Assessment of Bradford's Law in Publications of Central Institute of Plastics Engineering and Technology : A Study Based on Scopus Database.

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Abstract:

Bradford's Law states that for a given subject area the scattering of literature can be divided into three zones. The first zone (Zone 1)also called as core zone consists of very few number of sources (journals) with highest number of citations, the second zone (Zone 2) consists of moderate number of sources (journals) with a few number of citations and the third zone (Zone 3) consists of highest number of sources (journals) with seldom citations. The present study tests the applicability of Bradford's Law using 606 articles that were collected from the Scopus database for the period from 1988 to 29.02.2020. The 606 articles comprises of 7630 citations scattered in 226 journals. The journal distribution pattern does not comply with the Bradford's law. However, when Leimkuhler's Model was employed the dataset follow the Leimkuhler's model A rank list of core journals is prepared and the "Journal of Applied Polymer Science" ranked the top journal with 923 (12.10%) of total citations followed by Polymer Composites (10.20%), Polymer - Plastics Engineering & Technology and Engineering (6.79%) and Journal of Reinforced Plastics and Composites (5.45%) . The distribution of the journals in three zones was done and the number of citations in each zone is calculated. The citation pattern of publication of Central Institute of Plastics Engineering and Technology (CIPET) has been analysed. The half life of Plastics Engineering & Technology journals is calculated and found to be 8.38 years.

Keywords: Bradford's Law; CIPET; Citation Analysis; Half Life; Obsolance; Bibliometric Law.

Introduction:

Journals constitute a major part of scholarly communication and in every field or subject some journals are frequently referred by researchers as those journals are closely related to their area of research work. Those highly referred journals are termed as core journals of the specific subject. A higher concentration of relevant articles in a particular discipline is always contained by these core journals and authors with related field of study wish to publish in those core journals.

In 1934 S.C. Bradford's in his Article "Sources of information on specific subjects" explained how the research articles on any given subject field scattered or spread across different journals and it was first reported in the journal Engineering. Later, in 1948 Bradford explained the verbal formulation and graphical representation of his law in the book titled "Documentation".

The present study examines the application of Bradford's law to the Plastics Engineering & Technology literature published by CIPET during 1988 to 29.02.2020, analyses the citation pattern and half life of journals. Bibliometric analysis of literature of CIPET in the field of Plastics Engineering & Technology has not been conducted in the past. Therefore, an attempt is made to analyse the different characteristics of publication of CIPET.

Objective of the Study: The following key objectives are drawn for the study-

1. To identify the chronological pattern of citation.
2. To test the applicability of Bradford's law of scattering.
3. To prepare a rank list of core journals in Plastics Engineering & Technology.
4. To see the half life of journals.

Review of Previous Literature:

Sudhier, K.G[1] reviewed of the scholarly contribution on the various facets of Bradford's Law. The study was conducted on five-year data of journals (2004-2008) cited by the physicists at the Indian Institute of Science (IISc), Bangaluru. Applicability of Bradford's Law of Scattering was tested on the dataset, which include 690 periodicals containing 11,319 references collected from 79 doctoral theses during the period 2004-08. Ranked list of journals was prepared, and Physical Review-B with 9.53 per cent citation, followed by Physical Review-A with 7.69 per cent, and Astrophysical Journal with 5.47 per cent citations were the most preferred journals.

Ram and Paliwal[2] performed an "Assessment of Bradford Law's of Scattering to Psoriasis Literature through Bibliometric Snapshot" during 1960 to 2009. They analyzed the data from PubMed for the period of 50 years (1960-2009) and found 24031 citations. A ranked list of

journals has been prepared and it is found that British Journal of Dermatology is most productive journal which has published 8.54 % article on psoriasis. The theoretical aspects of Bradford law does not fit to the dataset, but the Leimkuhler model was found good for Psoriasis literature.

MC, Lakshminarasimhappa and TD, Kemparaju[3] performed a study to test the applicability of Bradford's law of scattering on the literature of Drone Technology. They studied, a total of 3433 articles retrieved from Web of Science database during the span of 2008-2017. They found 3433 articles were scattered in 1155 journals. The journal distribution as per Bradford's law revealed the ration as 32:195:928 in drone technology, dispersion of journal titles in drone technology does not satisfy Bradford's law of Scattering in theoretical aspect. However, through Leimkuhler model, it is found fit for the Bradford Multiplier (k) at 3.85.

