first place with 11371 citations. It is followed by IIM-C (9560 citations); IIM-B (8592 citations), and IIM-L (2260 citations). Least rank were positioned by IIM-R (129 citations); IIM- Kashipur (149 citations) and IIM- T (213).

The ranks were assigned based on RAI, URAI, UAI and RFI. The RAI ranges between 0.50 and 1.23. According to RAI, the first three places were IIM-A; IIM-B and IIM-C. Least rank were for IIM-R, IIM-U and IIM-T. Similarly based on URAI, the first three positions were for IIM-A, IIM-C and IIM-S. The least were for IIM-R; IIM-U and IIM-T. The first three ranks based on UAI were IIM-R; IIM-T and IIM-U. The least preferences were IIM-C, IIM-S and IIM-A.

Collaborated papers RFI for individual IIMs were calculated and rank were assigned. Based on RFI, IIM-S were positioned first. It is followed by IIM-T; IIM-Kashipur and IIM-U Least positions were ranked by IIM-A, IIM-C and IIM-B.

The ranks of total, solo and collaborated papers Citation, RAI, URAI,UAI and RFI rank were compared and the same has been shown in Table 9

Table 9 Total, Solo and Collaborated Papers – RAI, URAI, UAI and RFI Rank Comparison

S. No.	IIMs	Total Papers					Solo paper					Collaborated papers				
		Citation Rank	RAI Rank	URAI Rank	UAI Rank	RFI Rank	Citation Rank	RAI Rank	URAI Rank	UAI Rank	RFI Rank	Citation Rank	RAI Rank	URAI Rank	UAI Rank	RFI Rank
1	IIM-A	1	4	10	10	13	1	6	8	8	13	1	1	1	11	13
2	IIM-B	3	2	12	12	12	2	5	9	9	12	3	2	4	8	11
3	IIM-C	2	1	13	13	11	4	4	10	10	11	2	3	2	13	12
4	IIM-I	6	8	6	6	10	6	9	5	5	9	6	9	10	5	9
5	IIM-Kashipur	12	10	4	4	4	8	7	6	6	4	12	10	9	6	3
6	IIM-K	5	3	11	11	8	7	2	12	12	8	5	7	6	9	7
7	IIM-L	4	6	8	8	9	3	3	11	11	7	4	6	5	10	10
8	IIM-Raipur	8	9	5	5	7	10	11	2	2	5	7	5	8	4	8
9	IIM-R	13	12	2	2	6	13	8	7	7	1	13	13	13	1	6
10	IIM-Rohtak	7	5	9	9	5	5	1	13	13	2	8	8	7	7	5
11	IIM-S	9	7	7	7	1	9	12	3	3	3	9	4	3	12	1
12	IIM-T	10	11	3	3	2	11	13	1	1	6	11	11	11	2	2
13	IIM-U	11	13	1	1	3	12	10	4	4	10	10	12	12	3	4

XIII. CONCLUSION

Although there are several strategies such as citation analysis, indices, uncited publications, mapping the output outlined in number of studies, in this study a method thus derived giving due importance to number of papers and number of authors of the organization besides number of citation in calculating the Richness factor index and Reach Activity Index. The data thus obtained for calculation were from Scopus database and the RAI, URAI, UAI and RFI were calculated based on the Scopus data during the study period from 1965 to 2017. It seems the factors that has been identified that attributed for reach and richness of publications seems to be meaningful instead of taking citation alone has a criteria to predict the value of the paper.

