APPLICATION OF BRADFORD'S LAW AND LEIMKUHLER MODEL ON THE RESEARCH PUBLICATIONS OF MANONMANIAM SUNDARANAR UNIVERSITY DURING 1992-2020

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ABSTRACT

The present study deals with the applications of Bradford's law of scattering and Leimkuhler model on the research publications of Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu during 1992-2020. The bibliographic data was retrieved from Web of Science database. A total of 1546 research documents were published from Manonmaniam Sundaranar University in 631 journals were analysed. The analysis shows the mean value of relative growth rate and doubling time as 0.23 and 5.41 respectively. The core journal of research publications identified and Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy ranked first followed by Journal of the Indian Chemical Society. The Bradford's law of scattering and Leimkuhler model were also applied to verify the data set.

Keywords: ***Bradford's Law of Scattering, Leimkuhler Model, Relative Growth Rate, Doubling Time. Bibliometrics, Scientometrics, Web of Science, Manonmaniam Sundaranar University.***

1. Introduction

Research publication is very important process in the development of the quality education especially in the higher educational institutions. It contributes to the world of knowledge. It helps in linking the information provided from various research communities in a specific subject field to enhance further research activities among the new researcher community. There is a rapid growth of research publication in Indian Universities. These research publications are in the form of journal articles, books, book chapters, conference and seminar papers, thesis, patents, research reports and so on. Among the various information sources, journals are considered as an important primary source for scientific information. It contains nascent information, which helps to develop and led new research and ideas in a particular subject.

S. C. Bradford coined the concept of core journal in 1934, which is now called as Bradford's law of scattering. He described that how journal articles on specific area scattered or distributed in the literature. He applied this law on engineering journal and he wrote a book named as Documentation in 1948 about Bradford's law of scattering. He derived a formula to examine the distribution of journals as 1: n: n^2 where n is a multiplier.

In this study, Manonmaniam Sundaranar University, which is situated in Tirunelveli, South Tamil Nadu of India has been considered as the research area. It was established by the government of Tamil Nadu as a teaching-cum-affiliating university on 7th September 1990 to cater to the needs of the people in the southern part of Tamil Nadu (www.msuniv.ac.). It is named after the renowned Tamil poet and scholar Professor Manonmaniam Sundaram Pillai. It has 24 departments in various subjects such as arts, science, language, technology, etc. and 102 colleges affiliated with the university, which was situated in four districts (Tirunelveli, Tenkasi, Thoothucorin and Kanyakumari).

This paper examines the applications of Bradford's law of scattering and Leimkuhler model on the research publications of Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, India.

2. Review of Literature

There are plenty of literature available on the application of bradford's law, but the application of leimkuhler is comparatively few. Some of the latest ones are reviewed here.

Borgohain and others (2021) discussed the theoretical aspects of Bradford's law and implicated Leimkuhler model after finding that Bradford's distribution not fit to the dataset. They concluded that the information science literature in Scopus dataset during the study period 2001 to 2020 fit to the Leimukuhler model with minor percentage of error. Application of bradford's law to the scientific literature of two UPE status universities of India with the help of Web of Science has been conducted by Gourikeremath et al. (2021). This study by Naheem et al.(2021) examines application of bradford's law of scattering on the global synthetic biology literature.

A joint study by Chaturbhuj and Batcha (2020) deals with the application of Bradford's law on fluid mechanics. Bradford's law on capital structure literature during 2014-2019 was applied by Alves (2019). From Web of Science database, a total of 7272 records were collected from 2828 journals on the research topic. The results showed that the data set did not match in both Bradford's law and Leimkuhler model.

Satish Kumar and Senthilkumar (2018) examined the application of Bradford's law of scattering on the research publications of Astronomy and Astrophysics of India during 1988 to 2017 and concluded that Bradford's distribution does not fit to the data set. Then they also tested the data set using Leimkuhler model and failed to prove it. The objective of the paper by Chaman Sab (2018) is to analyse the application of bradford's law to chemical science literature.

Implication of Bradford's law and Leimkuhler model on neural network literature in India published from 2001 to 2015 were studied by Amsaveni (2016). The author revealed that the theoretical formulation did not fit but Leimkuhler model was fit to the data set.

Girap, Ashok and Bhanumurthy (2014) evaluated the book collection available in the Bhabha Atomic Research Centre library. In this study, the authors used Bradford's law to evaluate and analyse the book collection of BARC library. The authors arranged the book collection in to subject headings to identify the applicability of Bradford's law and the results showed that the data set did not obey the Bradford's law.

