



Application of Bradford's Law of Scattering to the Literature of Social Science

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Abstract

This papers aim to apply the Bradford law of scattering and Leimkuhler model to social science literature published by Indian authors during 2007-2020 and find out the core journals in the field of social science. A total of 7645 papers published in 793 journals were retrieved from Web of Science and analyzed. Ranked list of journal was prepared, Value in Health, Contribution to Indian Sociology, Energy Policy and Political Studies Review were the most preferred journals. The journal distribution pattern in the present data fit the Bradford's distribution pattern with 0.7795% percentage of error.

Keywords: Bibliometrics, Bradford's Law of Scattering, Bradford's Multiplier, Core Journals, Literature Growth, Leimkuhler Model, Social Science

0. Introduction

Social is a cluster of academic disciplines that study human behaviors by scientific methods to comprehend how people behave and interact with each other, advance as a society and impact the world. The origin of social science can be traced back to the ancient Greeks in the sixth century BC where there were hints of basic notions of social convention and hypothetical knowledge was formulated. By the fifth century there was a refined understanding of many methodological issues (McDonald, 1993). However social science as an academic field of study



is closely related to the modern world and its requisite for empirical knowledge about society. This started in the west during the Age of Enlightenment which flourished through much of the eighteenth century and continued with industrialization and the rise of the nation-state in the nineteenth century. An incredible growth of the social science was seen in the twentieth century in term of theory and methodology and social science became an important tool for management, evaluation techniques and policy making etc.(Kazancigil& Makinson,1999).

Bradford's law of scatterings a law of diminishing returns and scattering, it was first published by Samuel C. Bradford in the year 1934 and it is one of the most important law of bibliometric and one of the best model of scientific research that is available in Library and Information Science. The law states that documents in a given subject are distributed according to a certain mathematical function and growth in documents requires a growth in the number of journals. Bradford's law has been used for collection building, selection of journals to be indexed in bibliographies and by Bradford himself as a model for organizing bibliographical works and scientific documentation(Hjorland and Nicolaisen, 2005).

1. Review of related literature

A number of studies have been conducted using Bradford's law of scattering. Some of the notable ones are reviewed below.

Sangam (2015) explained the concepts, history, implications and verbal and graphical representation of Bradford's law. He tested the application of Bradford's law to 30 journals and 281 citations and references in the field of psychology and found that result was in accordance with Bradford's hyperbolic curve, therefore the law holds well with psychology journals. The further discussed the library acquisition policy based on Bradford's law. Paliwal (2016) studied the papers of all the authors of Annals of Library and Information Studies (ALIS) from 2009-2013 and determined the most cited journals. Her study revealed that the journal distribution pattern fit Bradford's distribution pattern as well as Leimkuhler model with $n=5.82$ and $n=6.767$ with negligible percentage of errors.SB and Batcha M (2020) analyzed 7653 documents published during 2001-2019 in the field of fluid mechanics. They applied various bibliometric indicators to find out the growth pattern and collaboration pattern. Their study also revealed the most preferred journals and most productive authors.The study found that distribution of articles in the journals does not fit in the Bradford's law of scattering however for verification



Leimkuhler model was applied and the result shows that Bradford's law will fit with 2:57:1462 with 0.005% of error. Singh and Bebi (2014) studied the Bradford's law of scattering in the journals citations of the 260 Ph.D. theses in the field of social science submitted to the University of Delhi during 1995-2008. It was found that Bradford's law of scattering fit the data of the study with a ratio of 4:55:875. The study also analyzed the types of documents, geographical distribution, year-wise number of publication and ranked the cited journals. VT and S (2020) conducted a scientometric study on research publications of nanophysics and found that the journal distribution does not follow Bradford's law of scattering nor Price's Square Root Law and Parretto Principle. Neelamma and Anandhal (2016) tested the applicability of Bradford's law to the literature of botany. They plotted a graph by taking the total number of citations on "Y" axis and log of cumulative number of journals on "X" axis. It was observed that the bibliography started rising in nature and then follow a linear curve indicating that the data fit the Bradford's law of scattering.