REFERENCES

[1] Abramo, Glovanni and D'Angelo, Ciriaco Andrea, "How do you define and measure research productivity?", *Scientometrics,* 101(2): 1129-1144, 2014.
[2] Ajiferuke, I, "Collaborative Co- efficient : A single measure of the degree of collaboration in research", Scientometrics, 14(5-6), 421-433, 1988.
[3] Almind, Tomas C. & Ingwersen, Peter, "Informetric analyses on the world wide web: Methodological approaches to 'webometrics'", *Journal of Documentation*, 53: 404-426, 1997.
[4] Alonso, S., Cabrerizo, F., Herrera-Viedma, E. and Herrara, F, "hgindex: a new index to characterize the scientific output of researchers based on the h and g indices", *Scientometrics*, 82: 391-400, 2010.
[5] Bathrinarayanan, AL and Tamizhchelvan, M. (2014), Indian Research output on MEMS literature using Scopus Database: A Scientometric study. *Journal of Theoretical and Applied Information Technology*, 67(1): 90-102
[6] Bornmann, L,"How are excellent (highly cited) papers defined in bibliometrics? A quantitative analysis of the literature", *Research Evaluation*, 23(2):166-173, 2014.
[6] Callon, M, "The Sociology of an Actor-Network: The Case of the Electric Vehicle. In: Mapping the Dynamics of Science and Technology", edited by M. Callon, J. Law, A. Rip. Macmillian, London, 1986.
[7] Callon, M.N., Courtiaol, J.P.N. & Laville, F.N, "Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry", *Scientometrics*, 22(1): 155-205, 1991.