Wardikar, Vijay Ganesh Viju[4] studied the application of Bradford's Law of Scattering on the data of journals cited by Ph.D. research scholars at the universities in Maharashtra for their doctoral research**.** The study include 798 periodical containing 5467 references collected form 138 theses during the period 1982-2010. A Rank list was prepared and Annals of Library Science and Documentation ranked 1 with 207 citations.

Savanur, Kiran. P.[5] tested the applicability of Bradford's Law of Scattering to the Economics Literature of India and China. The author studied, 887 journals publishing 1924 economics subject publications from India and 1627 journals published 4427 Chinese economics publications. A rank list of journals was prepared and it is found that journals distribution pattern of the economics literature fit Bradford's distribution pattern in the study.

Singh, K.P. and Bebi[6] studied the Application of Bradford's Law on Ph.D. theses in social sciences of University of Delhi. They studied 260 Ph.D. theses submitted during 1995-2008 with a total of 9,997 references scattered in 934 journals. Bradford's law of scattering was found fit to the study. The study found that the journal Economic & Political Weekly is the most cited journal with 22.8% citations, followed by The Punjab Past and Present with 1.80% citations.

Gayan, M.A. and Singh, S. K.[7] investigated the citation pattern of Chemistry theses submitted to Central Library of Tripura University and tested the applicability of Bradford's law to list out the core journals and the half life of Chemistry journals was found to be 12.6 years

Zafrunnisha, N[8] analysed 140 Ph. D theses accepted in the field of psychology to find the Bradford's Zones and productivity of journals in psychology doctoral theses submitted to Sri

Venkateswara University, Osmania University and Andhra University. The journal distribution as per the Bradford's law reveals the ratio as 17:46:358 and dispersion of journal titles in psychology did not satisfy the Bradford's Law of Scattering.

Methodology:

The study is conducted on the Publication of CIPET in the field of Plastics Engineering & Technology based on Scopus Database for the period 1988 to 29.02.2020. A total of 606 number of articles were retrieved from the Scopus Database by refining the search query **"Affiliation = Central Institute of Plastics Engineering and Technology OR Affiliation = Central Institute of Plastics Engineering & Technology OR Affiliation = CIPET OR Affiliation=cipet".** The 606 articles comprises of 7630 citations. Based on the citations the Bradford's law is tested and other analysis is carried out.

Chronological Citation Pattern:

The data represented in the Table 1 shows that a total of 582 numbers of articles with 7622 citations were published by CIPET during the period from 1988 to 2019. The period does not include the years 1991, 1992, 1993, 1995, 1996, 1997, 1998, 2003 and 2004 as there were no contributions during these years. The total citation per year along with the average citation per article is also show in the table. The period 1988 to 2005 shows single digit publication of CIPET. From 2006 to 2013, though the publication is double digit still it is recorded very less. From the year 2014, there had been significant increase in the number of publication of CIPET. Highest number of citations (1101) was recorded in the year 2015; however, highest number of average citations (93) per article is recorded in the year 2001.

Table 1: Year wise citation pattern.

Year	No. Of Publication	Total Citation	Average Citation Per Article
1988	1	4	4.00
1989	1	9	9.00
1990	1	9	9.00
1994	3	31	10.33
1999	3	205	68.33
2000	1	47	47.00
2001	2	186	93.00
2002	3	203	67.67
2005	2	37	18.50
2006	11	599	54.45
2007	19	476	25.05
2008	12	242	20.17

2009	14	478	34.14	
2010	18	622	34.56	
2011	26	394	15.15	
2012	36	442	12.28	
2013	35	533	15.23	
2014	58	511	8.81	
2015	67	1101	16.43	
2016	52	379	7.29	
2017	68	511	7.51	
2018	63	467	7.41	
2019	86	136	1.58	
2020	24	8	0.33	
Total	**606**	**7630**	**18.67**	

Applicability of Bradford's law of Scattering:

Bradford's Law of Scattering and the idea of core journal was put forwarded by **S. C. Bradford**[9] in the year 1934. The law states that resources are scattered or spread in a varying amount of journals in a particular subject. According to this law, "if scientific journals are arranged in decreasing order of productivity of articles on a specific subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same articles as the nucleus, where the number of periodicals in the nucleus and succeeding zones can be represented as $1:n:n^2$, where 'n' is a multiplier known as Bradford's multiplier. His observation revealed that there is a common pattern in the ratio of the title in each zone.