2. Objectives

The objectives of the study are stated as:

1. To find out the bibliographic form wise distribution of documents.
2. To analyse the year-wise growth of literature.
3. To rank the journals based on the number of articles published and identify the core journals in the field of social science.
4. To test the applicability of Bradford's law of scattering and Leimkuhler Model to the literature published in the field of social science.

3. Scope and methodology

This study covers the literature of social science published by Indian social scientists that are available in Web of Science for the period of 2007-2020. For this study, social science includes the following sub-disciplines namely, Economics, Education, Geography, History, Law, Political Science, and Sociology. The required data has been collected from Social Science Citation Index (SSCI) accessed via Web of Science. A total of 7645 papers were extracted which were published in 793 journals. The data was analyzed using MS Excel and presented in tables and graphs for the purpose of interpretation.



4. Data analysis

4.1. Bibliographic forms wise distribution of papers

Table 1 show that journals contribute the highest number of papers accounting for 63.44% of the total publication. This indicated that social science researcher prefers to publish their research work in journals. The next preferred is meeting abstracts (17.44%), followed by book reviews (14.09%).

Table 1

Distribution of papers by bibliographic form

Sl no.	Bibliographical form	No. of papers (%)	Cumulative no (%)	Rank
1	Article	4850(63.44)	4850 (63.44)	1
2	Meeting Abstract	1333(17.44)	6183(80.88)	2
3	Book Review	1077(14.09)	7260(94.96)	3
4	Editorial Material	154(2.01)	7414(96.98)	4
5	Review	86(1.12)	7500 (98.10)	5
6	Proceedings Paper	78(1.02)	7578(99.12)	6
7	Correction	23(0.30)	7601(99.42)	7
8	Letter	17(0.22)	7618(99.65)	8
9	Biographical-Item	16(0.21)	7634(99.86)	9
10	Book Chapter	6(0.08)	7640(99.93)	10
11	News Item	3(0.04)	7643(99.97)	11
12	Reprint	1(0.01)	7644(99.99)	12
13	Retracted Publication	1(0.01)	7645(100)	12

4.2. Year-wise growth of literature

Table 2 show the year-wise growth of literature in the field of social science from 227 papers in 2007 to 1088 papers in 2020. A steady growth can be seen each year except for 2017 where there was a slight decrease in the number of publication.

Table 2

Year-wise distribution of papers

Sl no.	Year	Total n of publication (%)	Cumulative
1	2007	227 (2.97)	227
2	2008	309 (4.04)	536



3	2009	343 (4.49)	879
4	2010	344 (4.50)	1223
5	2011	390 (5.10)	1613
6	2012	396 (5.18)	2009
7	2013	454 (5.94)	2463
8	2014	512 (6.70)	2975
9	2015	607 (7.94)	3582
10	2016	724 (9.47)	4306
11	2017	656 (8.58)	4962
12	2018	783 (10.24)	5745
13	2019	812 (10.62)	6557
14	2020	1088 (14.23)	7645

4.3. Ranked list of Journals

It is shown in Table 3 that the journal with highest number of papers occupied the highest rank while the titles with least number of publications are placed at the bottom. The top 48 journals are arranged in order of their ranks. It can be determined that Value in Health occupies the first rank as the most preferred journal with 1338 papers accounting for 17.50% of the papers published during the period of study. Contribution to Indian Sociology scores the second highest with 402 papers, followed by Energy Policy and Political Studies Review with 235 and 197 papers respectively. The top 10 journals in the ranked list together account for 37.70% of the total publication.