[8]   Cronin, B, "The Citation Process", *The Role and Significance of Citations in Scientific Communication*, 103p. Taylor Graham, Oxford, 1984.
[9]   Cronin, B, "Hyperauthorship: a postmodern perversion or evidence of a structural shift in scholarly communication practices?", *Journal of the American Society for Information Science and Technology Banner*, 52(7) : 558-569, 2001.
[10]   Dannenberg, A.L. et al., "Use of epidemiology in medical specialties: An examination by citation analysis", *American Journal of Epidemiology*, 121 (1): 140–151, 1985.
[11]   Devis, J.C & Gonzalez, J.G, "Scholarly Journal Article about the Asian Tiger Economics Authors : Journal and research fields 1986-2001" - *Asian Pacific Economic Literature,* 17(2): 15-61, 2003.
[12]   Egghe, L, "Theory and practice of the g-index", *Scientometrics*, 69(1): 131-152, 2006.
[13]   Gangan Prathap, Rekha Mittal, "A performance index approach to library collection", *Performance Measurement and Metrics*, 11(3): 259-265, 2010.
[14]   He, Q, "Knowledge discovery through co-word analysis", *Library Trends,* 48: 133-159, 1999.
[15]   Hirsch, J.E, "An index to quantify an individual's scientific research output" (available at http://www.pnas.org/content/pnas/102/46/16569.full.pdf), 2005.
[16]   Javed, M, "Rawal Medical Journal – An Analysis of Citation Pattern", *Rawal Medical Journal*, 33(2): 254-257, 2008.
[17]   Jin, B.H, "H index: an evaluation indicator proposed by scientist", *Science Focus*, 1(1): 8-9, 2006.
[18]   Jin, B.H., Liang, L., Rousseau, R. and Egghe, L, "The R- and AR-indices: Complementing the h-index", *Chinese Science Bulletin*, 52(6): 855-863, 2007a.
[19]   Jin, B.H, "The AR-index: complementing the h-index", *ISSI Newsletter*, 3(1), 2007b.
[20]   Karpagam, R, "Global research output of nanobiotechnology research: a Scientometircs study", *Current Science*, 106(1490), 89: 1490-1499, 2014.
[21]   Karpagam, R., Gopalakrishnan, S., Natarajan, M. and Babu Ramesh, B, "Mapping of nanoscience and nanotechnology research in India: a scientometric analysis, 1990–2009", *Scientometrics*, 89: 501–522, 2011.
[22]   Kosmulski, M, ""I" - a bibliometric index". Forum Akademickie, 11: 31, 2006.
[23]   Krishnamoorthy G., Ramakrishnan, J. & Devi, S, "Bibliometric analysis of literature on diabetes (1995-2004)", *Annals of Library and Information Studies*, 56: 150-155, 2009.
[24]   Lawani, S.M, "Quality Collaboration and citations in cancer research : A bibliometric study". Ph.D Dissertation, Florida State University, 395p., 1980.
[25]   Leydesdorff, L, "The Triple Helix as a Model for Innovation Studies : Conference Report", *Science & Public Policy,* 25 (3): 195-203, 1997. http://www.leydesdorff.net/th2/spp.htm (accessed on 15-10-2018).
[26]   Leydesdorff, L. "Alternatives to the journal impact factor: I3 and the top-10% (or top-25%?) of the most highly cited papers", *Scientometrics*, 92: 355-365, 2012.
[27]   Moed, H.F., De Bruin, R.E. & Van Leeuwen, T.N., "New bibliometric tools for the assessment of national research performance: Database description, overview of indicators and first applications", *Scientometrics*, 33 (3): 38-422, 1995.
[28]   Persson, Olle, "Are highly cited paper are international? Scientometrics", *Scientometrics* 83(2): 397-401, 2010.
[29]   Peters, H. P. F., & van Raan, A. F. J, "Co-word based science maps of chemical engineering, by combined clustering and multidimensional scaling", *Research Policy*, 22: 47–71, 1993a.
[30]   Peters, H. P. F., & van Raan, A. F. J, "Co-word based science maps of chemical engineering, Part I: Representations by direct multidimensional scaling", *Research Policy*, 22: 23–45, 1993b.
[31]   Prathap Gangan, "The fractional and harmonic p-indices for multiple authorship", *Scientometrics*, 86(2): 239-244, 2011.
[32]   Rahman, M., Haque, T.L., & Fukui, T, "Research articles published in clinical radiology journals: Trend of contribution from different countries", *Academic Radiology*, 12(7): 825-829, 2005.
[33]   Rajendiran, P, Ramesh Babu B and Gopalakrishnan, S, "Bibliometric Analysis of "Fiber Optics literature", *Annals of Library and Information Studies*, 52 (3): 82-85, 2005.
[34]   Rajendram, R., Lewison, G., & Preedy, V, "Worldwide alcohol-related research and the disease burden", *Alcohol and Alcoholism*, 41(1): 99-106, 2006.
[35]   Sidiropoulos, A., Katsaros, D. and Manolopoulos, Y, "Generalized hirsch h-index for disclosing latent facts in citation networks". *Scientometrics,* 72(2): 253–280, 2007.
[36]   Subramanyam, K, "Bibliometric studies of research in collaboration: a review", *Journal of Information Science*, 6(1): 33-38, 1983.
[37]   Tamizhchelvan, M and Gopalakrishnan, S, "Measure the Reach of Scientific Publications: A Scientometric Study", *International Journal of Research in Library Science*, 4(2), 2018a.
[38]   Tamizhchelvan, M and Gopalakrishnan, S, "Measuring Richness of the Research Output: A Scientometric Method", *Journal of Advances in Library and Information Science*, 7(3) p. 212-226, 2018b.
[39]   Van Noorden R., Maher, B and Nuzzo, R, "The top 100 papers", *Nature*. 2014 Oct 30;514 (7524) : 550-3, 2014.
[40]   van Raan, Anthony F. J, "For Your Citations Only? Hot Topics in Bibliometric Analysis, *Measurement: Interdisciplinary Research and Perspectives*, 3(1): 50-62, 2005.
[41]   Viswanathan, V and Tamizhchelvan, M. (2014) Bibliometric Analysis on Growth of Literature on Spacecraft During 2009-2013: A Scopus Database Study, *International Journal of Information Retrieval and Management*, 2(4): 15-18
[41]   Zhang, C.T, "The e-index, complementing the h-index for excess citations", *PLoS ONE*, e5429. doi:10.1371 /journal. pone. 0005429, 4(5). 2009.