Wardikar and Gudadhe (2013) applied Bradford's law of scattering in library and information science Ph.D. theses citations submitted to the University of Maharashtra. A total of 5467 citations collected from 138 theses during the study period of 1980 to 2010. The authors concluded that *Annals of Library*

and Information Studies ranked first with 207 citations followed by *College and Research Libraries* with 184 citations. They also stated that the data set Ph.D. theses of University of Maharashtra does not fit to the Bradford's law.

In a study Sudhier (2010) applied Bradford's law of scattering and Leimkuhler model to the doctoral theses in Physics of Indian Institute of Science. Here also the author found that IISc doctoral theses did not fit to the Bradford's law of distribution. Leimkuhler, Goffman and Warren [1969] interpreted the verbal formulation of Bradford's law and demonstrated the law in graphical formulation.

Vickery (1948) was the first person who applied the Bradford's law in his article and found that Bradford's law does not fit to the total accordance.

Bradford's law (1934) of scattering analysed in two forms such as verbal and graphical representation.

3. Objectives of the Study

1. To know the relative growth rate and doubling time of research publications of Manonmaniam Sundaranar University.
2. To identify the top ten journals based on the scattering of the research publications.
3. To apply Bradford's law of scattering to the research publications.
4. To apply Leimkuhler model to the research publications.
5. To draw graphical representation of research publications using Bradford's law.

4. Hypotheses

H1. Bradford's law of scattering fits to the research publications of Manonmaniam Sundaranar University.

H2. Leimkuhler model fits to the research publications of Manonmaniam Sundaranar University.

5. Scope and Limitation

The scope of the present study is to verify the application of Bradford's law of scattering and Leimkuhler model in research publications of Manonmaniam Sundaranar University. The study focussed on the scattering of research publications in various journals and limited for the specific period from 1992 to 2020 (accessed on 23rd March 2021).

6. Methodology

The present study deals with the applications of Bradford's law of scattering and Leimkuhler model on the research publications of Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu. For the study, Web of Science database has been used to collect the bibliographical data of research publications of Manonmaniam Sundaranar University from 1992 to 2020 (accessed on 23rd March 2021). There were 1546 research publications published in various document formats. The collected data was analysed and tabulated using MS Excel software package.

6.1. Relative Growth Rate and Doubling Time

Relative growth rate is defined an increasing research publications in a particular time. **Blackman (1919) and Hunt (1982)** originated the definition of relative growth rate in the field of financial investment and Botany. The mean relative growth rate can be calculated by using the formula as given below.

$1 - 2^R = (Log_e W_2 - Log_e W_1 / T2 - T1)$

Where, $1 - 2^R$ = Mean relative growth rate over the particular period of interval

$Log_e W1$ = log of initial number of articles

$Log_e W2$ = log of final number of articles after a particular period of interval

T2 – T1 = difference between the initial time and the final time of the period

Doubling time is defined as the number of research publications double during the study period. Thus the doubling time can be calculated by using the formula DT = 0.693/ R.

6.2. Bradford's Law

The quantitative relation between the journal and the research publications are explained through Bradford's law of scattering. Samuel Clement Bradford, analysed two journals of research publications bibliographies namely current bibliography of applied geophysics (1925-1931) and quarterly bibliography of lubrication (1931-1933) to derive the law of scattering. He arranged the references in the descending order of productivity and divided the total number of research publications in to three zones, which is approximately equal. He named first zone as nuclear zone, second as moderately productive zone and third as peripheral zone. From the above concept, he derived a mathematical formula to find the fitness of scattering of publications. The formula is 1: n: n^2. (Bradford, 1934)

6.3. Leimkuhler Model

Leimkuhler (1967) derived another mathematical formula for Bradford's law of distribution. Leimkuhler mathematical model shown as below:

$k = (e^y * Y^m)^{1/p}$ where $e^y = 1.781$

k = multiplier value

P = number of zones i.e. =3.