Table 2: Scatter of Bradford's Law

Sl. No	RANK	NO. OF JOURNAL	CUM. NO. OF JOURNAL	Citations	TOTAL CITATION	CUM. CITATION	Log of Cum. No. Journal
1	1	1	1	923	923	923	0
2	2	1	2	779	779	1702	0.69
3	3	1	3	518	518	2220	1.10
4	**4**	**1**	**4**	**416**	**416**	**2636**	1.39
5	5	1	5	373	373	3009	1.61
6	6	1	6	330	330	3339	1.79
7	7	1	7	260	260	3599	1.95
8	8	1	8	231	231	3830	2.08
9	9	1	9	210	210	4040	2.20
10	10	1	10	153	153	4193	2.30
11	11	1	11	150	150	4343	2.40
12	12	1	12	140	140	4483	2.48
13	13	1	13	119	119	4602	2.56

14	14	1	14	112	112	4714	2.64
15	15	1	15	102	102	4816	2.71
16	16	2	17	101	202	5018	2.83
17	17	1	18	93	93	5111	2.89
18	**18**	**2**	**20**	**91**	**182**	**5293**	3.00
19	19	1	21	87	87	5380	3.04
20	20	1	22	85	85	5465	3.09
21	21	1	23	84	84	5549	3.14
22	22	1	24	78	78	5627	3.18
23	23	1	25	73	73	5700	3.22
24	24	1	26	72	72	5772	3.26
25	25	1	27	65	65	5837	3.30
26	26	2	29	62	124	5961	3.37
27	27	1	30	56	56	6017	3.40
28	28	1	31	53	53	6070	3.43
29	29	1	32	49	49	6119	3.47
30	30	1	33	47	47	6166	3.50
31	31	1	34	43	43	6209	3.53
32	32	2	36	42	84	6293	3.58
33	33	1	37	41	41	6334	3.61
34	34	2	39	39	78	6412	3.66
35	35	1	40	38	38	6450	3.69
36	36	2	42	35	70	6520	3.74
37	37	1	43	34	34	6554	3.76
38	38	2	45	33	66	6620	3.81
39	39	2	47	30	60	6680	3.85
40	40	1	48	28	28	6708	3.87
41	41	1	49	27	27	6735	3.89
42	42	1	50	23	23	6758	3.91
43	43	2	52	22	44	6802	3.95
44	44	1	53	21	21	6823	3.97
45	45	2	55	20	40	6863	4.01
46	46	2	57	19	38	6901	4.04
47	47	2	59	18	36	6937	4.08
48	48	2	61	17	34	6971	4.11
49	49	6	67	15	90	7061	4.20
50	50	2	69	14	28	7089	4.23
51	51	7	76	13	91	7180	4.33
52	52	2	78	11	22	7202	4.36
53	53	4	82	10	40	7242	4.41
54	54	3	85	9	27	7269	4.44
55	55	7	92	8	56	7325	4.52
56	56	14	106	7	98	7423	4.66
57	57	7	113	6	42	7465	4.73

58	58	8	121	5	40	7505	4.80
59	59	8	129	4	32	7537	4.86
60	60	16	145	3	48	7585	4.98
61	61	14	159	2	28	7613	5.07
62	62	17	176	1	17	7630	5.17
63	**63**	**50**	**226**	**0**	**0**	**7630**	5.42

The above table indicates that total 7630 citations were done in 226 journals. The rank 1 journal consists of 923 citations followed by 779 and 518 citations. A sum of 17 journals consists of only one citation and 50 journals do not have any citations at all.

