Application of Bradford's Law to the Scientific Literature of two UPE (University with Potential for Excellence) status Universities of India: A study based on the Web of Science Database

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Abstract

In bibliometric research, Bradford's Law of Scattering is the most commonly used bibliometric law. The paper gives a review of the scholarly contribution of the academic community on the various facets of Bradford's Law. The study covered the period of 15 years. The University of Mysore, Mysuru has published a total of 3153 articles in 788 journals and the Karnatak University, Dharwad has published a total of 1854 articles in 488 journals. The study reveals that the journal distribution pattern of the University of Mysore, Mysuru and the Karnatak University, Dharwad does not confine to Bradford's Distribution pattern i.e. 1:n:n^2. When the Leimkuhler model is applied for the verification of Bradford's law, it is evidenced that the law is valid for the data set in both universities.

Keywords

Academic Community; Bradford's law; Bradford's multiplier; core journals; UPE

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1. Introduction

A group of people in higher educational institutions who are engaged in core intellectual activities such as teaching, learning, and research are mentioned as the academic community. This community uses a variety of resources to remain up-to-date in their field of interest, some of these resources are conference proceedings, electronic media, periodicals, peer-reviewed journals and textbooks (Scheckler,1982). Often, peer-reviewed journals have been used by the academic community to maintain proficiency in their respective fields, but this has become increasingly more strenuous given the exponential expansion of scientific literature, which is at present doubling in size every seven years (Tenopir et al., 2007). In every subject some journals are high priority, such journals are referred to as core journals. These journals are frequently referred to by the teachers, researchers and students because of the close relationship between the subject of the journals and the areas of research work. The core journals are considered as 'nuclear' of journals, which reflects the conceptual essence of the research being reported in the discipline'(Summers, 1984).

The core journals concept is derived from Bradford's Law of Scattering, which was formulated by Samuel Clement Bradford in 1934. Bradford Law is a pattern first explained in 1934 that estimates the increasing scatter of relevant journal articles on a given topic. In the year 1948 Bradford outlined his study by connecting the number of journals in the nuclear, or most productive zone, to the number of journals in successively less productive zones containing equal numbers of papers (Bradford, 1948). Bradford's Law of Scattering is conceivably the most popular and the recognized concept of all the bibliometric techniques that endeavour to describe the effective working of science by application of Mathematics (Mahapatra, 2009).

The contribution of the Indian universities to the entire Indian scientific research is highly significant. The University Grants Commission (UGC) identifies some of the universities and is awarded as University with Potential for Excellence (UPE). In Karnataka, there are two Universities awarded with UPE status they are University of Mysore, Mysuru and the Karnatak University, Dharwad. In the present study, Bradford's Law is applied and compared to these two UPE status awarded universities of Karnataka state in India.

2. Objectives of the Study

The main objectives of the study is bibliometric analysis of preferred journals by the scientific community of University of Mysore, Mysuru and Karnatak University, Dharwad.

- to prepare a rank list of most-cited journals by the academic community of both the universities;
- to study the phenomenon of scattering for citation data of both the universities;
- to test the appropriateness of verbal and graphical formulation of Bradford's Law of Scattering in both universities.

3. Methodology

The study covers a period of fifteen years' publications from 2002 to 2016. The records for the analysis of this comparative study have been retrieved from the Science Citation Index (SCI) of ISI Thomson Reuter's Web of Science multidisciplinary bibliographic database. The University of Mysore, Mysuru has published 3153 articles in 788 journals and the Karnatak University, Dharwad has published 1854 articles in 488 journals. These journals with bibliographic details were downloaded for analysis.

4. Application of Bradford's law

In all the disciplines, few journals are regularly cited by the researchers because of the compassion between the subject coverage of the journals and the area of the research work. The highly-cited journals are enumerated as core journals of the subject. The concept of core journals was first coined by S. C. Bradford in 1934 which is popularly known as Bradford Law of Scattering. Bradford Law of Scattering narrates how the literature on a subject is scattered or distributed in journals.