Y^m= number of publications in the first rank core journal

T = total number of journals.

r_o is calculated by using the below given formula

Hence, $r_o = T (k-1)/(k^p-1)$

7. Data Analysis and Interpretation

7.1. Relative Growth and Doubling Time

A total of 1546 research publications were scattered in 631 journals during the study period. The analysis given in table 1 shows the year wise distribution of Manonmaniam Sundaranar University research publications from the year 1992 to 2020 and the calculation of relative growth rate and doubling time (DT). A total of 1546 records were published during the study period. The highest number of publications recorded in the year 2018 with 200 publications, followed by 2019 with 158, 157 publications in 2016 and 148 in the year 2017. The lowest number of publications recorded from the year 1992 to 1994. It is also observed that more than 110 publications were recorded from the year 2015 to 2019 and there is a slight fluctuation in the growth of research productivity, relative growth rate and doubling time. The mean value of relative growth rate is 0.23 and doubling time is 5.41 for the study period.

Table 1

Relative Growth Rate and Doubling Time of Research Publications

Year	Publications	Cumulative Publications	Log_eW1	Log_eW2	RGR	DT
1992	2	2	-	0.69	-	-
1993	5	7	0.69	1.95	1.25	0.55
1994	4	11	1.95	2.40	0.45	1.53
1995	19	30	2.40	3.40	1.00	0.69
1996	11	41	3.40	3.71	0.31	2.22
1997	12	53	3.71	3.97	0.26	2.70
1998	15	68	3.97	4.22	0.25	2.78
1999	23	91	4.22	4.51	0.29	2.38
2000	21	112	4.51	4.72	0.21	3.34
2001	22	134	4.72	4.90	0.18	3.86
2002	16	150	4.90	5.01	0.11	6.14
2003	20	170	5.01	5.14	0.13	5.54
2004	24	194	5.14	5.27	0.13	5.25
2005	20	214	5.27	5.37	0.10	7.06
2006	14	228	5.37	5.43	0.06	10.94
2007	37	265	5.43	5.58	0.15	4.61
2008	37	302	5.58	5.71	0.13	5.30
2009	46	348	5.71	5.85	0.14	4.89
2010	59	407	5.85	6.01	0.16	4.42
2011	71	478	6.01	6.17	0.16	4.31
2012	80	558	6.17	6.32	0.15	4.48
2013	93	651	6.32	6.48	0.15	4.50
2014	91	742	6.48	6.61	0.13	5.30
2015	114	856	6.61	6.75	0.14	4.85
2016	157	1013	6.75	6.92	0.17	4.12
2017	148	1161	6.92	7.06	0.14	5.08
2018	200	1361	7.06	7.22	0.16	4.36
2019	158	1519	7.22	7.33	0.11	6.31
2020	27	1546	7.33	7.34	0.02	39.33
Total	**1546**	—	—	—	**Mean 0.23**	**Mean 5.41**

7.2. Top Ten Journals

Out of 631 journals,*Spectrochimica Acta Part A-Molecular and Biomolecular Spectroscopy* ranked as first with 30 articles. This is followed by *Journal of the Indian Chemical Society* with 29 articles and *Journal of Materials Science-Materials in Electronics* with 26 articles. In addition, *Indian Journal of Chemistry Section A-Inorganic Bio-Inorganic Physical Theoretical & Analytical Chemistry* ranked as fourth with 24 articles, *Journal of Molecular Structure* with 23 articles and ranked as fifth and so on. Thus it is seen that most of the articles from the MS university are published in Indian journals. A journal from Netherlands is seen among the top ten journals.

Table 2

Rank List of Top Ten Journals

Journal Name	No. of Articles	Rank
Spectrochimica Acta Part A-Molecular and Biomolecular Spectroscopy	30 (1.94%)	1
Journal of the Indian Chemical Society	29 (1.88%)	2
Journal of Materials Science-Materials in Electronics	26 (1.68%)	3
Indian Journal of Chemistry Section A-Inorganic Bio-Inorganic Physical Theoretical & Analytical Chemistry	24 (1.55%)	4
Journal of Molecular Structure	23 (1.49%)	5
Indian Journal of Geo-Marine Sciences	23 (1.49%)	5
Indo American Journal of Pharmaceutical Sciences	17 (1.10%)	6
Pramana-Journal of Physics	15 (0.97%)	7
Physiological and Molecular Plant Pathology	14 (0.91%)	8