Bradford's Zone for Publication of CIPET in the field of Plastics Engineering & Technology:

Based on the Table 2, three Bradford Zones having approximately one third (1/3rd) of citations are presented in the table 3 below.

Table 3: Bradford's Zone

ZONE	NO. OF JOURNALS	NO. OF CITATION	CUM. NO. OF. CIT	BRADFORD MULTIPLIER
1	4	2636 (34.54%)	2636	1
2	19	2566 (33.63%)	5202	4.75
3	203	2428 (31.82%)	7630	10.68

The first zone contains 4 journals with 2636 citations; the second zone contains 19 journals with 2566 citations and the third zone contains 203 journals with 2428 citations.

According to Bradford's Law the expected ratio of Bradford's distribution is: **1: n: n^2**

Form the table 3 the ratio of Bradford's distribution is – **1 : 4.75 : 10.68**

instead of expected ratio of **1: 4.75 : 22.56**

Thus, it does not fit well into the law. Hence[7], to examine the verification of Bradford's Law of Scattering, Leimkuhler Model (Leimkuhler, 1967)[10] of distribution is employed. Leimkuhler model has been used many times in previous studies such as (Wardikar & Gudadhe, 2013)[11] (Kalita, 2016)[12] (Tripathi & Sen, 2016)[13] to study its applicability for calculating non cumulative rank frequency calculation.

Leimkuhler model of Bradford's distribution is a size frequency measure and in this model at first the core journals with specific citations in the first zone is determined and then Bradford Multiplier is found out. Accordingly with its multiples the journals in the following zones are

counted. Bradford's multiplier (K) for Leimkuhler distribution is counted with Egghe's formula (Egghe, 1986)[14].

Leimkuhler's model based on Bradford's verbal formulation is,

R0 = T (K-1) / (Kp-1),
To apply this formula, first we have to find out value of "K" with the following formula,

$K = (e^y Y_m)^{1/p}$ where, $\{e^y = 1.781 \text{ (Euler's No)}\}$

Y_m = no of citations in the most productive journal i.e. Y_m = 923 (From table no. 2)

P =Bradford's group of no of zones of distribution i.e. P =3

By applying our data,

$K = (1.781 * 923)^{1/3}$

$= (1643.863)^{1/3}$

K = 11.80

Now, let's find out number of journals in the Nucleus of each zone by using Leimkuhler model,

R0 = T (K-1) / (K^P-1), [T = Total no of journals = 226 (from table 2)]

$= 226 * [(11.80-1) / \{(11.80)^3-1\}]$

= 226 * {10.80/ (1643.032-1)}

=226 * (10.80/ 1642.032)

=226 * 0.0065772

= 1.49

So, for this dataset R0= 1.49

That means in the Leimkuhler model of Bradford's distribution the core group contains 1.49 (≈2) journals.

Hence, the modified Bradford's distribution from Leimkuhler model can be written down as

= R0: R0 *K: R0 *K^2

$= 1.49: 1.49 * 11.80: 1.49 * (11.80)^2$

= 1.49:17.58:207.46

=226.52

Error % = {(226.52-226)/226}*100

= 0.23%

From the above calculation it is found that, the percentage of error is **0.23%** which is negligible. Therefore, we can acknowledge the applicability of new Bradford's distribution based on Leimkuhler model.

The three zones after application of Leimkuhler model are illustrated in table 4, the core zone which is Zone 1containing 2 journals with 22.30 % share of citations, Zone 2 containing 17 journals with 44.67 % and Zone 3 containing 207 journals with 33 % share of citations.

Table 4: Leimkuhler model Bradford's Distribution in 3 zones

ZONE	NO. OF JOURNALS	CUMULATIVE NO OF JOURNALS	TOTAL CITATIONS SHARE	CUMULATIVE NO OF CITATIONS	% SHARE TO TOTAL CITATIONS
1	2	2	1702	1702	22.31%
2	16	18	3409	5111	44.68%
3	208	226	2519	7630	33.01%
Total	226		7630		100%

**Core journals of CIPET Publication in Plastics Engineering & Technology:**

In the present study, a total of 226 journals have been cited for 7630 citations and only two journals have cited 1702 citations out of 7630 citations. These first two journals cover 22.31% of the total journal citations and the rest 77.69% is scattered amongst 224 journals. Table number 5 depicts the ranking of top four journals presented in decreasing order of their citations.