Bradford's Law of Scattering is one of the important bibliometric laws, which is applied most frequently in bibliometric research. Bradford's law is an arrangement that evaluates the rapidly diminishing returns by extending a search for references in science journals. Bradford's technique is if journals in a field are arranged by the number of articles into three groups, each with about one-third of all articles, then the number of journals in each group will be proportional to 1: n: n^2. The first nucleus zone comprises a small number of highly productive journals say n1, the second zone has a larger number of temperately productive journals say n2, and the third zone has a still larger number of journals of low productivity say n3. He enunciated his law as

1: n: n^2, where 'n' is a multiplier. (Sen, 1992).

In the present analysis, the Bradford law has been tested for journal articles of the University of Mysore, Mysuru and the Karnatak University, Dharwad from 2002 to 2016.

4.1 University of Mysore, Mysuru

For testing Bradford's law in the University of Mysore, 3153 articles dispersed in the 788 journals are divided into three zones in the Table no 4.1.

4.1 Application of Bradford's Law

Table 4.1: Parameter value for the Bradford's Distribution in the University of Mysore, Mysuru

No. of Journals	Cum. no. Journals	Log (n)	Publi cations	Total no. of Publi cations	Cum. No. of Publi cations
1	1	0	463	463	463
1	2	0.69	80	80	543
1	3	1.10	47	47	590
1	4	1.39	43	43	633
1	5	1.61	40	40	673
1	6	1.79	35	35	708
1	7	1.95	34	34	742
4	11	2.40	29	116	858
1	12	2.48	28	28	886
1	13	2.56	27	27	913
1	14	2.64	26	26	939
1	15	2.71	25	25	964
2	17	2.83	24	48	1012
1	18	2.89	21	21	1033
1	19	2.94	20	20	1053
4	23	3.14	19	76	1129
1	24	3.18	17	17	1146
6	30	3.40	16	96	1242
5	35	3.56	14	70	1312
4	39	3.66	13	52	1364
3	42	3.74	12	36	1400
9	51	3.93	11	99	1499
7	58	4.06	10	70	1569
6	64	4.16	9	54	1623

9	73	4.29	8	72	1695
16	89	4.49	7	112	1807
21	110	4.70	6	126	1933
35	145	4.98	5	175	2108
40	185	5.22	4	160	2268
70	255	5.54	3	210	2478
142	397	5.98	2	284	2762
391	788	6.67	1	391	a3153
788				3153	

Table 4.2: Scatter of Journals and Publication over Bradford's zone

Zone	Journals	Publications	Bradford Multiplier
1	19	1053	
2	126	1055	6.63
3	643	1045	5.10
Total	788	3153	5.87*

*Mean value of Bradford multiplier

The Bradford's multiplier factor was arrived at by dividing journals of a zone by its previous zone journals. In the present data set it was observed that 19 journals covered 1053 articles, the next 126 journals covered 1055 articles and the next 643 journals covered 1045 articles. In other words, one-third of the total in the present study is 19:126:643. By this, it was found that the relationship of each zone in the present study does not fit into Bradford's distribution (Table 4.2).

4.2 Application of Leimkuhler Model

Therefore, further Leimkuhler model is applied for studying the applicability of Bradford's law. For testing the Bradford's law of the University of Mysore with Leimkuhler model the data from the Table4.1is used. The 788 journal titles are divided in to three zones, since Bradford assumes that there should be minimum three zones i.e., when p=3 then the value of k can be calculated using below formula

$k=(e^{Y}y_m)^{1/p}$, where Y is Euler's number (e^{Y}=1.781), y_m= number of publications in the most productive journal.

Therefore $k = (1.781*y_m)^{1/p}= (1.781*463)^{1/3}$ =9.39

Furthermore, $Y_0 = \frac{A}{p}$ where A denotes total of publications and p=3

$r_0 = T(k-1)/(k^p-1)$ where T is total number of journals, r_0 denotes the number of journals in the first group

Therefore, Y_0 = 1051 and r_0 = 8.011

The findings of the calculations are shown in Table 4.3

As per table the number of journals in the nucleus is found to be 7 and k = 10.12, is a multiplier. Therefore, the Bradford distribution is:

7: 7X10.12:7X10.12^2≈ 1: n: n^2

7: 70.84: 716.90≈ 794.74 approximately 795

percentage of error = $\frac{795-788}{788}$X100 = 0.88%

The percentage error of the distribution is 0.88% and it is also observed thatthe number of journals contributing the articles to each zone increase by a multiplier of 10.12. Specifically, the first zone, containing 7 journals, contributing 742 articles, the second zone containing 66 journals produced 953 articles, and the third zone accounting for 715 journals produced 1458 articles.