ANNEXURE – I

Measure of Reach

      Chelvan and Gopal formula for **Measure of Reach** as stated below has been used in this study**.**

      Measures of reach of scientific output were made using Reach Percentage (RP); Reach Activity Index (RAI); Unreach/Reach Activity Index (URAI) and Unreach Activity Index (UAI). The method of calculation were as follows

1.   **Reach $_\%$ = Reach output of Institution/ Total output of the institution . . . (1)**

2.   **Reach Activity index**

The formula reads as follows:

$$RAI = \frac{R_{ij}/T_{io}}{R_{oj}/T_{oo}} \quad \ldots (2)$$

Where, R_{ij}= Number of Reached / Cited publications for the particular Institutions a particular country
T_{io}= Total publications for the particular Institution
R_{oj}= Number of Reached / Cited publications of all the Institutions
T_{oo} = Total publications of all the Institutions

3.   **URAI = Unreach/Reach Activity Index**

The formula reads as follows:

$$URAI = \frac{R_{ij}/U_{io}}{R_{oj}/U_{oo}} \quad \ldots (3)$$

Where, R_{ij}= Number of Reached / Cited publications for the particular Institution / a particular country
U_{io}= Total Unreached / Uncited publications for the particular Institution
R_{oj}= Number of Reached / cited publications of all the Institutions
U_{oo} = Total Unreached / uncited of all the Institutions

4.   **UAI = Unreach Activity Index**

The formula reads as follows:

$$UAI = \frac{U_{ij}/T_{io}}{U_{oj}/T_{oo}} \quad \ldots (4)$$

Where, U_{ij}= Number of Unreached / uncited publications for the particular Institution / a particular country
T_{io}= Total publications for the particular Institution
U_{oj}= Number of Unreached / uncited publications of all the Institutions
T_{oo} = Total publications of all the Institutions

ANNEXURE – II

Richness Factor Index (RFI)

      Chelvan and Gopal formula for Richness Factor Index (RFI), stated below, has been used in this analysis.

Richness Factor Index (RFI) = No. of citations/no. of authors*age of the paper
The RFI can be
- for a paper
- for a organization
- for a year
- for an author

1. **Richness Factor Index for a paper**
                      Cit $_{paper}$

$$RFI_{Paper} = \frac{}{Tot_{author} * AoP} \quad .... (5)$$

where RFI_{Paper} = Richness Factor Index of paper
$\quad$ Cit_{Paper} = No. of Citations of a paper
$\quad$ Tot_{author} = Total No. of authors of a paper
$\quad$ AoP = Age of a paper
Age of a paper can be calculated as follows
AoP = (Base year of the study – Paper published year) + 1
Eg. Let Base year may be 2018
$\quad$ Paper publication year may be 2017
Therefore AoP = (2018-2017) + 1 = 1+1 = 2

2. Richness Factor Index for an Organization

$$RFI_{Org} = \frac{Cit_{Org}}{Tot_{author} * NoP} \quad .... (6)$$

where RFI_{Org} = Richness Factor Index for an organisation
$\quad$ Cit_{Org} = No. of Citations of an organisation
$\quad$ Tot_{author} = Total No. of authors of a paper
$\quad$ NoP = Number of papers

3. Richness Factor Index for a year

$$RFI_{Year} = \frac{Cit_{Year}}{Tot_{author} * AoP} \quad .... (7)$$

where RFI_{Year} = Richness Factor Index of year
$\quad$ Cit_{Year} = No. of Citations of a Year
$\quad$ Tot_{author} = Total No. of authors of a year
$\quad$ AoY = Age of a year
Age of a Year can be calculated as follows
$\quad$ AoY = (Current Year – Year of Publication of the paper) + 1
Eg. Let Year of publication of the paper = 2014
Current year = 2018
Therefore AoY = (2018 -2014)+1 = 4+1 = 5

4. Richness Factor Index for an author

$$RFI_{author} = \frac{Cit_{author}}{Tot_{paper} * Tot_{authors} * PoP} \quad .... (8)$$

where RFI_{author} = Richness Factor Index of an author
$\quad$ Cit_{author} = Total Citations of a author
$\quad$ Tot_{paper} = Total No. of paper by an author
$\quad$ Tot_{author} = Total No. of collaborated authors
$\quad$ PoP = Period of Publish

Period of Publish can be calculated as follows
$\quad$ PoP = (Last paper published year – First published Paper year) + 1
$\quad$ Eg. Let first published paper year 2002
$\quad$ Last published Paper year may be 2018
$\quad\quad\quad$ Therefore AoP = (2018-2002) + 1 = 16+1 = 17