7. 3. Application of Bradford's Law

Table 3

Application of Bradford's Law

Rank	No. of Journals	Cum. No. of Journals	No. of Publica-tions	Cum. No. of Publications	% Cum. No. of Journals	% Cum. No. of Publications
1	1	1	30	30	0.16	1.94
2	1	2	29	59	0.32	3.82
3	1	3	26	85	0.48	5.50
4	1	4	24	109	0.63	7.05
5	2	6	46	155	0.95	10.03
6	1	7	17	172	1.11	11.13
7	1	8	15	187	1.27	12.10
8	3	11	42	229	1.74	14.81
9	3	14	39	268	2.22	17.34
10	3	17	36	304	2.69	19.66
11	2	19	22	326	3.01	21.09
12	4	23	40	366	3.65	23.67
13	8	31	72	438	4.91	28.33
14	8	39	64	502	6.18	32.47
15	**6**	**45**	**42**	**544**	**7.13**	**35.19 (Zone1)**
16	13	58	78	622	9.19	40.23
17	18	76	90	712	12.04	46.05
18	30	106	120	832	16.80	53.82
19	**48**	**154**	**144**	**976**	**24.41**	**63.13 (Zone2)**
20	93	247	186	1162	39.14	75.16
21	**384**	**631**	**384**	**1546**	**100.00**	**100.00 (Zone3)**

The research publications of Manonmaniam Sundaranar University were arranged in descending order from highest to lowest publications for applying bradford's law. Three zones were expressed boldly in table 3, 544 publications scattered in 45 journals in zone 1 followed by 432 publications in 109 journals in zone 2 and 477 journals with 570 publications in zone 3. Thus the research publications rapidly increase over period of time in the present study.

Table 4

Bradford's Law of Scattering of Research Output

Zone	No. of Journals	No. of Publications	Multiplier
1	45	544	—
2	109	432	2.42
3	477	570	4.38
Total	**631**	**1546**	**3.40**

Bradford's law of verbal formulation calculated the multiplier by dividing the number of journals in a zone by preceding zone's number of journals. The three zones contains one third of the articles in each zone, which reduce the percentage of error during the distribution of articles. A total of 1546 publications have been published by 631 journals during 1992 to 2020. The publications were divided in to three zones. The 544 research publications were published in 45 journals, 432 research publications in 109 journals and 570 publications in 477 journals. As per the Bradford's law formula 1: n: n^2, the present study denotes as 45: 109: 477. Hence, 45 journals represent the nucleus zone and the mean value of multiplier is 3.40. Therefore 1*45: 3.40*45: $(3.40)^2$*45 = 718.2 which does not fit to the Bradford's law of scattering for the present study.

HYPOTHESIS 1

Bradford's law of scattering fits to the research publications of Manonmaniam Sundaranar University.

The percentage of error denoted as 13.82, which is not negligible for the present study. Hence, the distribution of research publications does not fit and follow the Bradford's law. Therefore, it is concluded that the alternative hypothesis can be accepted.

7.4. Application of Leimkuhler Model

Leimkuhler model was applied to the present data to justify the Bradford's law of scattering. In this model the multiplier 'k' can be calculated as $k = (e^{y}*Y^{m})^{1/p}$. Here also the dataset is divided in to three zones. So, P = 3.

e^{y}= 1.781 (constant) and Y^{m} = 30 (no. of papers in the descending order of journal productivity)

Then, $k = (1.781*30)^{1/3} = 3.76$

Nucleus zone or first zone can be calculated by using the below formula:-

$r_o = T(k-1)/(k^{p}-1)$, Where T = Total number of journals in the data set of the study

$r_o = 631\ (3.76-1)/(3.76^{3}-1)$

$r_o = 33.39$

As per the values of Leimkuhler model the modified number of journals in different zones of Bradford's law of scattering shown in table 5.

Table 5

Leimkuhler Model of Bradford's Law of Scattering

Zone	No. of Journals	No. of Publications	Multiplier
1	33	544	
2	126	432	3.82
3	472	570	3.75
Total	**631**	**1546**	-

The zone distribution of journals as per Leimkuhler model is 1*33.39: 33.39*3.76: 33.39*$(3.76)^2$i.e., which supports the Bradford's law. The value of multiplier k is 3.82 in the zone 1 and 3.75 in the zone 2 respectively. The value of multiplier k obtained using the formula $k = (e^{\bar{a}} * Y^m)^{1/p}$ is same in one of the zone.

HYPOTHESIS 2

Leimkuhler model fits to the research publications of Manonmaniam Sundaranar University.

The calculated value of multiplier k using the formula have the same value (3.76) in one of the three zones and the percentage of error is in negative value (-0.0014%). Hence, the present data set fits to the Leimkuhler model.