Table 3

Rank list of journals in social science

Sl No.	Rank	Name of Journal	Articles Published	Cumulative Articles
1	1	Value in Health	1338 (17.50)	1338
2	2	Contributions to Indian Sociology	402 (5.26)	1740



3	3	Energy Policy	235 (3.07)	1975
4	4	Political Studies Review	197 (2.58)	2172
5	5	Journal of Intellectual Property Rights	155 (2.03)	2327
6	6	World Development	139 (1.82)	2466
7	7	Economic Modeling	138 (1.81)	2604
8	8	Medicine Science and the Law	112 (1.47)	2716
9	9	Indian Economic and Social History Review	90 (1.18)	2806
10	10	Social Indicators Research	76 (0.99)	2882
11	11	Applied Economics	73 (0.95)	2955
12	11	Journal of Development Studies	73 (0.95)	3028
13	12	International Sociology	72 (0.94)	3100
14	13	Applied Economics Letters	69 (0.90)	3169
15	14	Energy Economics	65 (0.85)	3234
16	15	Economics Letters	61 (0.80)	3295
17	16	International Journal of Emerging Markets	55 (0.72)	3350
18	17	Ecological Economics	50 (0.65)	3400
19	18	International Review of Economics & Finance	48 (0.63)	3448
20	19	Education and Information Technologies	46 (0.60)	3494
21	19	Singapore Economic Review	46 (0.60)	3540
22	20	Journal of Policy Modeling	45 (0.59)	3585
23	21	Interventions-International Journal of Postcolonial Studies	43 (0.56)	3628
24	22	Journal of Development Economics	42 (0.55)	3670
25	23	British Journal of Educational Technology	39 (0.51)	3709
26	24	South Asia-Journal of South Asian Studies	38 (0.50)	3747
27	25	Food Policy	37 (0.48)	3784
28	26	Transportation Research Part E-Logistics and Transportation Review	36 (0.47)	3820
29	27	Applied Geography	35 (0.46)	3855
30	27	Futures	35 (0.46)	3890
31	27	Review of Development Economics	35 (0.46)	3925
32	28	Empirical Economics	32 (0.42)	3957
33	28	Social Choice and Welfare	32 (0.42)	3989
34	28	Transport Policy	32 (0.42)	4021
35	29	Games and Economic Behavior	29 (0.38)	4050
36	29	Geoforum	29 (0.38)	4079
37	29	International Journal of Educational Development	29 (0.38)	4108
38	29	Journal of International Trade & Economic Development	29 (0.38)	4137
39	29	Journal of The Asia Pacific Economy	29 (0.38)	4166
40	30	Agricultural Economics	28 (0.37)	4194
41	30	Environment and Development Economics	28 (0.37)	4222
42	30	Transportation Research Part A-Policy and	28 (0.37)	4250



Practice			
43	31	BMC Medical Education	27 (0.35) 4277
44	31	Economic Development and Cultural Change	27 (0.35) 4304
45	32	British Food Journal	26 (0.34) 4330
46	32	Forest Policy and Economics	26 (0.34) 4356
47	33	International Feminist Journal of Politics	25 (0.33) 4381
48	34	Journal of World Trade	24 (0.31) 4405
49		Others (745 Journals)	3240 (42.38) 7645

4.4. Bradford’s Law of Scattering

In 1948, Samuel C Bradford formulated an empirical law of scientific productivity. The law states that “If scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the number of periodical in the nucleus and succession zones will be as 1:n:n²:...” (Bradford, 1948)

Table 4

Bradford’s zones and their number of journals

Zone	No of Articles	No of Journals	Bradford Multiplier
1	2604	7	-
2	2548	82	11.7143
3	2493	704	8.5854
	7645	793	10.1498

Table 4 specifies that zone 1 contained 7 journals with 2604 articles, zone 2 contained 82 journals with 2548 articles and zone 3 contained 704 journals with 2493 articles. The Bradford multiplier factor was derived by dividing the number of journals for a zone by its preceding zone.