Table 4.3: Bradford's zones of scattering based on Leimkuhler model

Zone	Journals	Publications	Bradford Multiplier
1	7	742	
2	66	953	9.43
3	715	1458	10.83
Total	788	3153	10.12*

*Mean value of Bradford multiplier

Bradford's algebraic interpretation of law 1: n: n^2 is followed in this study. But the number of publications in each zone does not follow one-third of the total articles. According to Cline (1981), the data which contains smaller percentage errors indicate a closer adherence to the Bradford distribution. Accordingly, Bradford's law almost fits well in this case.

4.3 Graphical Formulation

The graphical formulation is just the experimental verification of the verbal formulation which observes certain regularity in the distribution of scientific publications.

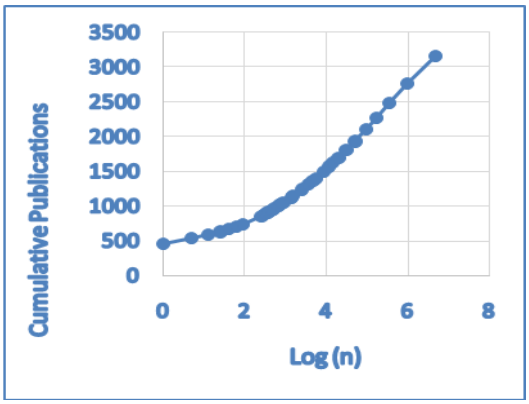


Fig 4.1 Bradford's Bibliograph of the University of Mysore, Mysuru

The graph in Fig 4.1 is a logarithmic plot of cumulative publications on the horizontal axis and the log of the cumulative number of journals on the vertical axis. If the distribution confines to Bradford's law it will show the characteristics in three distinct regions (a) rapid rise for the first few points (b) a major portion of the linear relation between two variables (c) a 'droop' at the tail end of the distribution indicating the incompleteness of the bibliography (Brookes, 1969). In this study, Fig 4.1 shows the typical Bradford curve of the University of Mysore with Groos drop.

5. Karnatak University, Dharwad

For testing Bradford's law in the Karnatak University, results are represented in table no 5.1.

5.1 Application of Bradford's Law

Table 5.1: Parameter value for the Bradford's Distribution in the Karnatak University

No. of Journals	Cumulative no. of Journals	Log (n)	Publi cations	Total Publi cations	Cum. Publi cations
1	1	0	95	95	95
1	2	0.69	53	53	148
1	3	1.10	45	45	193
1	4	1.39	41	41	234
1	5	1.61	30	30	264
3	8	2.08	27	81	345
2	10	2.30	26	52	397
1	11	2.40	23	23	420
2	13	2.57	21	42	**462**
1	14	2.64	20	20	482
1	15	2.71	19	19	501
1	16	2.77	18	18	519
2	18	2.89	17	34	553
1	19	2.94	16	16	569
3	22	3.09	15	45	614
3	25	3.22	14	42	656
2	27	3.30	13	26	682
3	30	3.40	12	36	718
4	34	3.53	11	44	762
8	42	3.74	10	80	842
1	43	3.76	9	9	851
8	51	3.93	8	64	915
11	62	4.13	7	77	**992**
20	82	4.41	6	120	1112
20	102	4.63	5	100	1212
27	129	4.86	4	108	1320
41	170	5.14	3	123	1443
93	263	5.57	2	186	1629
225	488	6.19	1	225	**1854**
488				1854	

Table 5.2: Scatter of Journals and publications over Bradford's zone

Zone	Journals	Publications	Bradford Multiplier
1	22	614	
2	80	598	3.63
3	386	642	4.83
Total	488	1854	4.23*

*Mean value of Bradford multiplier

There are 1854 articles scattered in 488 journals are divided into three zones in table no 5.2. The Bradford's multiplier factor was arrived at by dividing journals of a zone by its previous zone journals. In the present data set it was observed that 22 journals covered 614 articles, the next 80 journals covered 598 articles and the next 386 journals covered 642 articles. According to Bradford, the zones, thus identified will form an approximately geometric series in form 22:80:386. According to Bradford, the relationship between the zones is 1: n: n2, while the relationship of each zones in the present study is 22:80:386 which does not fit into Bradford's distribution.