7.5. Graphical Formulation of Bradford's Law

Verbal formulation of Bradford's law of scattering is verified by using **Brooke's** three conditions of graphical formulation method. They are (i) the graph may have a sharp rise at the beginning which denotes the core journals. (ii) a linear growth shown in the middle of the graph which indicating strong relation between the variables and (iii) a droop at the end point which indicating the incompleteness of the bibliography distribution (Brookes, 1969).

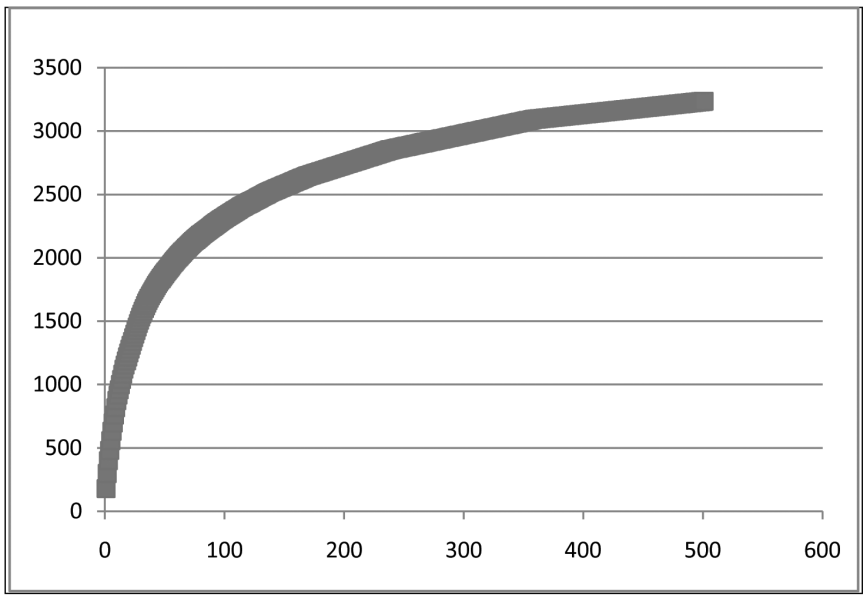

Fig.1: Graphical Formulation of Bradford's Law

Figure 1 shows the logarithmic plot of the cumulative number of articles in y-axis and the cumulative number of journals in x-axis. If the distribution of Bradford's law is confirmed through the graphical formulation then it is called as Bradford Bibliograph. It is found from the graph that the present study had no sharp rise at the beginning. Therefore, the graphical formulation of Bradford's law does not confirm the verbal formulation of Bradford's law of scattering.

8. Findings

The major findings of the study are as follows:-

- The mean value of relative growth rate and doubling time are 0.23 and 5.41 during the study period.
- The ranked list of the core journal shows that *Spectrochimica Acta Part A-Molecular and Biomolecular Spectroscopy* ranked first, followed by *Journal of the Indian Chemical Society*.
- According to the Bradford's law of scattering, 631 journals with 1546 research publications divided into three zones of equal number of journals. The relationship of the each zone is 45:109:477 for the present study and the percentage of error is not negligible. Thus Bradford's law does not fit to the data set.
- Leimkuhler model was applied to verify the Bradford's law of scattering. The relationship of the each zone is 33.39:125.546: 472.054 and the percentage of error is negligible.
- It is found from the graph that the present study had no sharp rise at the beginning. So, the graphical formulation of Bradford's law does not confirm the verbal formulation of Bradford's law of scattering.
- Hypothesis 1 is not proved because the percentage of error denoted as 13.82, which is not negligible for the present study. So, the distribution of research publications does not fit and follow the Bradford's law.
- Hypothesis 2 is proved because the calculated value of multiplier k using the formula have the same value (3.76) in one of the three zones and the percentage of error is in negative value (-0.0014%). Hence, the present data set fits to the Leimkuhler model.

9. Conclusion

The study provides the result of the relative growth rate and doubling time for the research publications of Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu. It also revealed that the application of Bradford's law, the Leimkuhler model, and the graphical for mulation of Bradford's law on research publications and concluded that Bradford's law does not fit the data set, whereas the Leimkuhler model verified that Bradford's law fits the data set and the graphical formulation of Bradford's law does not show a sharp rise at the beginning of the cumulative number of journals. As a result of this finding, that Manonmaniam Sundaranar University should increase its research publications in the future.

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