According to Bradford, the zones will form an approximately geometric series in the form 1:n:n². The relationship found in the present study was 7: 82:704

Here, 7 is the number of journals in the nucleus and n = 10.1498 which is the mean value of the Bradford multiplier.

Therefore, the values of journals in the zones are



$$7:7 * 10.1498:7 * 10.1498^2 :: 1 : n : n^2$$

$$= 7:71.0488:721.1327 > 799.1815$$

$$\text{Percentage of Error} = \frac{799.1815-793}{793} \times 100$$

$$= 0.7795\%$$

Here the percentage of error is negligible and the data of the present study follow the distribution of literature as per Bradford's law of scattering.

4.5. Applicability of Leimkuhler Model

In this study both Bradford's law as well as Leimkuhler model are tested to verify the scattering of literature in social science.

The Bradford Multiplier k can be calculated as

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

where e is Euler's number; $e = 2.718$ (constant); y^m is the number of articles in the highest rank journal; P is the number of Bradford's zones; T is the total number of journals.

Here, the data set has been divided in 3 zones,

$$\text{So, } p = 3$$

$$e^y = 1.781(\text{constant}) \text{ and } y^m = 1338$$

Now,

$$k = (1.781 * 1338)^{1/3}$$

$$= (2382.978)^{1/3}$$

$$= 13.3569$$

Therefore, $K = 13.3569$

$$r_o = T (k-1) / (k^P - 1)$$

$$= 793 (13.3569 - 1) / [(13.3569)^3 - 1]$$

$$= 9799.022 / 2381.961$$

Thus, $r_o = 4.1138$



$$Y_o = A/p$$

$$=7645/3$$

$$=2548.333$$

$$a = y_o / \text{Log}k = 2548.333 / \text{Log}13.3569$$

$$=2548.333 / 2.59033$$

$$=983.1406$$

$$b = k^{-1} / r_o$$

$$=13.3569^{-1} / 4.1138$$

$$=3.0038$$

Different Bradford's zone can be identified using the qualifier value of 'r_o' and k

$$\text{Nucleus zone} = r_o * 1 = 4.1138 * 1 = 4.1138$$

$$\text{Second zone} = r_o * k = 4.1138 * 13.3569 = 54.9476$$

$$\text{Third zone} = r_o * k^2 = 4.1138 * (13.3569)^2 = 733.9298$$

So after normalizing the number of journals in different zones, the Bradford's zone would be as shown below as per Leimkuhler model

Table 5

Scattering of journals and articles over Bradford's zone

Bradford's Zone	No of Journals	No of Articles	K
1	4	2172	
2	55	2464	1.1344
3	734	3009	1.2212
	793	7645	1.1778

Hence, Bradford's distribution by Leimkuhler model is represented as r_o:r_o * k: r_o * k²

$$= 4.1138 : 4.1138 * 13.3569 : 4.1138 * 13.3569^2$$

$$= 4.1138 : 54.9476 : 733.9298$$

As part of the above ratio we get 792.9912



Therefore, the percentage of error from the real count is;

$$\begin{aligned} \text{Percentage of Error} &= \frac{793-792.9912}{793} \times 100 \\ &= 0.0011\% \end{aligned}$$

So, the error of percentage is found to be 0.0011 which is negligible from the calculation above.

The finding of the Bradford's scattering based on Leimkuhler model as shown on Table 5 indicates that the number of journal representing articles of all the zones expand with a multiplier of 13 approximately

The data zonal analysis reveals that zone 1 consist of 4 journals with 2172 article, zone 2 consist of 55 journals with 2464 articles and zone 3 consist of 734 journals with 3009 articles.