Table No 5: List of Core Journals

Sl. No	Name of Journals	Place of Publication	Frequency	Percentage of Citations	Impact Factor (19-20)
1	Journal of Applied Polymer Science	United States	923	12.10%	2.188
2	Polymer Composites	United States	779	10.21%	2.268

From the above table it is found that all the core journals are published from United States and Journal of Applied Polymer Science got the first rank for being cited for 923 times with impact for 2.188 (2018-19) followed by Polymer Composites with 779 citations and impact factor of 2.268.

Fig: 1 Bradford Bibliograph
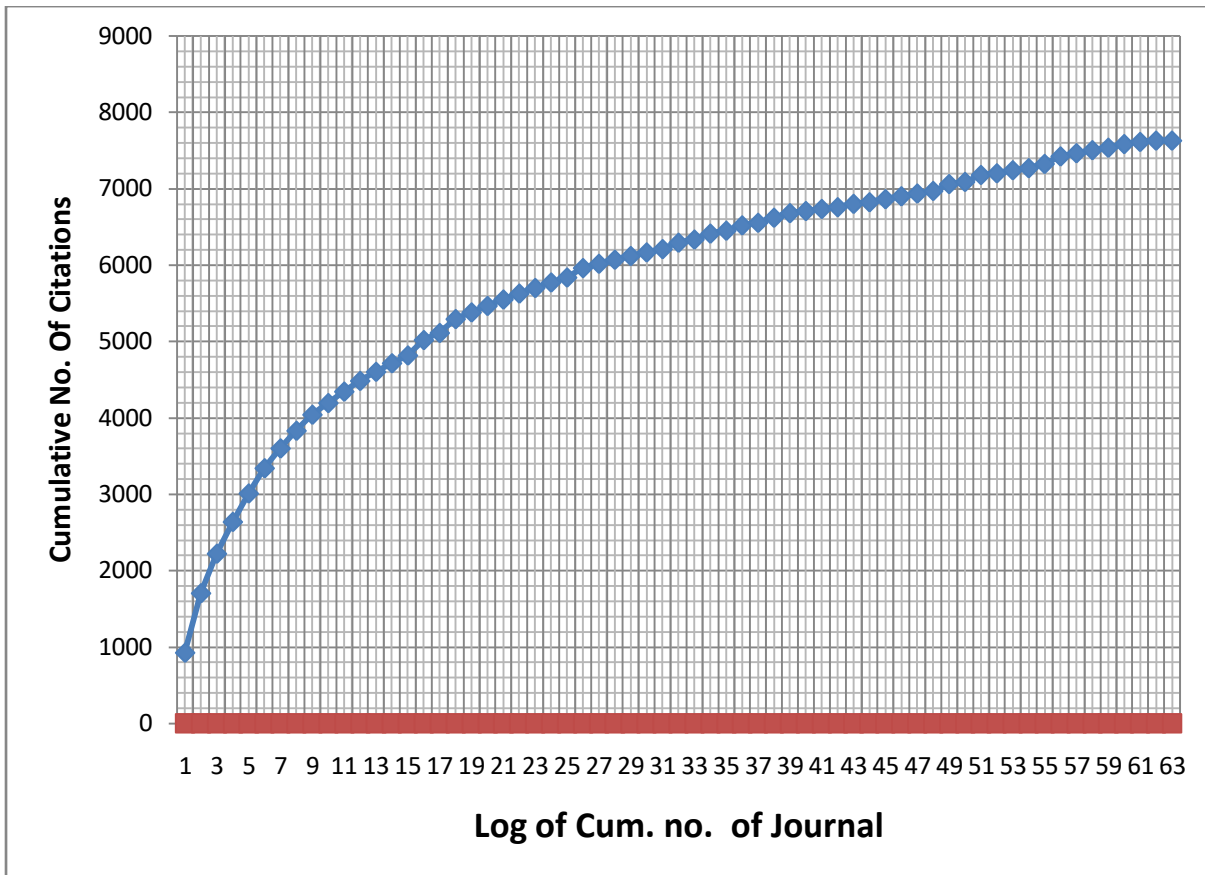
Half Life of CIPET Publication in the field of Plastics Engineering & Technology:

Sen B.K[10], in his paper Symbols and formulas for a bibliometric concept stated that, the half life is the integral number consisting of whole years in addition to a fraction of year. It can be represented as follows-

$T = Y + y$------------------equation no (1)

Where, Y is the number of whole year and y is the fraction of a year.