The distribution of journals and the corresponding number of publications in three zones along with the Bradford multiplier are shown in table 5.2.

5.2 Application of Leimkuhler model

Further Leimkuhler model is applied to test the applicability of Bradford's law. For testing Bradford's law of the Karnatak University with Leimkuhler model the data from table 5.1 is used. The 488 journals are divided into three zones, so p=3 then the value of k can be calculated as follows $k=(e^{Y}y_m)^{1/p}$, where Y is Euler's number (e^{Y}=1.781), y_m= number of publications in the most productive journal.

Therefore $k = (1.781*y_m)^{1/p} = (1.781*95)^{1/3} = 5.53$
Furthermore, $Y_0 = \frac{A}{p}$ where A denotes total of publications and p=3

$r_0 = T(k-1)/(k^p-1)$ where T is total number of journals, r_0 denotes the number of journalsin the first group

Therefore, $Y_0 = 681$ and $r_0 = 13.15$
The findings of the calculations are shown in Table 5.3
From the table 5.3 the number of journals in the nucleus is found to be 13 and k=5.57, is a multiplier. Therefore, Bradford distribution is
$13: 13X5.57:13X5.57^2 \approx 1: n: n^2$
13: 72.41: 403.3237≈ 488.7337 approximately 489
percentage of error $= \frac{489-488}{488} X100 = 0.20$

Table 5.3: Bradford's zones of scattering based on Leimkuhler model

Zone	Journals	Publications	Bradford Multiplier
1	13	462	
2	73	530	5.62
3	402	862	5.51
Total	488	1854	5.57*

*Mean value of Bradford multiplier

The percentage error of the distribution is 0.20% and it is also observed thatthe number of journals contributing the articles to each zone increase by a multiplier of 5.57. Specifically, the first zone, containing 13 journals, contributing 462 articles, the second zone containing 73 journals produced 530 articles, and the third zone accounting for 402 journals produced 862 articles.

5.3 Graphical Formulation

The graph in Fig 5.1 is a logarithmic plot of cumulative publications on the horizontal axis and the log of the cumulative number of journals on the vertical axis.

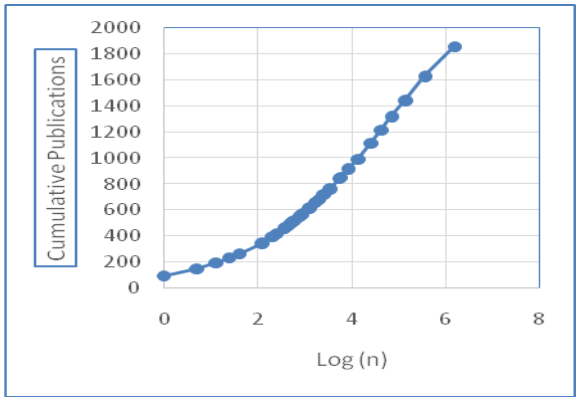


Fig 5.1Bradford's Bibliography of the Karnatak University, Dharwad

As described above if the distribution confines to Bradford's law it will show the characteristics in three distinct regions (a) rapid rise for the first few points (b) a major portion of the linear relation between two variables and (c) a 'droop' at the tail end of the distribution indicating the incompleteness of the bibliography. In this study, Fig 5.1 shows the typical Bradford curve of the Karnatak University with Groos drop, where journals are plotted against their productivity.

6. Conclusion

The application of Bradford's law to the University of Mysore and the Karnatak University highlights that the journal distribution pattern of the University of Mysore and the Karnatak University does not confine to Bradford's distribution pattern, i.e. 1: n: n2, and it may be due to incomplete bibliography or interdisciplinary nature of publications. When the Leimkuhler model is employed for the verification of Bradford's law, it is found that the law is valid for the data set in both universities. The percentage of error is found to be 0.88% and 0.20% for the University of Mysore and the Karnatak University respectively which is negligible. Bradford's Bibliography shows the typical Bradford's Curve with 'Groos Drop' in both the universities.

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