4.6. Graphical formulation of Bradford's law

The graphical formulation was developed by Brookes who tried to verify the verbal formulation of Bradford's law. The graph should depict three distinct characteristics: 1. A rapid rise, 2. A big portion of linear rise and 3. A 'droop' towards the tail. (Brookes,1969)

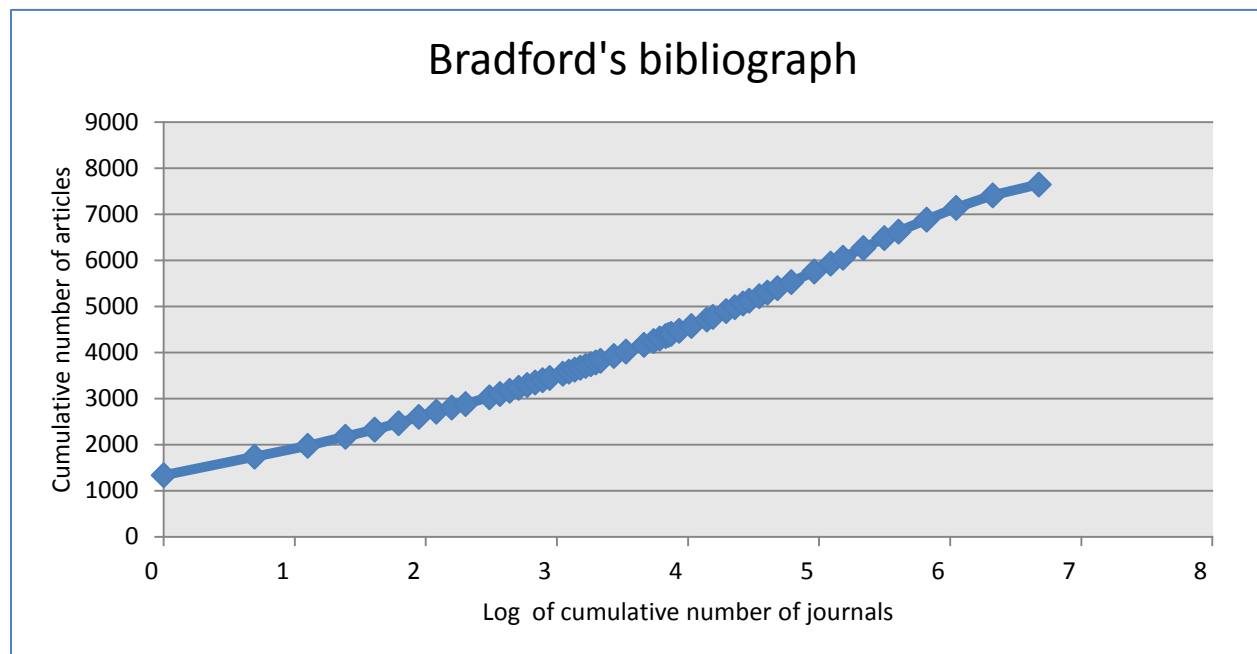


Figure 1: Bradford's Bibliograph

Figure 1 depicts a graphical formulation of Bradford's law. The graph is plotted for the cumulative number of articles with respect to the log of cumulative number of journals. The



graph in figure 1 satisfied the 3 distinct characteristic of Bradford's bibliography given by Brookes.

5. Conclusion

In recent years where we are experiencing a state of information explosion when there is too much to digest and people are unable to locate the information they need, the application of Bradford's law of scattering could help libraries and its users in a significant ways. For instance, selection or cancelling and wedding of journals in a library can be effectively done since the journals in Bradford nucleus are generally considered to be the core journals. Bradford ranking could be used as a checklist with higher zone journals, counting more than lower zone journals and a large segment of users' needs can be met by collecting the small numbers of journals in the nucleus.

In the present study the journal distribution pattern of social science literature fit the Bradford's distribution pattern i.e., $1:n: n^2$. When the Leimkuhler model was applied for verification of Bradford's law, it was found that the law is valid for the data set with a negligible percentage of error (0.0011%). Value in Health, Contribution to Indian Sociology, Energy Policy and Political Studies Review were identified as the core journals.

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