The fraction of a year can be calculated with the help of the following formula-

$y = (a-b) / (c-b)$ -------------equation no (2)

Where, **"a"** is the 50% of the citations, **"b"** is the 50% of the cumulative number of citations of the **sub-critical year** and **"c"** is the cumulative number of references of the **critical year.** Critical year is the year in which 50% of the citations are reached counted from the base year and sub-critical year is the year previous to critical year.

Table no 5: Reverse chronological order of Citation Distribution

Year	No. of Pub	Age of Citation	No. Of Citations	Cum. Citation	% of Citation	Cum. % of Citation
2020	24	0	8	8	0.10	0.10
2019	86	1	136	144	1.78	1.89
2018	63	2	467	611	6.12	8.01
2017	68	3	511	1122	6.70	14.71
2016	52	4	379	1501	4.97	19.67
2015	67	5	1101	2602	14.43	34.10
2014	58	6	511	3113	6.70	40.80
2013	35	Sub Crit. Year = 7	533	b=3646	6.99	47.79
2012	36	Critical Year = 8	442	c = 4088	5.79	53.58
2011	26	9	394	4482	5.16	58.74
2010	18	10	622	5104	8.15	66.89
2009	14	11	478	5582	6.26	73.16
2008	12	12	242	5824	3.17	76.33
2007	19	13	476	6300	6.24	82.57
2006	11	14	599	6899	7.85	90.42
2005	2	15	37	6936	0.48	90.90
2004	0	16	0	6936	0.00	90.90
2003	0	17	0	6936	0.00	90.90
2002	3	18	203	7139	2.66	93.56
2001	2	19	186	7325	2.44	96.00
2000	1	20	47	7372	0.62	96.62
1999	3	21	205	7577	2.69	99.31
1998	0	22	0	7577	0.00	99.31
1997	0	23	0	7577	0.00	99.31
1996	0	24	0	7577	0.00	99.31
1995	0	25	0	7577	0.00	99.31
1994	3	26	31	7608	0.41	99.71
1993	0	27	0	7608	0.00	99.71
1992	0	28	0	7608	0.00	99.71
1991	0	29	0	7608	0.00	99.71
1990	1	30	9	7617	0.12	99.83
1989	1	31	9	7626	0.12	99.95
1988	1	32	4	7630	0.05	100.00

From the above table no 5 it is observed that critical year is 8 as 50% of the total citations were reached in the 8th year and subcritical year is 7th year.

Hence, **Y = 8**

a = 7630/2 = 3815

b = 3646

c = 4088

By using these values in equation no (2) we get the value of y as follows-

y = (a-b) / (c-b)

= (3815 – 3646) / (4088 – 3646)

= 169 / 442

=0.38

Therefore, half life *T= Y+y*

 = 8+0.38

= 8.38 year.

The half life of journal of CIPET publication is found to be 8.38 years and 53.58% of journals citations are 8 years old. Half life is used to calculate the number of years taken to reach half of the total citations and it also helps to find out the time required for a particular literature to get obsolete.

Conclusion:

The study has been conducted to bring in to light some features of CIPET literature. It is found that CIPET researchers depend on highly on journal articles for pursuing their research. From the rank list of journals it is found that "Journal of Applied Polymer Science" is the most cited journal. The dataset of the study did not follow the Bradford's law. However, the dataset follow the Leimkuhler's model. The result obtained from the study will assist the researchers in the area of Plastics Engineering & Technology for better understanding the characteristics of the field; it will help the librarians in selection of documents and collection development of the library; it will also help the policy makers in decision making.

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